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Climatologists' methods of climate science communication to agriculture in the North Central Region of the United States

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**Climatologists' methods of climate science communication to agriculture in the North
Central Region of the United States**

by

Adam K. Wilke

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Co-Majors: Sociology; Sustainable Agriculture

Program of Study Committee:

Lois Wright Morton, Major Professor

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Iowa State University

Ames, Iowa

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ABSTRACT

Agriculture is particularly sensitive to environmental risks associated with uncertain atmospheric conditions, such as extreme weather events and variable climate patterns. As a result, it is important for farmers and the agricultural sector to access current climate science information while developing management portfolios to remain resilient and productive while adapting to and mitigating against environmental risks. State and extension climatologists have a unique role in collecting climate science information and disseminating this information to public data users, such as farmers. Because of complex social, cultural, and political factors that hinder the transfer of current scientific consensus on weather and climate knowledge from scientists to decision makers, it is important to understand how this information is communicated.

This study presents data from surveys (N=19) and interviews (N=13) with state and extension climatologists in the North Central Region of the United States regarding their perceived roles and currently employed patterns of communication. Results are analyzed utilizing an adaptation of Fischhoff's (1995) stages of uncertain risk communication, and Pielke's (2007) idealized roles of science in society. Findings indicate that the majority of climatologists in this region are focused on providing objective information in the role of a pure scientist. A lesser number of climatologists acknowledge the need to frame information as relevant and important, while considering connections of science to societal impacts. Very few climatologists recognize communication strategies of engaging and building trust with the audience, while outlining and enlarging options for individual and collective decision makers, including public policy development.

There is an urgent need for agriculture to adapt to extreme weather events and variable climate conditions so that local communities and the global society may continue to obtain food, fiber, feed, and fuel. Climatologists have an important role in communicating current knowledge regarding climate systems to assist agriculture in remaining resilient and productive. As society demands scientific information to assist in individual and collective decision making, scientists will be tasked with making connections between science and societal impacts. By relating scientific research to risk management and hazard mitigation, climatologists will be taking the necessary steps to help farmers, as well as society.

CHAPTER 1.

GENERAL INTRODUCTION

“Agriculture is nested in a social environment of uncertainty.”

– Lois Wright Morton
November 20, 2012

Introduction

Agricultural producers must make a series of management decisions in response to uncertain risks arising from changes in the physical environment as well as shifts in the social, economic, and political conditions that affect the productivity and efficiency of agricultural production (Hardaker, 2004; Slovic, 2000). It is therefore important when considering the development of agriculture management actions to understand both changing external conditions and producer responses to these conditions. Of particular interest over the past decade has been understanding how climate science information is communicated to public data users, such as farmers and other stakeholders in the agricultural sector.

As individuals designated to interpret and translate weather and climate information for the constituents of their region, state climatologists have a unique position to communicate between regional and federal climate centers and public climate data users, such as producers of grain crops. The structure of a state climate office is determined by each state, and while some offices are housed in state departments of agriculture, others are also tasked with extension and outreach. Regardless of differing structures, prominent in each state is the task of overseeing the state’s weather observation sites, including monitoring the compilation and quality control of climate records. Most importantly, the state climatologists’ role includes making these records available and accessible to the public. Oftentimes this information is displayed in some format, including text and graphical representations, on a state climate office website, or transferred to a regional climate center or extension climatologist for dissemination via other outlets, such as presentations, personal communications, or hard copy handouts.

In this chapter, I will start by briefly outlining theories regarding the roles of science and public engagement in addressing societal problems. Then I will discuss climate change as an environmental and human risk. I will then outline the risks of climate specifically

associated with agriculture, and opportunities for climate science to assist agriculture in adapting to and mitigating potential risks. I will conclude by stating the three research questions to be addressed in this thesis, followed by the thesis organization.

Science or service?

In the early 20th century, John Dewey and Walter Lippman famously debated about the role of public input in developing policy for the democratic society. By definition the appropriate advancement of policy in a democratic government framework required public citizen opinion, Dewey declared, and this input is necessary for the democracy to function as established. On the other hand, society was changing so rapidly, both alleviating and creating complex social problems by advancements of technology; Lippman argued that the role of public citizen input was becoming less important in modern society. As a result, Lippman stated that policy questions should be approached by an educated group of expert leaders, while Dewey maintained that democratic policy decisions require active consideration of all citizen input.

Society was indeed changing in the early 20th century. The establishment of the railroad system, phonograph communication technologies, food preservation advances such as refrigeration, and other important inventions seemingly made life better and brought people closer together. However already at this time our ancestors were noticing problems still encountered today, such as pollution and resource depletion. In the present year 2013, society is continually advancing to accommodate new technologies, such as wireless communications, global commerce, and genetically modified organisms—to name a few—and social problems are once again being alleviated and created in response to these new influences in life. Perhaps not surprisingly, policy development in our democratic society still grapples with the revolving question of who makes the decisions about how to deal with and respond to these problems: all capable citizens, including public participants, or a group of informed experts?

As to be expected, this dichotomy is still being addressed and debated today. Dan Kahan and Cass Sunstein have continued debating in recent years the roles of citizen and expert input in scientific consensus and subsequent policy development. Kahan's group has argued for the "cultural cognition of scientific consensus," stating 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 et al., 2006, 1072). On the other hand, Sunstein asserts that a cost-benefit analysis conducted by experts is important to separate irrational public fears from important public values, allowing for less subjective and therefore more democratic policy suggestions (Sunstein, 2005).

Potential hazard and risk is an important consideration in most all aspects of scientific research and subsequent public policy development. To a large extent, scientific endeavors are pursued to address and solve queries or problems whose solution may directly or indirectly benefit the social world. As a result, one could argue that all scientists are public servants in the sense that the work they conduct is directly relative to real-world risks and impacts faced in a modern society.

The definition of risk, however, is up for debate itself. Risk is often defined as “the chance of injury, damage, or loss” (Sloan 1999, citing Websters dictionary). However, there is a multitude of social science research that argues that risk itself is inherently subjective (Otway, 1992; Pidgeon et al., 1992; Slovic, 1992; Wynne, 1992). Slovic argues that “human beings have invented the concept risk to help them understand and cope with the dangers and uncertainties of life” (Slovic, 1999, 690). Although we understand that hazards and risks are real in themselves, there may actually be no such thing as “objective risk.” Risks assessments often entail subjective judgments, which themselves are modulated by complex social and cultural vantage points.

Climate as risk

For those of us with connections to the social world, we may have noticed the increasing news concerning what is commonly referred to as climate change. Even for those with little or no connection to the news, they may have noticed a similar phenomenon in terms of increasingly extreme weather events and climate conditions. One could argue that changing climate is one of the most impending social and environmental concerns of modern times.

The Intergovernmental Panel on Climate Change (IPCC), for example, has emphasized that because agriculture is particularly sensitive to climate variability, societies must develop more resilient and productive agriculture management systems (Field et al. 2007). To highlight the urgent need for members of the public to understand climate change science, the United States Global Change Research Program (USGCRP) released in April, 2012 a 10 year strategic plan containing four key goals to accomplish by the year 2022. Two of these goals are directly relevant to a citizen's capacity to comprehend climate science information: "(1) Conduct Sustained Assessments: Build a sustained assessment capacity that improves the Nation's ability to understand, anticipate, and respond to global change impacts and vulnerabilities. (2) Communicate and Educate: Broaden public understanding of global change and support the development of a scientific workforce skilled in Earth-system sciences" (USGCRP, 2012). It therefore has become evident that to appropriately address human responses to global climate change, social scientists must consider how the current scientific consensus information on climate is presented, communicated, and diffused to the public.

Tom Armstrong, the Executive Director of the USGCRP said, "It is no longer enough to study the isolated physical, chemical, and biological factors affecting global change, advanced computing technologies and methods now allow us to integrate insights from those disciplines and add important information from the ecological, social, and economic sciences. This new capacity will deepen our understanding of global change processes and help planners in realms as diverse as storm water management, agriculture, and natural resources management" (USGCRP, April 27, 2012).

The United States National Climate Assessment Federal Advisory Committee's Draft Climate Assessment Report states that disruptions to agricultural production are projected to increase, causing negative impacts to most crop and livestock systems by mid-century. The rate at which agriculture adapts to climate change will be important as critical thresholds in production systems are reached, impacting global food security (Walthall et al., 2012). An increase in extreme weather events in the last decade suggests connections to a changing climate (Coumou and Rahmstorf, 2012), matching IPCC projections of "more frequent and more intense extreme weather" (World Meteorological Organization, 2011, p. 2).

The Iowa Climate Change Impacts Committee released a Report to the Governor and the Iowa General Assembly titled *Climate Change Impacts on Iowa 2010*, in which they concluded, among other things, that Iowa has experienced an increase in extreme spring-time precipitation events (1.25 inches), and increase in frost free days, an increase in summer dew points, and fall soil temperatures. Throughout this time, agricultural yield have increased. “Recent weather events and climatic trends are stressing agriculturally related resources. Increased rainfall, and frequency of much heavier-than-normal rainfall events, result in disproportionately negative impacts on soil and water resources and on crop production. Climate extremes, not the averages, frequently control productivity of crops and livestock” (Iowa Climate Change Impacts Committee, 2010, p. 17).

On November 19, 2012, 138 scientists from Iowa released the Iowa Climate Statement, stating that “we have confidence in recent findings that climate change is real and having an impact on the economy and natural resources of Iowa. We feel that it is important for citizens of Iowa to understand its implications... As global citizens, Iowans should be a part of the solution. Iowa should lead innovation in reducing greenhouse gas emissions, improve resilience in agriculture and communities, and move towards greater energy efficiency and increased use of renewable energy” (Iowa Climate Statement, 2012, p. 1).

Clearly, climate change has been and will continue to influence environmental risks and hazards. While the extent to which these risks will be realized in the future is currently up for debate, and largely influenced by individual beliefs and social, cultural, and political contexts, it is challenging to deny that climate’s influence on agriculture should not be addressed. As a result, it is necessary to further understand how climate will impact agriculture.

Climate and agriculture

The North Central Region of the United States encompasses the region commonly referred to as the “Corn-belt” which currently produces a large portion of corn and soybeans to provide local and global supplies. These valuable commodity products are utilized for a large number of outputs, including food, oils, soy-products, fed to animals, silage used for bedding, ethanol, and many other valuable commodities. United States agriculture produces around \$300 billion worth of commodities a year. Because agricultural production is

dependent on environmental variable such as weather and climate, the United States' National Weather Service is an important resource for the agriculture industry.

Weather observations collected at sites within each state also are fed back to the National Weather Service (NWS), which is a component of the National Oceanic and Atmospheric Administration (NOAA), an Operating Unit of the U.S. Department of Commerce. This information helps inform models that are publicly available through the National Weather Service, such as Climate Outlooks, Seasonal Drought Outlooks, Soil Moisture Forecasts, and the Drought Monitor. Subsequently, the data gained from these observations become available to private weather service companies, who in turn customize it and provide location-specific information to multiple industries, including components of the agriculture sector. In contrast to the public information available by NOAA, which provides seasonal forecasts for the vast spatial region of the whole United States, the forecasts provided by private services are highly personalized and much more spatially precise, offering the public involved with the agriculture sector more localized weather information to guide in them in their various management decisions, from seed selection and population density, to dry-down and marketing.

One could ponder the benefits of NOAA producing publicly available seasonal forecasts with more refined spatial precision, but the lack of funding and other limitations prohibit them from doing so. One notable limitation results from the transfer in 1996 of NWS Agriculture Weather Services to the Private Meteorological Sector as a result of a budget decision on the Commerce Appropriations bill. Since 1890, when the U.S. Congress established the Weather Bureau as an agency of the Department of Agriculture, which eventually became the National Weather Service, the United States government had been providing free and publicly available weather and climate information the citizens. Much of this information was specifically targeted for application to the agriculture sector. After the privatization of agriculture weather services in 1996, interested citizens have been pointed to a directory of private agriculture weather providers available on the NWS website at <http://www.nws.noaa.gov/im/>

Currently, the most widely accessed source of weather and climate information is a private service called DTN, formerly known as Data Transmission Network, based in Omaha, Nebraska. This company also delivers commodity prices, market information, and

agricultural news to over 120,000 unique subscribers. In 2007, DTN purchased from Time Warner *The Progressive Farmer*, an agricultural oriented magazine reaching approximately 650,000 homes. As previously stated, DTN's weather information is location-specific, and much of the weather forecasting is focused on days or a week to in the future, rather than months or seasons.

The most reliable and available seasonal forecasts at state and climate region within state scales are provided by state climatologists working in conjunction with State and regional climate offices. However, this information is generally not displayed in a consistent or readily available format in most states. It is often challenging to navigate the websites of state climate offices in search of specific climate information, a task most citizens and particularly farmers are reluctant to perform. To assist the USGCRP's goals in broadening public understanding of global change, it will be important to understand how scientific climate information is communicated from climatologists through various formats and channels and ultimately received by the public, particularly agricultural producers. Specifically, to ensure the productivity and resilience of grain cropping systems in the North Central Region of the United States amid increasingly uncertain environmental variables, it will be beneficial to concentrate on that region of the country.

Relating science to risk

The general public has a skewed conception of science and its role in knowledge and policy development. The emphasis in the scientific method on uncertainties, particularly in atmospheric and other modeling based sciences, is misinterpreted by the public. When the average citizen thinks about and tries to understand science, they wonder what question it is attempting to address. For instance, how will this science make my life better? In other words, they are attempting to relate science to risks in their life. "Learning processes, or acceptance of new information, are seldom based on concepts of uncertainties or proof, but on risk and risk management" (McBean and Hengeveld, 2000, 13). Scientists, on the other hand, embrace the discussion of uncertainties in the continuous advancement of scientific debate.

The Intergovernmental Panel on Climate Change (IPCC) recognizes three scales of uncertainty. (1) Qualitative uncertainty represents level of understanding, including the

amount of scientific evidence and agreement amongst scientists. (2) Quantitative uncertainty refers to the confidence of a certain finding in being correct. (3) Probabilistic uncertainty acknowledges the likelihood of the occurrence of a certain event. Interestingly, each of the three IPCC Working Groups differentially approached the concept of uncertainty, because of necessary differences of methodological approaches and subject matters between scientific disciplines (Swart et al., 2009). The inconsistencies of how uncertainty is addressed and perceived is a large barrier in the public's interpretation and reception of scientific findings of the IPCC report (Jonassen & Pielke Jr., 2011).

The complex social, cultural, and political contexts, as well as general perceptions of science, that influence that ability to public weather and climate data users to understand currently available science is of utmost importance. As individuals tasked with providing scientific knowledge to the public, state and extension climatologists have a unique role to assist farmers and the agricultural sector access climate information for use in developing agricultural management portfolios to adapt to and mitigate environmental risks in order to remain resilient and profitable. Because of this, it is necessary to understand how climatologists currently communicate information, including perceptions of their roles as scientists, and opportunities for more effective climate science communication. In this thesis, I will examine the following research questions.

Research questions

(1) How is climate science information currently communicated to the agricultural audience in the North Central Region of the United States?

(2) How do climatologists view their communication techniques and effectiveness of techniques with farmer audiences?

(3) How do climatologists in the North Central Region perceive their role in communicating climate science to agriculture?

Thesis organization

This thesis is structured as five chapters. The First chapter, Agriculture and Climate Science, introduced the topic, explained why it is a problem, outlined theoretical areas relevant to the problem, and provided three research questions that will be addressed. Chapter 2, Research Methodology, elaborates on qualitative and quantitative research methodologies used to answer the research questions. Chapter 3, Communicating climate science: Elements of engaging the agricultural audience, is a stand-alone paper applying an adaptation of Fischhoff's (1995) stages of uncertain risk communication to address the first two research questions. Chapter 4, Climatologists' pattern of communicating science to agriculture is the second stand-alone paper in which Pielke's (2007) framework of idealized role of science in society is applied to address the third research question. Chapter 5, Communicating Science for Agriculture Adaptation and Resilience, ties everything together and discusses opportunities for future research, as well as limitations of this study.

CHAPTER 2.

RESEARCH METHODOLOGY

Methodology

As part of United States Department of Agriculture (USDA) – National Institute for Food and Agriculture (NIFA) grants 2011-68002-30190 “Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems” and 2011-68002-30220 “Useful to Useable: Transforming Climate Variability and Change Information for Cereal Crop Producers,” this study seeks to inform the development of agricultural management decision support tools to assist farmers in remaining resilient and productive while continually adapting to increasingly uncertain environmental variable.

In particular, it is investigating the role of state and extension climatologists in providing location-specific weather and climate information to the agriculture sector and understanding the current formats and channels of communications. Also, inquiring as to how climatologists perceive that information is being received and utilized by agricultural grain producers, and ways in which climate data could be more effectively disseminated. To further explore the topic of climate information communication from Climatologists to the agriculture sector, 11 state climatologists and 11 extension climatologists (N=22) were selected from a purposeful sample to represent main outlets of publicly available and location-specific climate information in the North Central Region of the United States, or the “Corn-Belt.” For this thesis, data from 13 qualitative interviews and 19 surveys are analyzed and discussed.

Research methods involve both qualitative and quantitative components. Climatologists were initially contacted by e-mail and given details about the research, and also contacted via follow-up telephone calls as necessary (See APPENDIX A). All 22 climatologists agreed to participate in the study and signed informed consent documentation (See APPENDIX B). Interview and survey content, study protocols, and informed consent documentation were approved prior to administration by Iowa State University Institutional Review Board (IRB) #12-022 (See APPENDIX C).

Both quantitative survey questions and qualitative interview questions were developed collectively by a committee of scientists involved in the two USDA-NIFA projects. Specifically, the President of the American Association of State Climatologists, another state climatologist, two professors of sociology, one climate scientist, one other sociology graduate student, and a project manager formed the committee which was led by the researcher. Several meetings of members of this group occurred for three months as the survey and interview instruments were developed and validated. Both instruments were pilot tested by a group of climate scientists to further ensure validity prior to implementation.

Prior to the interview, participants were asked to fill out an optional mini-questionnaire, of which nineteen (N=19) completed (See APPENDIX D). The climatologist survey includes questions regarding beliefs in climate change, perceptions regarding influence of forecasts in farmer's decisions, other influences on decisions, and knowledge of seasonal timing of common management practices. The results of some of the questions on climatologist survey will be compared to those on the producer survey, allowing for statistical comparisons between responses from the two groups.

Interview content involved climatologists' roles and responsibilities, relationships with other climatologists and farmers, communicating climate information, agriculture decision making, including influence of climate information, advisors and other sources of information (See APPENDIX E). Interviews were transcribed, and analyzed line by line using open, axial, and selective coding. NVivo Qualitative Data Analysis Software was used to assist in the detection and frequency of emergent themes (NVivo, 2009). All themes were first detected, and then analyzed and mapped to understanding their relative importance. Transcripts were read and analyzed by the researcher and one a senior sociologist involved in both projects in order to ensure inter-rater reliability.

To further insure inter-rater reliability while analyzing the interview transcripts, a qualitative analysis codebook was developed (See APPENDIX F). This codebook was created with the assistance of a professor of science communication, as well as two graduate students studying science communication. MacQueen, McLellan, Kay & Milstein's "Codebook development for team-based qualitative analysis" (1998) was also of great assistance in developing the codebook. This codebook enabled researchers to quantify their coding of certain communication techniques mentioned in the transcript, allowing for direct

comparisons among coders. Further, these quantified codes were statistically tested for significance to further ensure inter-rater reliability using the measure of Cohen's kappa (Cohen, 1960; 1968).

Utilizing the code book, each coder searched for eight themes. These themes were (1) Accurate and objective, (2) Agricultural management relevance, (3) Agricultural economics and marketing, (4) Agricultural decision timing relevance, (5) Location relevance, (6) Format, (7) Engagement, and (8) Conservation management relevance. More specific information regarding the protocol for determining themes is available in APPENDIX F.

Inter-rater reliability data for interview coding by theme and questions is presented below in Table 2.1. Reliability data for interview coding by theme is presented in Table 2.2. The average means of questions in Table 2.1 are a range from 1.0 to 0.89. Average means for themes are 1.0 to 0.88. In Table 2.2, the Kappa values for the eight themes range from 1.0 to 0.866. A respected figure in inter-rater kappa calculation, Krippendorff (1980) concludes that values greater than 0.8 indicate good reliability (Carletta, 1996). As a result, our lowest inter-rater reliability values of 0.89, 0.88, and 0.866 indicate good reliability of coding between our two interview transcript analyses.

Many of the questions for the climatologist survey were selected from a lengthier producer survey distributed to 19,000 farms in the North Central Region, of which 4778 responded. The location of this survey corresponded with the 11 states represented by the climatologists. The producer survey was developed and validated by Dr. J. Gordon Arbuckle in the Department of Sociology at Iowa State University and Dr. Linda Prokopy in the Department of Forestry and Natural Resources at Purdue University, and was administered by the National Agriculture Statistics Service (NASS) in February 2012. NASS was responsible for survey administration because names and addresses of agriculture producers are tightly held and protected by the USDA.

The climatologist survey includes questions regarding beliefs in climate change, perceptions regarding influence of forecasts in farmer's decisions, other influences on decisions, and knowledge of seasonal timing of common management practices (See APPENDIX B). The results of some of the questions on climatologist survey are compared to those on the producer survey, allowing for comparisons between responses from the two groups.

Since the roles and responsibilities of climatologists are public knowledge and may be obtained through government and academic sources, it is possible to compare some expected findings with what is actually found. Further, it is possible to continually remain aware of news appearances and other outlets utilized by climatologists to convey information to the broader public. Communication may also be maintained between the climatologists and the researcher, allowing for the continual transfer of information via personal communication as the research develops.

Table 2.1. Inter-rater reliability data for interview coding by theme

Theme	Cohen Kappa Value
1	1.00
2	0.961
3	1.00
4	0.867
5	1.00
6	0.942
7	0.866
8	0.954

CHAPTER 3.
COMMUNICATING CLIMATE SCIENCE: ELEMENTS OF ENGAGING THE
AGRICULTURAL AUDIENCE

A paper to be submitted to *Weather, Climate, and Society*

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Abstract

The agricultural sector relies on weather and climate information to formulate management decisions which hedge against uncertain environmental risks. State and extension climatologists are important actors in providing forecast and outlook information to the public, including the agricultural sector. As a result of increasingly variable climate patterns and extreme weather events, scientific information about weather and climate is becoming necessary to develop productive and resilient agricultural management portfolios. However, the public in general has been reluctant to accept and implement climate science information into risk management planning and public policy. This is particularly evident in the agricultural sector. In this paper, I will explore how climate science is currently communicated to agricultural producers in the North Central Region of the United States. Results from interviews (N=13) and surveys (N=19) suggest that climatologists in this region are focused on providing accurate and objective information, and letting the science speak for itself. Communication theory indicates that it is important to also frame information in ways that are relevant to the audience, while creating a trusted atmosphere. Further, the public's perception of science in general relies on its ability to hedge against risks. On the other hand, the process of scientific consensus embraces uncertainty, which may be a large barrier in the public's reception of climate science. Findings from our research suggest that it is becoming increasingly important for climate science information to be framed as relevant for the intended audience. In the case of the agricultural sector, it may be necessary for climatologists to connect abstract scientific information to real world impacts and scenarios. This advanced method of communication may greatly assist the agricultural sector in remaining productive and resilient in response to increasingly uncertain environmental risks.

Key Words: climate, science communication, agricultural management, risk, climatologists

Introduction

The potential impacts of climate change are evident in national and international discourses. Connections to risks from increasingly uncertain climatic patterns have been made to public health, environmental sustainability, planning and policy, and most all sectors of commerce (Takle et al., 2006; Field et al., 2007; Coumou and Rahmstorf, 2012; Walthall et al., 2012). Agriculture is one sector that is particularly vulnerable to climate variability, according to the International Panel on Climate Change (IPCC) and the draft United States National Climate Assessment report released in January 2013 (Walthall et al., 2012). Predictions about the potentially negative impacts associated with increasingly variable climate patterns on agricultural production have been pointed to for many years (Adams et al., 1990) and are well elaborated in the new United States Department of Agriculture (USDA) report, *Climate Change and Agriculture in the United States: Effects and Adaptation* (Walthall et al., 2013). Many local communities in the North Central Region of the United States, which encompasses the predominantly grain-growing region known as the “Corn-Belt,” witnessed these extreme variabilities first-hand during the last five years as flooding and drought (Olson et al. 2011; Morton and Olson 2013) have created huge uncertainties and unanticipated hazards during the growing seasons. The 2012 drought had substantial impacts throughout the region, reducing the national corn crop harvest by 13% from 2011, an average decrease of 23.8 bushels per acre, according to the United States Departments of Agriculture National Agricultural Statics Service. (USDA NASS, 2013). In the state of Illinois, for example, corn production was down 34% from 2011.

The National Climate Assessment Federal Advisory Committee’s Draft Climate Assessment Report concludes that disruptions to agricultural production are projected to increase, causing negative impacts to most crop and livestock systems by mid-century. The rate at which agriculture adapts to climate change will be important as critical thresholds in production systems are reached, impacting global food security (Walthall et al., 2012). An increase in extreme weather events in the last decade suggests connections to a changing climate

(Coumou and Rahmstorf, 2012), matching IPCC projections of “more frequent and more intense extreme weather” (Field et al., 2007).

Agricultural producers are tasked with developing management plans to hedge against uncertain environmental risks (Hardaker, 2004). This means that weather forecasts and climate predictions are important for the agriculture sector to access as they develop short- and long-term management portfolios. Public weather and climate information comes from a variety of sources, often aggregated by the National Oceanic and Atmospheric Administration (NOAA), and disseminated by the National Weather Services (NWS) as well as various other private outlets. Regional Climate Centers and State Climate Offices are critical components in the collection, archival, and forecasting of weather and climate information. With the increasing need of location and site-specific information by agricultural producers, State and Extension Climatologists are very important actors in the effective dissemination of weather and climate information for the agriculture sector.

The USDA and other federal agencies are making a concerted effort to assist agricultural producers in implementing productive management practices that are resilient by adapting to and helping to mitigate increasing variable climate patterns and extreme weather events. As scientists tasked with disseminating climate information to the constituents of their states and regions, State and extension climatologists are in a unique position to provide information that is relevant to the agricultural sector. Particularly, they have the ability to access, interpret, and translate complex scientific information and tailor to the needs of the data user. As a result, climatologists have become important stakeholders in the effective communication of weather and climate information to the agricultural sector to assist with adaptive management.

The historical dissemination of agricultural weather services is important to understand when addressing current efforts to communicate climate science for agricultural management. National Agricultural Weather Services were discontinued by an act of Congress in 1996. At this time, agricultural weather forecasts, weather advisories for agricultural operations, 30-day agricultural weather outlook, and other agricultural-tailored services were transferred to the private sector. At this time, many local weather offices were closed, and agricultural producers began obtaining weather and climate information from private enterprises, such as Data Transmission Network (DTN). Today, farmers receive relevant information through private sources, including crop consultants, seed dealers, and agricultural advisors. Because of the

crucial importance of integrating modern climate science into agricultural management planning, it is important for farmers to also access publicly available information for their state and region. By doing so, they are better equipped with information necessary to incorporate available science into developing productive and resilient short- and long-term management portfolios.

The need to communicate weather and climate science to the public to prepare for uncertain environmental risks is increasingly evident. For instance, the United States Global Change Research Program (USGCRP) 10-year strategic plan directly addresses communication and education to “Broaden public understanding of global change” (USGCRP, 2012). Further, the plan sets a goal to “Build a sustained assessment capacity that improves the Nation’s ability to understand, anticipate, and respond to global change impacts and vulnerabilities” (USGCRP, 2012). Calls have been made to increase public climate science literacy, declaring that “formal and informal education and broad communication channels will help in clarifying climate confusion” (McCaffrey & Burh, 2008, p. 524).

Communication and social scientists have also highlighted the need for more effective communication of uncertain climate risks (Pidgeon and Fischhoff, 2011). Unfortunately, there are many challenges associated with communicating climate change, often stemming from political viewpoints or culturally-reinforced perceptions (Kahan, Jenkins-Smith, & Braman, 2011; Moser, 2010; Weber, 2010). Climate science needs to be carefully communicated to ensure that the public, policy makers, or institutions are able to effectively adapt and mitigate to the uncertain risks associated with a changing climate (Nisbet, 2009; Moser, 2010). As a result, it is necessary to examine how state and extension climatologists currently communicate scientific information to agriculture.

In this paper, we first define climate science and concepts of risk and uncertainty applied to agricultural management. Then we connect theories of sociology and communication and their applicability to expert climate science communication to different audiences. Fischhoff’s (1995) stages of communication are particularly appropriate in examining how uncertainty and risks are conveyed to farmers and their advisors. Thirteen in person interviews and nineteen surveys conducted in 2012 with State and Extension Climatologists about their current communication strategies with the agricultural sector in their state and region are analyzed utilizing Fischhoff’s (1995) lens on communication. We find a number of emergent themes from our short survey and interviews which reflect his stages of communicating uncertain risk. Our findings suggest that

his seven stages encompass three key elements associated with communicating risk: (1) accuracy and objectivity, (2) relevant and important, and (3) trusted and engaged. We close the paper with a discussion of the findings and implications for building trusted relationships and communicating climate science to farmers and agricultural policy makers so that they can most effectively access and process information that could improve their adaptation strategies under extreme and highly variable climate conditions.

Climate Science

According to the IPCC Working Group 1 Report, “The Physical Science Basis,” the term “climate change” refers to “the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer” (Solomon et al., 2007, Section 9.1.1). An important distinction follows in this definition that, “It refers to any change in climate over time, whether due to natural variability or as a result of human activity.” Climate variability then refers to “variations in the mean state and other statistics of the climate on all temporal and spatial scales beyond that of individual weather events” (Solomon et al., 2007, Section 9.1.1). Once again, this may be influenced by “natural internal processes within the climate system, or to variations in natural or anthropogenic external forcing.”

Whether or not observed climate change and variability are influenced by natural causes or human forcing or a combination of each, it may be regarded as the change or deviation from expected patterns over a period of time. As a popular science writer once noted, “Climate is what you expect; weather is what you get” (Heinlein, 1973). It is important to remember that climate is dynamic, and by definition is always changing as weather records and forecasting technologies continually update climate-projected models. The fact that climate will change over time is not up for debate, however the extent to which it has changed and will continue to become variable and unpredictable in the future is currently subject to many scientific inquiries, social debates, and political controversies.

Climate science may then be regarded as the state of scientific knowledge available on the subjects of climate change and variability. Parallel to the predictions of climate change, climate science is continuously evolving as more historical weather information becomes available and technology allows for more precise and accurate longer-term forecast modeling.

The scientific consensus surrounding climate change is subsequently always adapting to advances and changes in the field of climate science. As a result, regardless of individual or collective public opinions on climate change projections, climate science is an important tool for creating and assessing long-term projections involving the interaction of Earth's terrestrial surface and atmosphere. It is useful to distinguish between scientific assessments and individual opinions to understand that each is grounded in different types of data and leads to differing interpretations. For instance, it has been demonstrated that perceptions of climate change are influenced by values, beliefs, opinions (Leiserowitz, 2006), particularly influencing farmers' use of climate forecasts (Hu, 2006). This coincides with the notion that personal experience influences belief in the reality of climate change (Myers, 2012).

Some roles of the social sciences, particularly sociology are 1) to better understand the underlying human individual and collective experiences, beliefs, concerns and perceptions of risks associated with changes in climate conditions, 2) to delineate structural and institutional factors that frame and influence human action, or inaction, and 3) to understand how humans connect what is currently known science about the interaction of the Earth's terrestrial surface and atmosphere, including bi-directional relationships to human activities, and human capacities to interpret and respond as this information is individually and collectively evaluated.

Scientific information is valuable in assisting society in adapting to and mitigating potential risks associated with extreme weather events and climate variability. The discourse surrounding environmental consequences is most often discussed in terms of risk (Beck, 1992), although hazard and impact are terms also associated with environmental risks. The Webster's Dictionary definition of risk conceptualized is as "the chance of injury, damage, or loss" (Webster, 1983). However, the concept of risk is a social construction, and ultimately subjective (Slovic, 1999). For instance, risk is utilized to help individuals "understand and cope with the danger and uncertainties of life" (Slovic, 1999, p. 690). As a result, the conceptualization of risk involves individual judgments and values perceptions. Humans commonly understand risks created by direct environmental threats, such as hurricanes or tornados, but more acute and perceivably less severe threats such as flooding and drought may not activate the same sense of risk (Sjoberg, 2000). It is important to consider the whole range of potential environmental risks investigated by climate science, particularly since all terrestrial-atmospheric interactions may

directly or indirectly influence (or be influenced by) common cultivation practices associated with agricultural production (Howden et al., 2007).

Uncertainty is a term often employed by the climate science community to describe current scientific consensus involving potential environmental risks associated with weather and climate. For instance, uncertainties are often highlighted by scientists to demonstrate gaps in literature (Lewenstein, 1992), and justify the need for additional scientific research (Zehr, 2000). One of these gaps is the current limitation of climate science in downscaling what is known on a global basis to localized site specific impacts (Pielke Sr., et al., 2011). The inaccuracies and uncertainties in short-term climate (less than 5 years) predictions associated with localized weather and climate conditions can be a factor in the dissonance between farmer local experiences and the expert scientific knowledge (Roncoli, 2006). In the meteorological and climate sciences, uncertainties are particularly important to illustrate variance and statistical error potential of forecasting. Because of this, uncertainty is a term often utilized in climate science to represent probabilities, the levels of scientific confidence based on advanced statistical analysis. However, the IPCC offered three scales of uncertainty that were variously represented in reports by the three working groups, including qualitative (evidence), quantitative (confidence), and probabilistic (likelihood) (Jonassen & Pielke Jr., 2011). It is argued that scales of uncertainties are important to accommodate different methodological approaches and subject matter between scientific disciplines (Swart et al., 2009).

There is strong evidence to support the public's misinterpretation of uncertainty, which may influence their ability to understand the advances and importance of climate science in addressing environmental risks (McBean & Hengeveld, 2000; Zehr, 2000; Rabinovich & Morton, 2012; Delicado, 2012). Because of this, understanding human assessments of risk and uncertainty, often informed by how climate science is communicated, is of crucial importance. Climate science can greatly assist the agricultural sector in predicting and preparing for such risks if social science can better understand the communication factors and social pathways used individually and collectively to process experiences and scientific information needed to guide the development of plans to respond to changing climate conditions.

Communicating climate science

There is a body of literature that refers to the public's lack of understanding and skepticism towards science labeled the "deficit model" (Wynne, 1991; Layton et al., 1993; Gross, 1994). In this model, it is postulated that the public's doubts surrounding scientific consensus result from ignorance of the scientific itself, and may be remedied by simply providing more information to them (Sturgis & Allum, 2004). Since only about 20% of the American public are scientifically literate (Miller 2004), and the majority have limited climate literacy (Leiserowitz et al., 2010), the public understanding of science may appear to be a pinnacle barrier in climate science communication. However, there is now strong evidence to indicate that the deficit model is not the most appropriate framework to understand the public's inability to understand science (Wynne, 2006), and that experiential factors, such as affect, imagery and social-reference value system influence how people perceive and respond to scientific consensus (Leiserowitz, 2006; Kahan & Braman, 2006).

As a result, the "public engagement in science and technology" model has been suggested important framework useful for more effectively transmitting scientific information to different publics (Wynne, 2006). Although science is at the core of addressing most every problem faced by society, simply educating about science-based issues has not positively influenced the public's skepticism about science (Leshner, 2003). By actively engaging the public in a bidirectional dialogue about scientific initiatives, it may be possible to increase the public's trust in science (Wynne, 2006). It has been argued that the scientific community has an obligation to develop closer links with the public, to assist in helping the general population understand not only the benefits, but also the limits to science and technology (Leshner, 2003; Wilsdon & Willis, 2004).

There are a number of reasons why different groups of the public may be reluctant to respond to the current scientific consensus on climate change (Moser, 2012). For instance, psychological science has demonstrated that humans are significantly more physiologically responsive to direct, acute stimulation (Lang, Simons, & Balaban, 1997). Further, it is understood that physiological feedbacks act as an important interface to signal cognitive processes, such as attention and motivation (Lang, Bradley, & Cuthbert, 1990). An example of this could be a scenario of being on a boat during the unexpected onset of a torrential lightning and hail storm—the physiological response to this threat activates an aversive mechanism to

obtain security and protection, and the mind is propelled to seek cover immediately and return to shore. This is a response to a direct risk.

Climate change, on the other hand, is arguably not a direct threat in the sense that uncertain risks may not activate physiological response. A changing climate is slow by definition, therefore potential risks are non-linear and diffuse, and such risks have not yet been experienced in one human lifetime (Weber, 2006). As a result, this may hinder an appropriate and timely response from the American public to potential risks suggested by current climate science consensus (Weber, 2010; Weber & Stern, 2011). A 2011 survey of farmers in the North Central Region of the United States indicates that only 8% of farmers believe that climate change is occurring and caused mostly by human activities (Arbuckle et al., 2013). Further, it is demonstrated that beliefs about climate change directly correlate to concerns of environmental risks and attitudes toward adaptation and mitigation. For instance, farmers who do not believe that climate change is occurring are much less likely to support action to protect land from increased weather variability (Arbuckle et al., 2013). This indicates that perception of climate change is a crucial component of an individual's action to respond to changes. Perceptions of climate further influence collective social action as individuals, such as farmers, frame action to potential risk in accordance with their self-identified social reference group (Kahan et al., 2011).

Baruch Fischhoff has outlined seven progressive stages (see Table 3.1) of communicating uncertain risks (Fischhoff, 1995) that can help us understand how potential environmental impacts associated with climate change are communicated to the public. Fischhoff argues that risk communication is sensitive, and that any doubts cast upon the audience by the communicator may be irreversible. As a result, he presents a spectrum of communication techniques as a means to approach the preferred communication techniques necessary to reach an intended audience. It is important to remember that these stages are steps of an evolving communication dialogue and uniquely represent a certain communication technique. In other words, Fischhoff declares, "Each stage builds on its predecessors. It does not, however, replace them" (Fischhoff, 1995, p. 138).

Table 3.1. Fischhoff (1995) Seven stages of uncertain risk communication

1. "All we have to do is get the numbers right"
2. "All we have to do is tell them the numbers"
3. "All we have to do is explain what we mean by the numbers"
4. "All we have to do is show them that they've accepted similar risks in the past"
5. "All we have to do is to show them that it's a good deal for them"
6. "All we have to do is treat them nice"
7. "All we have to do is make them partners"

Since climate change is arguably an uncertain environmental risk, at least in the eyes of much of the American public, it is necessary to carefully approach communicating climate science (Dunlap & Saad, 2001; Pew Research Center, 2009). Fischhoff's typology of uncertain risk communication is directly relevant to understanding the opportunities and barriers of effective communications between climatologists and various agricultural audiences. Further, his framework offers a beginning point to analyze the current communication efforts employed by climatologists in the North Central Region of the United States.

As we examine how farmers and the agricultural sector utilize weather and climate information, it is valuable to understand how this information is framed and presented to them. Therefore, it is useful to consider current communication techniques employed by climatologists to communicate with farmers, and potential steps for improving communication pathways. To apply Fischhoff's stages of uncertain risk communication, we propose an adaptation to highlight three important elements of communication that help explain how climate science is communicated to farmers and how underlying social relationships influence responses to information (See Table 3.2).

Table 3.2. Elements of Climate Science Communication (adapted from Fischhoff (1995)).

<p>Element 1. Objective and Accurate</p> <p>Focus of communication relies on completely non-bias presentation of the message, or letting the science speak for itself. In this stage, the audience is tasked with interpreting the relevance of scientific information to real-world risk management situations. The agricultural sector must therefore employ methods which relate the science to particular impacts and intended outcomes.</p>
<p>Element 2. Relevant and Important</p> <p>Focus of communication relies on presenting information in way in which it is relevant and important to a selected audience. In many cases, the science is presented in manner which frames the most important or necessary components for the audience to consider in their own circumstances. Science that is presented as relevant for the agricultural sector is most often framed to emphasize relations productivity, resilience, or other certain management techniques that are directly impact the sector.</p>
<p>Element 3. Engaged and Trusted</p> <p>Communication at this component recognizes the importance of social capital in the transfer of scientific information. For instance, scientists take extra measures to ensure that they are perceived as a trusted source for information. Furthermore, scientists actively engage the audience in participatory activities to obtain precise and locally-specific information. Members of the agricultural sector are welcomed to contribute weather observation data which feeds into local forecast and climate outlooks.</p>

Accuracy and objectivity

The first two stages of Fischhoff's communication framework, "All we have to do is get the numbers right" and "All we have to do is tell them the number," correlate with communication techniques that provide information in a neutral and non-bias manner and allow the audience to decide for themselves how to interpret the information. Fischhoff's stages are written for an audience of communicators, where "we" refers to the communicator and "them" refers to the intended audience. In our research we are examining climatologists and how they represent their information to agricultural audience. Climatologists are scientists first and communicating is a by-product of their profession, thus most have little training in communication. Fischhoff's concept of getting the numbers or the science right encompasses a concept we label "accuracy and objectivity." Scientists whose communication focuses on accuracy and objectivity are likely to believe that the science speaks for itself and needs little interpretation (Nielsen, 2001). In *Knowledge and Public Policy* (1994), Judith Innes offers several striking examples in which scientists are most respected and effective if they "stick to the 'facts,' and keep out of politics" (Innes, 1994, p. 75). It is argued that objectivity in the process of producing facts is essential to ensure public confidence and reception of scientific findings (Innes, 1994).

Relevant and important

The next three stages of Fischhoff's framework are focused on the important aspects of the information that would have meaning to the communicator's audience: "All we have to do is explain what we mean by the number," "All we have to do is show them that they've accepted similar risks in the past," and "All we have to do is show them that it's a good deal for them." These communication patterns acknowledge the necessity of some level of translation of the science "facts" in order for the audience to relate to the information and perceive those facts as useful. Thus our 2nd element of communicating risk is relevant and important. By tailoring messages to a specific audience and using examples that trigger thoughts regarding the subject matter, scientists can "break through the communication barriers of human nature, partisan identity, and media fragmentation" (Nisbet, 2009, p. 15). Framing information as relevant and important is necessary to circumvent individual value judgments and convey information in a

way in which the audience recognizes real-world connections to scientific consensus (Kahneman, 2003). Nisbet and Scheufele (2009) argue that “any science communication efforts need to be based on a systematic empirical understanding of an intended audience’s existing values, knowledge, and attitudes, their interpersonal and social contexts, and their preferred media sources and communication channels” (p. 1767).

Trusted and engaged

The final two stages of Fischhoff’s framework, “All we have to do is treat them nice” and “All we have to do is make them partners,” reflect the technique of actively engaging the intended audience and encouraging participation in message construction and dissemination. The concept of trusted and engaged has strong sociological foundations. James Coleman’s influential work described trust as a decision under risk, arguing that trust is extended when benefits are noteworthy (Coleman, 1990). Further, social structures and institutions, such as university affiliation or proximity location (e.g., neighbor) influence the extension of trust. Network embeddedness, or social connections, also increases trust (Buskens & Weesie, 2000). Trusted information sources have been demonstrated to shape thinking and opinion, particularly in regards to concern about climate change (Malika, Krosnick, & Langer, 2009). In the article, “Potential benefit of climate forecasting to agriculture,” Jones et al. (2000) make the important distinction that “although farmers understand and contend regularly with the uncertain nature of the climate, researchers need to work with farmers to develop a common language for communicating probabilistic climate information. Second, effective communication of climatic or any other new information is best accomplished through providers of information and advice that farmers already know and trust” (p. 180).

These three elements of communicating provide a structure for analyzing how climatologists perceive their roles and the strategies they use to interact with their agricultural audiences and communicate climate information. Specifically we ask the following questions, and test them to see if there is support for this framework. (1) How is climate science information currently communicated to agricultural audiences in the North Central Region of the United States? (2) How do climatologists view their communication techniques and effectiveness of communication with farmer audiences?

Methodology

To answer our research questions we apply a mixed method research design incorporating qualitative and quantitative methodologies (Neuman, 1994). Quantitative survey methods allow for numerical summaries across subjects (Dillman et al., 2009). Qualitative interviews allow for a more deep understanding into the pathways of how climatologists relate to and communicate with farmers.

Eleven State Climatologists and 11 Extension Climatologists (N=22) from 11 states were selected from a purposeful sample to represent main outlets of publicly available and location-specific climate information in the North Central Region of the United States, or the “Corn-Belt.” For this paper, we will share the results of 19 surveys and 13 interviews.

Climatologists were initially contacted by e-mail and given details about the research, and also contacted via follow-up telephone calls as necessary (See APPENDIX A). All 22 Climatologists agreed to participate in the study, and signed informed consent documentation (See APPENDIX B). Prior to the interview, participants were asked to fill out an optional survey, of which nineteen (N=19) completed. The content of this questionnaire was focused on the climatologists’ current interactions with the agriculture sector, including their communication techniques, as well as their perceived opportunities and barriers for more effective communication with agricultural audiences (See APPENDIX D). The interviews followed the survey to ground-truth and allow the climatologists to elaborate upon the survey inquiries. Interview and survey content, study protocols, and informed consent documentation were approved prior to administration by Iowa State University Institutional Review Board (IRB) #12-022 (See APPENDIX C).

Both quantitative survey questions and qualitative interview questions were developed collectively by a committee of scientists involved in two USDA-NIFA projects related to climate and agriculture: Climate and Corn-based Cropping Systems Coordinated Agriculture Project and Useful to Useable: Transforming Climate Variability and Change Information. Specifically, the President of the American Association of State Climatologists, another State Climatologist, two professors of sociology, one climate scientist, one other sociology graduate student, and a Project Manager formed the committee which was led by the researcher. Several meetings of members

of this group occurred for three months as the survey and interview instruments were developed and validated. Both instruments were pilot tested by a group of climate scientists to further ensure validity prior to implementation.

Interview questions and prompts focused on climatologists' roles and responsibilities, relationships with other climatologists and farmers, communicating climate information, agriculture decision making, including influence of climate information, advisors and other sources of information (See Appendix E). Interviews were transcribed, and analyzed line by line by two coders and with qualitative software. NVivo Qualitative Data Analysis Software (NVivo, 2009) was used to assist in the detection and frequency of emergent themes. All themes were first detected, and then analyzed and mapped to understanding their relative importance. Transcripts were read and analyzed by the researcher and one of the senior social scientists involved in both projects in order to ensure inter-rater reliability. A qualitative analysis code book assisted in analysis (See APPENDIX F). Cohen's kappa was computed (Cohen 1960; 1968).

Many of the questions for the climatologist survey were selected from a lengthier producer survey distributed to a random sample of 19,000 farmers in the North Central Region, of which 4778 responded. The location of this survey corresponded with the 11 states represented by the Climatologists. The producer survey was developed and validated by Dr. J. Gordon Arbuckle in the Department of Sociology at Iowa State University and Dr. Linda Prokopy in the Department of Forestry and Natural Resources at Purdue University, and was administered by the National Agriculture Statistics Service (NASS) in February 2012. NASS is responsible for survey administration because names and addresses of agriculture producers are tightly held and confidentially protected by the USDA.

The climatologist survey includes questions regarding beliefs in climate change, perceptions regarding influence of forecasts in farmer's decisions, other influences on decisions, and knowledge of seasonal timing of common management practices. Differential and descriptive statistics were computed and analyzed.

Results

Roles and responsibilities

All climatologists indicate that their roles and responsibilities include providing public service to the constituents of their states. In the North Central Region of the United States, this often includes farmers and other stakeholders of the agricultural sector. As a result, one role of state and extension climatologists in this region is connecting scientific research of weather and climate to various public data users' and other stakeholders' needs.

Several climatologists noted that they maintain their states' Mesonet services, which are automated networks of weather stations. They are also active in the documentation and compilation of weather and climate information collected from weather stations. In this regard, climatologists often remarked that they provide services related to "archiving" and "retrieving" climate-related information. "Mostly what I do is document the weather, what's going on climate-wise, so it's mostly recordkeeping," one climatologist noted (1205010503, 1).

Some climatologists, often in an extension role, mention their responsibility of traveling to talk with different stakeholder groups. Climatologists will speak to any group that requests their services, from storm water managers of municipalities to farm commodity organizations such as the Soybean Association. They attempt to provide information that is tailored to the group in which they are presenting. For instance, a municipality would be presented with urban-specific precipitation information, while agricultural audiences may expect more information related to soil moisture, growing degree days, and other agriculture-relevant information.

Climatologists are also scientists and researchers, which involves "trying to understand temporal and spatial trends of climate within the state and...also projected climate in the future" (1204200901, 1). Many climatologists mentioned projects they are working on with different departments and universities, working to provide climate-related information for various applications such as storm water management, highway transportation, or agricultural engineering.

Climate beliefs

When we surveyed 16 male and 3 female climatologists, representing state climate offices of 10 North Central Region states, one regional climate center, and the NOAA central region, about their beliefs regarding climate change, none of them responded that climate is not changing. This follows the patterns of the IPCC definition that climate is dynamic and will be changing regardless of human activity. Interestingly, during the qualitative interviews, several of the climatologists directly addressed this question, stating that this question was irrelevant, since climate change is not a belief, it is a scientific fact. “It’s not a belief,” one climatologist declared. “It’s not like believing in God or believing in ghosts or believing in Santa Claus. There’s evidence, and you can ignore the evidence or not” (1203120202, 11).

Table 3.3 demonstrates responses climatologists’ responses to the survey prompt, “There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change.” As the figure indicates, more than half of the climatologists (53%) selected that *climate change is occurring, and it is caused mostly by human activities*. Only one climatologist (5%) indicated that *there is not sufficient evidence to know with certainty whether climate change is occurring or not*. None of the climatologists (0%) selected that *climate change is not occurring*.

Table 3.3. Climatologists' beliefs about climate change

There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change. (Please circle one number.)

	Climatologists (N=19)
a. Climate change is occurring, and it is caused mostly by natural changes in the environment	5%
b. Climate change is occurring, and it is caused mostly by human activities	53%
c. Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities	37%
d. Climate change is not occurring.....	0%
e. There is not sufficient evidence to know with certainty whether climate change is occurring or not.....	5%

Effective climate science communication

During the interviews, State and Extension Climatologists recognized the need for more effective communication of climate science to the public. “The information, even if it is researched,” one State Climatologists remarked, “it has to be disseminated to the public, and that’s always a challenge” (1203120101, 7). Climatologists also recognized the challenges inherent in communicating science to different and diverse stakeholder groups. Effective communication to the agricultural audience is perceived to be greatly influenced by political atmosphere, market economy, and other complex social factors.

Climatologists also emphasized their presence and availability, or lack thereof, to the agricultural audience. Several references were made indicating the average public is not aware of their position and roles, and as a result are unsure of whom to contact to inquire about climate information. This could potentially be an artifact of the privatization of agricultural weather services more than 15 years ago, since many farmers receive weather and climate information through private sources. Also, the public is more familiar with the broadcast meteorologist as a source of information. Increasingly, weather and climate data users are able to access information through the internet. Because of these reasons, state climatologists are not often

contacted to provide specific information. Since farmers are generally not requesting information from climatologists, this may escalate the disconnection between what information is available and what information is desired and useful.

The Elements of Climate Science Communication framework (Table 3.2) provides a way to analyze the interview transcripts and answer the questions about how climate science is communicated by climatologists and the effectiveness of their message.

Accuracy and objectivity

Although the structure of State Climate Offices varies by state, the vast majority of climatologists interviewed in the North Central Region have direct connections with state land grant universities. With the exception of one state climatologist who is housed in a state Department of Agriculture, all climatologists made reference to their connections and roles within the land grant institution. State land grant universities were established by the Morrill Acts of 1862 and 1890, and the three pillars include teaching, research, and extension. Extension and outreach is an essential component of the land grant mission, and provides research findings and scientific information to the communities and general public of the state, including various and diverse stakeholders. As a result, several climatologists referred to themselves as public servants, and considered climate data users within their state as constituents. Perhaps because of their primary role as employees of public land grant institutions, the majority of climatologists adamantly declared their communication techniques to always be neutral and objective. Further, climatologists stressed the ability to only communicate scientifically accurate information. Because of the emphasis and recurring mentions of accurate and objective communication styles, this appeared as a major theme during transcript analysis.

True to the land grant mission, one climatologist remarked, “We want to be always seen as an impartial deliverer of climate data, data that people can trust, and know it was not provided by somebody with an agenda” (1203220401, 9). Although accuracy and objectivity were not specifically referenced in this statement, undertones strongly suggest the need to remain unbiased and neutral when communicating scientific climate information. As another climatologist stated, “I’m just presenting information that’s impartial, it’s nonbiased, there’s no agenda with it” (1203150301, 14).

The complex political atmosphere was also mentioned in reference to the need to remain objective. “I try to make it as apolitical as possible,” one climatologists remarked, “and just show the facts, the data, the information and let folks come up with their own decision or assessment on what they think might be happening” (1203150301, 12). In this case, the climatologist references one of the key communication strategies comprising Element One, which entails letting the audience decide how to interpret the information.

Relevant and important

The extension climatologists interviewed are employees of land grant institutions. As a result, they were generally much more proactive in employing communication techniques in accordance with Element Two, Relevant and Important. In other words, they recognized the need to not only objectively convey accurate information and let the audience decide how to interpret it, but also to frame the information in a way in which it is perceived as relevant and important to the intended audience.

For instance, one extension climatologist remarked of employing communication techniques to engage the audience, stating “I usually try and relate it to something they’re familiar with” (1203120202, 6). By making the information relevant to the real-world impacts of the agricultural operation, the extension climatologist recognizes that science communication may be more efficient and productive. This is a major concept of Element Two, and reflects an important step in risk communication techniques.

A few references were made indicating that abstract climate science concepts must be grounded in real-world situation. For instance, climatologists often utilize the El-Nino Southern Oscillation (ENSO) as a tool to predict climate patterns out for a growing season or more. However, many farmers are not aware of ENSO, and thus are unable to relate why that science would be important to their operation. As a result, it is important to relate the science necessary for climate model forecasting to real-world risk impacts. “We look at the most relevant models, whether they’re ENSO-based, atmospheric patterns,” one climatologists stated, “we try to identify what’s going on and try to project that type of pattern as we move to the growing season to give the producers a risk assessment” (1203300701, 1). By doing so, the climatologist has more effectively gained the attention of the agricultural audience to which the message is intended.

Trusted and engaged

Although the majority of references to the three element themes revolved around remaining accurate and objective, and a few mentioned relevance and importance, there were also some references to Element Three, Trusted and Engaged. Climatologists who acknowledged this stage recognized the importance of the agricultural audience's local and indigenous knowledge. As one climatologist remarked, "A couple of things you need to understand about farmers: First, there aren't any dumb ones. If there was ever such a thing as the old dumb farmer, they've been out of business now for decades" (1203280501, 6).

The Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) is a public weather observation program, commonly referred to as citizen-science. Through CoCoRaHS, the public enters their local weather observations into the system, which then feeds back into NWS forecasts, the Drought Monitor, and other agriculturally-relevant weather and climate information. Since the majority of weather stations are located near airports or universities, and not necessarily in the fields of the farmers who are hoping to retrieve site-specific information, this network is a tool for scientists to assist in precision and localization of forecasts. Almost all of the acknowledgments that climatologists made in reference to engaging and gaining trust from the agricultural audience were in reference to this citizen-science network.

One climatologist remarked, "Many of our observers are farmers, and so they provide us not only with the climate measurement, like the low temperature for the night, but they also provide us with field assessments of whether or not there was any damage" (1205020402, 3). Clearly, the CoCoRaHS network is important for alerting climate scientists to weather-related risks and impacts. This greatly assists the climate science community in more adequately adjusting their forecasts to meet the needs of farmers. Further, the increased density of data points, particularly in rural areas, increases the certainty of weather and climate forecasting.

To most effectively communicate climate science to the agricultural community, it may be necessary to engage them and build trust to mutually assist the development and practical implementation of the science to real-world impacts. "I think the real approach to get farmers to adapt and change their practices so that their family farm is sustainable and can keep going economically is to approach them as a team of educators" (1205020402, 11), remarked one extension climatologist. In doing so, climatologists and farmers would benefit in increased

access to site-specific climate forecasts, as well as advanced knowledge of potential risks associated with such forecasts.

Discussion and implications

While climatologists acknowledge roles beyond scientific research, such as providing information to public data users and interacting with various stakeholders, this study suggests that the majority are focused on providing information that is objective and accurate. As employees of public land-grant institutions with high-profile and often politically-sensitive positions, this reliance on objectivity may be expected.

However, there was indication amongst climatologists that reflected roles involving public service. For instance, a few climatologists mentioned that it is necessary to relate and highlight relevant information to various stakeholder audiences. Some climatologists also recognized the need to provide information in a way that it is trusted, which may be achieved by engaging stakeholders in a participatory process of research development and scientific consensus. Citizen science programs are a rapidly emerging outlet to assist this element of scientific communication.

Climatologists can greatly benefit farmers and the agricultural sector by providing weather and climate information that will assist in developing long-term agricultural management portfolios. This knowledge will greatly help farmers to remain resilient and profitable, while adapting to and mitigating uncertain environmental risks and hazards. By not only providing accurate and objective information, but also framing it as important and relevant, climatologists may more effectively communicate their science for all stakeholders. Further, by engaging farmers in citizen science programs and various other methods to obtain site-specific and more locally-relevant information, climatologists will become an even more trusted and crucial source of information. As climatologists advance their techniques of communication to encompass objective, relevant, and trusted information, they will greatly advance their capacity to assist the agricultural sector with climate science.

Conclusion

The findings of this research suggest the need for climate science communication techniques that are more relevant, important, engaging, and trustworthy. By advancing climate

science communication techniques to encompass these necessary elements, climatologists will obtain a greater capacity to assist agriculture in adapting to and mitigating uncertain environmental risks. Many climatologists already recognize the need to extend scientific information to public data users, and agriculture in particular could directly benefit from such communication techniques. The findings of this study should help climatologists recognize their roles as scientists within the land grant system extend beyond simply gathering information, and include providing this information to public data users, such as farmers.

Particularly, climatologists should recognize that communications intended for an agricultural audience must relate to direct impacts of climate on agricultural management systems if they strive for more effective communication. Further, such communications should be framed in a way in which farmers would perceive the message as important and relevant for their specific location and operation. Messages should also be presented in a way in which they are engaging to the target audience, and ideally presented through channels and outlets that are viewed as trustworthy (Nisbet, 2009). Considering that climate is always changing by definition, climatologists may avoid social, cultural, and political influences that negatively affect farmer's reception of scientific information by simply communicating long-term projections in terms of "climate," as opposed to "climate change." This may assist climatologists in focusing on communicating beneficial scientific information, and further moving towards elements of engagement and trust.

There has been argument for a "new social contract" for science, implying that scientists have a responsibility to engage in political affairs, particularly when scientific consensus is influential in public policy development (Lubchenco, 1998). Communication scientists have highlighted that facts rarely "speak for themselves," and must be translated or framed as meaningful for society (Nisbet & Scheufele, 2007; Nisbet, 2009; Pidgeon & Fischhoff, 2011). Others have indicated that because society increasingly comprises and distorts information presented by science, scientists themselves have a unique role and responsibility to reacquaint science to reality, by making connection to real-world problems (Rockstrom, 2012). In doing so, it is only natural for scientists to connect the scientific consensus in which they are engaged to matters of individual and collective decision making, including public policy development. As a result, direct connections between real-world risks and scientific research could become inevitable. Improving the ability of scientists to communicate information regarding impacts and

outcomes of uncertain environmental risks associated with weather and climate for agricultural management will help farmers remain resilient and profitable, and society to remain healthy and food secure.

CHAPTER 4.
CLIMATOLOGISTS' PATTERNS OF COMMUNICATING SCIENCE TO
AGRICULTURE

A paper to be submitted to *Agriculture, Society, and Human Values*

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Abstract

Climatologists have a unique role in providing various stakeholders and public data users with weather and climate information. In the North Central Region (NCR) of the United States, farmers and the agricultural sector are important audiences for climate science. Various social, cultural, and political influences affect the ability of climatologists to communicate scientific information to data users. Because of this, it is necessary to understand how climatologists perceive their role as scientists, and how this may influence their ability to communicate climate science to agriculture. In this study, we present information from interviews (N=13) and surveys (N=19) of state and extension climatologists in the NCR to understand their perceived roles and responsibilities as scientists and communicators. Results are analyzed using Pielke's (2007) framework of the idealized roles of scientist and their communication patterns (pure scientist, science arbiter, issue advocate, and honest broker). Findings indicate that the majority of climatologists perceive their role to provide information as pure scientists, while some engage in an arbiter role when requested. A lesser amount of climatologists perceive their role as not only producing science, but also relating it to society. This suggests the need for a two-pronged approach to climate science communication for agriculture, in which science is produced and then also actively communicated to the receiving audience. To more adequately assist the agricultural sector in remaining resilient and profitable by adapting to and mitigating environmental risks, climate science information should be framed in terms of hazard mitigation and risk management.

Key Words: science communication; science and society; idealized roles; decision making; policy; agriculture; climatologists

Climate and Climatologists

Changes in climate are slow and gradual modifications of average climate conditions (Weber 2010). The climatologist is trained to systematically detect this complex phenomenon over time using statistical methods to track and document patterns embedded in the random fluctuations of conditions in both stable and changing climates. To the climatologist, climate science is based in these empirically confirmed data and unrelated to personal beliefs and opinions. Although most sectors of the public observe and experience changes in weather, they often do not differentiate between climate and weather and do not accurately recall past climate conditions (Weber, 2010). Further public meanings of science are considered a “more subtle contextual interaction between physical and social factors” (Fischer, 2005, p.72). Thus, even when scientific consensus is present, there is often a disconnect among scientists, the public, and policymakers as knowledge is regarded as negotiable (Innes, 1994). Fischer (2005, p.73) elaborates this by suggesting that the public considers many empirical truths as scientific opinion or belief derived from an “amalgam of technical and social judgments.” It is these differences in expert and general public perceptions of climate science that underlie the unprecedented challenges US agriculture faces as extreme weather events and unpredictably variable climate patterns continue to increase (Walthall et al., 2012).

US agriculture, producing \$300 billion a year in commodities, is vulnerable to climate change through direct effects on crop and livestock development and yields as well as indirect effects arising from changes in severity of pest pressure, availability of pollination services and the performance of water, soil, and other ecosystem services (Walthall et al., 2012). The 2012 USDA Climate Change and Agriculture in the United States, Bulletin 1935, well articulates scientific consensus on the need for adaptive action to manage the effects of climate change by altering patterns of agricultural activity to take advantage of emerging opportunities while minimizing the negative effects. But how can scientists help farmers and the value chain that supports them internalize what is known and what is not known about climate science and give meaning to the consequences of different adaptation strategies? Without some joint understanding of the problem and how to transform it into their situation, it is unlikely that

agreement on effective actions will be easily or quickly formulated (Innes 1994). The state climatologist, a central source of regional and localized climate information is a critical actor in linking what is known about climate conditions such as temperature, precipitation, and unexpected variability to public policy and farmer adaptation responses. However, little is known about state climatologists' interactions with agriculture and the role they play in conveying and interpreting climate science. How can their role be enhanced to better connect technical, social, and economic factors to the climate patterns they know so well and motivate individual and collective actions?

It has been demonstrated that the public's perception of scientific consensus is a factor in the acceptance of science (Kahan, Jenkins-Smith, & Braman, 2011; Lewandowsky, Gignac & Vaughan, 2012). And these perceptions affect whether societal action occurs to address climate-related issues and implement climate policy (Ding, et al., 2011; Kahan et al., 2012; Rabinovich & Morton, 2012). Further, public engagement with science and technology research (e.g. Holden, 2002) suggest that the "deficit model," based on the public's lack of understanding of science, may not adequately address the barriers of integrating scientific knowledge to influence behaviors and support appropriate policies (Wynne, 2006). Particularly in the case of climate science, it has been suggested that a multitude of complex social factors influence the general public's reception and acceptance of scientific consensus, including values (Nilsson, Borgstede, & Biel, 2004), emotions (Leiserowitz, 2006), and socially-reinforced perceptions (Kahan et al., 2011).

The call for a more engaged role of scientists in communicating their accumulating knowledge to the public (Marincola, 2003; Friedman, 2008; Meyer et al., 2010) presents a challenge to state and extension climatologists. The advocacy of public response and policy implementation to a particular scientific consensus can stretch the boundary role of publicly employed professionals and traditional land-grant institution ideals as they attempt to carry out their extension and outreach role in a non-partisan way (Bonnen, 1998). Many scientists recognize the delicate issue at hand, and advise caution when extending scientific consensus to society and translating known facts derived from scientific experiments and observations into societal consequences, impacts and risks (Lach et al., 2003; Groffman et al., 2010; Wilhere, 2011; Nelson & Vucetich, 2009). A crucial question involves understanding the roles expert scientists can play in transforming climate data into practical, useful information that bridges the

gulf between them and different publics. Roger Pielke, Jr. (2007) provides a useful framework for thinking about the types of roles scientists can play in balancing scientific facts, arbitrating science information, advocating, and brokering alternatives.

In this paper, we explore the sociological concept of ideal types and apply them to Pielke's (2007) general typology of roles in communicating science. Pielke Jr.'s (2007) typology is a valuable tool for discovering barriers that may be inherent in how climatologists view and communicate their science. Qualitative and quantitative data from 13 interviews and 19 surveys with state and extension climatologists from 11 states in the North Central Region of the United States are analyzed based on this typology. Criteria are developed for assigning climatologists to one of four typologies: pure scientist, issue advocate, science arbiter, and honest broker. In our results, climatologists' beliefs about climate change are compared to Midwestern farmers, followed by an examination of climatologist self-reflected roles and views on how they communicate their science. We conclude the paper by discussing the evolving role of state and extension climatologists, negotiating boundaries between science and policy, and opportunities for scientists to ethically engage in policy advocacy while remaining neutral and objective.

Ideal types and a typology of how scientists communicate their science

Sociologist Max Weber is credited with developing the concept of ideal types to explain the abstractions of analysis in understanding the social world (Aronovitch, 2012). Ideal refers not to preferred, but to the world of ideas, which are constructs used to put the complexities of social reality into perspective (Cahnman, 1965). Weber argues that facts in the construction of ideal types must be seen in their cultural significance (Weber, 1977; 1978). Further, "synthesis of selected aspects of this category of culturally significant facts must take cognizance of the relationships of meaning and significance logically compatible with the theoretical interest informing the investigation and the logic of the social actors concepts" (Hekman, 1983, p. 122).

The concept of ideal types is a theoretical construct that allows for a comparative method (Ragin, 1987). Ideal types are context specific, which in this case, allows for the analysis of climatologists' perceived roles of communicating science to a framework of idealized roles in society. This construct is a mechanism of social research to "bring together certain relationship and events of historical life into a complex, which is conceived as an internally consistent system" (Weber, 1949, p. 90).

It is important to remember that ideal types are social constructs, often utilized as organizing devices to analyze and explain social phenomena (Little, 1991). This occurs by working “back and forth between the abstract theoretical concept and the concrete social phenomena, shedding light on the concrete phenomena by showing how its various elements hang together” (Little, 1991, p. 226). In the context of climate and agriculture, social scientists are attempting to understand how patterns of science communication may influence agricultural management decisions. The topic of climate change is an example of how an ideal type can be applied to increase understanding of how different social actors interpret and respond to individually observed and scientifically documented changes.

Roles of scientists

Lach et al. (2003) offer five potential roles for scientists in communicating information. These are reporting scientific results, interpreting scientific results, integrating results into decisions, advocating certain decisions, and actually making decisions. While Lach et al. (2003) do not make reference to a scientist who addresses all potential policy options, their study is important for understanding how perceived roles influence currently employed communication techniques. In their survey of scientists, other stakeholders, and the attentive public surrounding a topic of natural resource decision making, they found that the majority of each of these groups prefer that a scientists’ role include integrating scientific results into management decisions (Lach et al., 2003).

Elaborating the roles of scientists, Roger Pielke, Jr. (2007) outlines four types of science communicators that have differing approaches to what they communicate and with whom: pure scientist, science arbiter, issue advocate, and honest broker. The pure scientist is focused on empirical facts and scientific truth derived from evidence-based data and confirmed or revised by ongoing research that asks questions and seeks answers. An underlying assumption is that a trained scientist has expertise that others do not have. The roles of a scientist may be different depending on whom you ask, but more or less describes an individual who utilizes the scientific method to answer a question (Lehn, 1998). According to Pielke (2007), the pure scientist chooses to avoid policy questions altogether by limiting engagement with political implications. These scientists may often be engaged in what is considered “basic” science, and do not actively address societal impacts of their research findings.

The science arbiter provides expert information to decision makers who have specific questions, but focuses on issues that are resolvable with science. In this regard, science arbiters are pure scientists who understand the political implications of their research findings, but do not advocate any particular stance or pursue the formation of outcome options. When policy makers request scientific information, scientists inform discussions with understandable and unbiased information (Lackey, 2007). The science arbiter is aware of the potential risk to credibility as a scientist, and as a result refrains from actively making connections between science and society, and instead responds to specific requests in an objective manner.

Issue advocates are scientists who have a sense of moral imperative beyond their science to actively align their viewpoints and research findings with specific social and political issues. Moral imperative refers to the perceived need for action or inaction on an issue perceived to be necessary (Kant, 1999). In particular, it refers to the need for individual action, or in this case, the desire of climatologists to take a position and actively communicate agriculturally-relevant information to induce action. Most often in this case, the scientist is siding with a particular public policy agenda item, interest group, or even political party (Pielke, 2007). In the case of climatologists, this may be manifested in public statements which advocate political intervention into issues involving atmospheric degradation, such as carbon tax.

The honest broker describes a scientist who acknowledges the influence of their research on individual and collective decision making, including public policy development. However, the honest broker not only considers and clarifies currently available options, but also identifies other possible options (Pielke, 2007). As a result, they enlarge current alternatives and allow for individual and public decision makers to become informed of all possible outcomes. While doing so, honest brokers do not advocate one particular decision; instead they recognize and address all possible outcomes and actively communicate these options to the public. Scientists who support this role claim that separation between scientific facts and societal applications is unavoidable (Lubchenco, 1998; Ehrlich, 2000; Nelson & Vucetich, 2009). Further, it has been argued that scientists are first and foremost citizens, and as a result have a responsibility to make the public aware of what the science means to society (Kaiser, 2000).

There are two important fundamental distinctions for understanding Pielke's four idealized types and the roles he elaborates to describe scientists and how they choose to engage or avoid policy and decision making. Each addresses the communicator's beliefs about the

relationship between the role of science in society and the role of the expert in democracy. The first involves the view of democracy. One approach, known as “interest group pluralism,” was described by James Madison (1787) in *Federalist 10*. Under what Pielke refers to as the “Madisonian democracy,” experts are perceived as best serving society by aligning themselves with a particular stakeholder or interest group, and offering their expert role as an asset in preferred policy implementation of political battle. The second approach argued by E.E. Schattschneider (1975) is that as a competitive system, democracy should allow the public to participate by voicing their viewpoints on options presented and considered in the democratic process. In what Pielke terms “Schattschnider democracy,” the science arbiter and honest broker consider the public’s ability to voice their opinion on decision options. This also reflects the process Innes (1994) describes as negotiating knowledge and Fischer (2005) discusses as scientific facts structured and shaped by social assumptions and meanings whereby experts and the public iteratively negotiate the issues and whether a social problem exists or not. The pure scientist and issue advocate follow the Madisonian democracy, with the viewpoint that expert input is the only necessary component in decision formation and implementation.

The other important distinction involves the view of science. One view of science is referred to as the linear model, and emphasizes the importance of basic research. This model suggests that knowledge accumulates in a flow beginning with basic research and eventually moves towards applied research for societal benefit, and that scientific consensus is required for political action. In contrast, the stakeholder model suggests that using science for societal purposes, such as policy development, requires “optimally matching scientific opportunity with social need” (Brooks, 1995, p. 33). Within this model, it is necessary to consider societal needs while making scientific progress to reach an optimal balance between need and opportunity. As a result, it is important to consider how science is applied and utilized in the decision making process in order to understand how effective the science will be (Stokes, 1997). Applying these distinctions to Pielke’s framework, the idealized roles of pure scientist and science arbiter are characteristic of the linear model in that they emphasize basic research and less intended connections to the end data users. Issue advocates and honest brokers, however, consider societal need in the progression of science and application of knowledge in the conduct of their roles as science communicators.

As noted in our introduction, there is substantive concern that US agriculture and the ecosystems that support productivity are increasingly vulnerable to predicted higher incidence of extreme weather (Walthall et al. 2012). State and extension climatologists are key actors in conveying climate science and giving meaning to agriculture in ways that encourage adaptive responses. It is important to understand how climate scientists perceive their role in communicating science and how they transfer scientific information to data users for use in both individual and collective decision making, including policy development. Specifically, we ask, how do climatologists in the North Central Region perceive their role in communicating climate science to agriculture? To answer this question, we use Pielke's (2007) typology as the basis to develop criteria for evaluating our data to find evidence of climatologists' patterns of communicating science (Table 4.1).

Table 4.1. Criteria for determining perceived role of science in society

	Criteria for selecting Climatologists' perceived role of science in society
Pure scientist	Scientist perceives research as having no connection to policy, and does not consider utility or use of findings. Results of research are perceived as adding to growing body of scientific knowledge, of which the public and policy makers utilize in information societal, environmental, and political decisions. Scientist simply performs research, and does not engage in policy or politics.
Issue advocate	Scientist focuses research on a particular policy outcome or political agenda. They accept that science is engaged with policy makers, and attempt to participate in the process. They are aligned with a particular stakeholder or interest group, and seek to advance these interests by connecting scientific outcomes with policy and politics.
Science arbiter	Scientist is removed from overt connection of outcomes to policy and politics, but do recognize that the public and policy makers require expert input. They accept direct interaction with policy makers, although stay focused on issues that may be addressed by science. Focus is on positive questions that are addressed from policy makers to scientists, and avoids normative questions and interactions with stakeholders.
Honest broker	Scientist accepts connection of science to policy and politics, and seeks to expand scope of options available to the policy makers. They do so by integrating scientific knowledge with public and stakeholders concerns. Similar to the science arbiter, this is often in the form of a requested committee or assessment. Unlike the issue advocates, they expand and clarify all potential options and outcomes.

Methodology

In order to investigate the research question, a mixed methodology approach has been utilized. Qualitative interviews (N=13) and quantitative survey questionnaires (N=19) were employed to further understand climatologists' in the North Central Region patterns of communicating climate science. Subjects were selected using a purposeful sampling technique, based upon their occupation as state or extension climatologist in one of the twelve states in the region. Purposeful sampling allows for the selection of a representative population of the group being investigated (Marshall, 1996).

Qualitative interviews are a useful methodology in exploratory research to obtain a detailed and in-depth picture of issues involved in the topic being investigated (Rubin and Rubin, 1995). Further, interviews allow the subject to elaborate and build new ideas which allows for the development of emergent themes as well as the ability to assess emphasis or hesitance in certain topics that are being investigated (Denzin & Lincoln, 1994). Quantitative survey methodology is also necessary because it offers access to information on beliefs, attitudes, and perceptions of specific topics and inquiries (Neuman, 1994).

Subjects were contacted by the researcher via e-mail with a request to participate in the study (See APPENDIX A). Follow-up calls were also utilized when necessary to increase response rate. Participation in the study was voluntary, and all of the potential subjects contacted agreed to participate. Prior to the study, participants completed an informed consent form (See APPENDIX B). Interview and survey content, study protocols, and informed consent documentation were approved prior to administration by Iowa State University Institutional Review Board (IRB) #12-022 (See APPENDIX C).

Quantitative survey questions and qualitative interview questions were developed collectively by a committee of climate and social scientists. Specifically, the President of the American Association of State Climatologists, another State Climatologist, two professors of sociology, one climate scientist, one other sociology graduate student, and a the manager of a USDA climate project formed the committee which was led by the researcher. Several meetings of members of this group occurred for three months as the survey and interview instruments were developed and validated. Both instruments were pilot tested by a group of climate scientists to further ensure validity prior to implementation.

Interviews were transcribed and analyzed using NVivo qualitative data analysis software (NVivo, 2009). Interviews were also read and hand-coded for themes by two independent reviewers. All interviews analysis was discussed and reconciled among reviewers. To further insure inter-rater reliability between the two coders of the interview transcripts, a qualitative analysis codebook was developed. This codebook enables researchers to quantify their coding of certain themes, allowing for direct comparison among coders (MacQueen et al., 1998). Further, this codebook allows for the computation of inter-rater reliability on SPSS utilizing Cohen's kappa (Cohen, 1960; 1968). For the 16 questions, the two coders had a mean average reliability rating of 0.907.

Climatologists were placed on a scatterplot representing four patterns of communication criteria based upon perceived role of science in society (Figure 4.3). Interview contents and survey responses were considered to determine which of the four patterns each climatologist represented. Further, all other patterns were considered to determine the spatial location in which the climatologist was placed on the scatterplot. The more a climatologist encompassed traits of multiple communication patterns, the closer they were located to the center. Likewise, the more they demonstrated traits of one certain communication pattern, the closer they were to the respective corner of the scatterplot.

Results

Beliefs about climate

Climate scientists and farmers have substantively different conceptions of what it means to have specific beliefs about climate change. In the interviews, several climatologists elaborated on the distinction between "beliefs" and "facts." For instance, "Prior to all this I wouldn't have had a problem with 'believe,' but with the fact that it's turned out to be such a political issue and believing this versus believing that," one climatologists stated. "It's not a belief," they continued." It's not like believing in God or believing in ghosts or believing in Santa Claus. There's evidence, and you can ignore the evidence or not" (1203120202, 11). Clearly, climatologists recognize that climate change is a fact, and not a belief.

Another climatologist elaborated, “And whether you believe in it just makes it too much like a religion and puts people on one side or the other. And I don't think that making people divide up onto sides is...I just don't think that's the way to go. It's not the way to make progress” (1203120203, 8). This statement indicates that in order for society to benefit from the application of climate science, all diverse stakeholders must first accept that climate change has been established through scientific consensus, and must make the transition from subjective belief to scientific fact. To make progress in continually accumulating and applying currently available climate science, individual perceptions regarding environmental health and human risks established through socially referenced viewpoints (Kahan et al., 2011) must be directly addressed.

A comparison of climatologists and farmers beliefs regarding climate change based on survey results reflects the qualitative data about beliefs based on climatologist interviews (Table 4.2). For instance, while 53% of climatologists believe that “climate change is occurring, and it is caused mostly by humans activities, only 8% of farmers believe this statement. Further, 31% of farmers responded that “there is not sufficient evident to know with certainty whether climate change is occurring on not,” compared to only 5% of climatologist. None of the climatologists believe that “climate change is not occurring,” and only 3.5% of farmers believe this statement. Further exploring idealized roles of science in society may shed light onto this divide between “beliefs” and “facts.”

Table 4.2. Climatologists’ and farmers’ beliefs about climate change

There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change. (Please circle one number.)

	Climatologists (N=19)	Farmers (N=4778)
a. Climate change is occurring, and it is caused mostly by natural changes in the environment.....	5%	25%
b. Climate change is occurring, and it is caused mostly by human activities	53%	8%
c. Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities.....	37%	33%
d. Climate change is not occurring.....	0%	3.5%
e. There is not sufficient evidence to know with certainty whether climate change is occurring or not	5%	31%

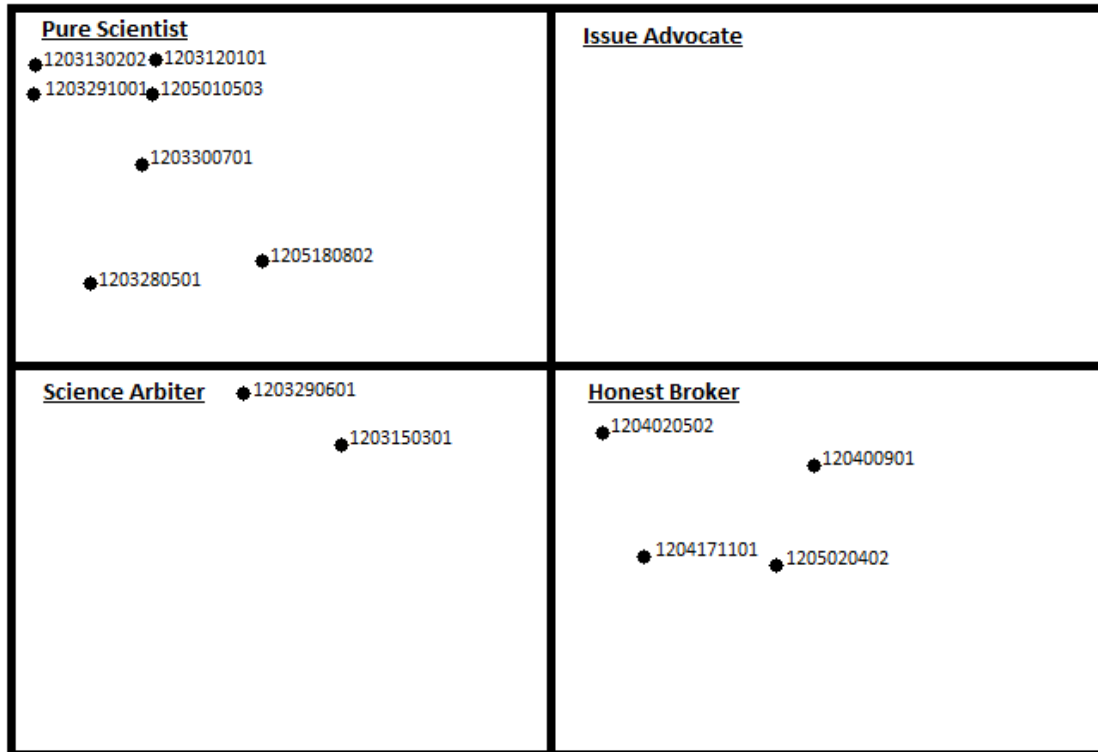
Idealized roles

Climatologists have a number of roles. For instance, they collect, document, and provide weather and climate information to public data users. Also, they make this information available to various stakeholders, which in the North Central Region, includes a large portion of farmers. “We worry about acquiring, archiving, and disseminating climate information,” one climatologist stated, while also recognizing “the responsibility of outreach and sharing this information with the agricultural community” (1203220401, 1).

When applying the idealized roles of scientists in society framework (Table 4.1) to the interview data, the majority of climatologists fall under the category of pure scientist (Figure 4.3). In the interviews, many of them made direct comments regarding the disconnection between science and policy. This suggests they think that science is a linear process and experts simply offer knowledge that is then built up. For instance, one climatologist remarked, “Where you get into big trouble is when you go beyond being a scientist and suddenly start advocating a

particular policy. That's where you're apt to see a lot of your push back. So...I don't do any of the policy issues" (1203120201, 11).

Figure 4.3. Climatologists' perceived roles.



There were also several mentions regarding an advert separation from politics and strictly presentation and not interpretation of data. "I try to make it as apolitical as possible," one climatologists remarked, "and just show the facts, the data, the information and let folks come up with their own decision or assessment on what they think might be happening" (1203150301, 13). Climatologists also generally recognized their role in science as remaining neutral and not tailoring or directing research to address and particular outcome. "I first of all don't want to be considered an advocate for any particular agenda that people might have on either side of the issue. I don't vet to our customers, and climate skeptics will get the same service from me as someone who is concerned about climate change. We want to be always seen as an impartial deliverer of climate data, data that people can trust, and know it was not provided by somebody with an agenda" (1203220401, 9).

A few climatologists even went so far as to reflect on the performance of their colleagues. “Some of the scientists have gotten so evangelical about this that they appear to have lost their objectivity.” This climatologist continued this statement to support the viewpoint of the pure scientist. “Because they’re promoting a position they’re not letting the science speak for themselves; they’re making an issue out of it beyond the basic science” (1203120202, 12). Another climatologist referred to avoidance of connecting science to policy. “The other one that I do stay away from are policy issues” (1203120201, 11).

However, there were two climatologists that appeared to represent what is considered the science arbiter role, in that they are willing to make connections between science and society, particularly when requested. For instance, there was hesitance to actively relate scientific consensus to society impacts, however, there was acceptance that these connections may be necessary. “We need to have observations, we need to have better forecasts, we need to have satellites – those are all things that are noncontroversial – they’re things we need to have to protect our citizenry and protect our economic livelihood. But when they become attached to climate by any stretch, sometimes they become controversial” (1203290601, 7). These remarks come from an extension climatologist, whose role encompasses serving requests from public data users, as well as policy makers. In regards to their role as a scientist, they stated that “We are truly people who are trying to help people understand what climate is, how climate varies, potential impacts of changes, and how things are going to change in the near and longer term” (1203290601, 11).

There were also a few climatologists who could be considered in the idealized role of honest brokers of alternatives. For instance, once climatologist remarked, “Likely we as public citizens are going to have to make some really challenging decisions in the future – what, if anything, to do about climate change. We have to be informed. We have to be educated about those. We can’t afford to be ignorant” (1204200901, 10). It is important to understand that scientists are citizens first and foremost, and are equally affected by application of scientific consensus to decision making and policy development, or lack thereof. The classic role of the honest broker was illustrated in the statement:

“So we could produce some very likely scenarios that farmers could evaluate and think about how they would respond to these scenarios. We’re not saying they’re going to happen, but these are plausible scenarios. So I think what farmers could do to adapt is to consider conditions outside the range of very recent experience,

because there's going to be a higher likelihood... We have high confidence that there will be more of these conditions outside the range of recent experience" (1204020502, 9).

There was recognition of climate science communication as requiring a "two-pronged education effort." For instance,

"We've made more and more effort in extension and with other groups to educate people and to show them the data and to show them the consequence of these changes. There's a twofold or two-pronged educational effort here. The first prong or the first path is to simply take the data and the history for a location and show how we are now measuring climate attributes that are outside the bounds of what we have measured historically. And we've got scads of examples of that. The second path or the second prong is to show what the consequence of that has been—how it has changed the landscape, how things are different than what they once were" (1205020402, 10).

This two-pronged education approach seems like an important consideration to understand the idealized roles of science in social and patterns of communication employed by climatologists. Another important consideration was voiced that will greatly assist the second prong of the approach, to demonstrate all possible consequences while being mindful of the influence of social and cultural viewpoints that create diverse mental models among stakeholders. This approach involves discussing environmental and social impacts associated with climate not in terms of regulation, pollution, or emissions, which it has most often been presented, but in terms of hazard and risk mitigation. This will assist farmers in utilizing currently available science to help develop adaptive and mitigative management practices. Social and decision scientists have emphasized the importance of framing, which is a technique of communication which connects to concepts. It appears clear that climatologists would benefit greatly by framing climate science in terms of hazard avoidance and risk management.

"Talk about it through hazard mitigation or early warning system for extreme events. That is the kind of thing that we need to move towards in terms of alerting the public or a particular sector that big things are coming or may be coming or may be more frequent than they used to be. That actually is a way into perhaps changing not only perception but also changing decisions" (1204181101 11).

Discussion

Climatologists' perceptions of their role as scientists and their patterns of communication are necessary to explore when considering how climate science information is transferred to public data users, including farmers and the agricultural sector. The construction of four idealized roles of science in society, which reflect distinct patterns of communication, assist us in analyzing currently employed techniques of communication. Although the majority of climatologists perceive their role as simply creating objective science, communication and social research indicates that it is also crucial for scientists to outline potential societal impacts associated with current knowledge.

The observation by Weber (2010) that there is a substantive mismatch between climate scientists and citizen perceptions of how big a problem climate change will not easily be resolved. However, state climatologists have a role and opportunity to help the public, particularly farmers whose livelihoods depend on adapting to changing weather and condition conditions, to better understand how to interpret and use the empirical facts they know so well. Our data suggest that some climatologists are ready and willing to be honest brokers, by providing potential outcomes and options of societal response to scientific findings. However, many climatologists perceive their role as simply providing information and letting data users interpret its application. As science is developed that may potentially inform individual and collective decisions to mitigate hazards and management risks, it will be important to outline potential options for how the public and policy-makers may interpret and respond to the science.

It is now becoming widely accepted that science, and particularly biophysical sciences such as meteorology and climatology, are directly relevant to many societal problems. As a result, scientists are increasingly expected by members of the public, policy-makers, and their colleagues to connect and applying research to improving the health and wellbeing of society. Science is no longer perceived as separate from policy and politics, but as a necessary and valuable resource in informing complicated decisions that involve complex networks of stakeholders.

A distinction has been made between "research science" and "policy science" (Weinberg 1972; 1985). Fundamentally, this approach argues that as complexity and uncertainty of the scientific investigations increase, so does the democratization of how the science is conducted (Carolan, 2006). In other words, science proceeds in a more closed manner when uncertainty

and complexity are low, but as complexity increases, such as in the case of environmental risks, scientific investigations become more normative and uncertain. Understanding potential environmental risks associated with climate change, for instance, increasingly require scientists to address concepts such as “ecosystem health” which, Carolan argues, as a value statement (Carolan, 2006, p. 662). Risk and impacts related to nature are generally regarded as subjective, and rests on individual beliefs about how we perceive nature should be and what healthy is.

The impact of individual beliefs is apparent in how science in general is perceived. Pielke (2007) makes a distinction between tornado and abortion politics. Tornado politics is argued to be a situation in which decision makers share a common outcome, which in the case of an impending tornado, would be the goal to preserve human life. Abortion politics, on the other hand, are more highly influenced by individual viewpoints, values, and perceptions. In the process of reaching a consensus involving issues with highly value-laden outcomes, such as “ecosystem health,” continuous bargains, compromise, and negotiation are necessary. Although climatology and meteorological science may sometimes be considered tornado politics, such as in the case of a certain impending storm, they are more often falling under the category of abortion politics. For instance, the environmental and human health impacts associated with increasing extreme weather events and variable climate conditions is considered by many to be a subjective value judgment. Hence, the large number of people consider potential outcomes of climate change to rely on “belief” as opposed to “fact.”

Conclusion

There have been an increasing number of suggestions from the scientific community to assist in the application of science to benefit society. For example, The National Science Foundation (NSF) has sponsored a series of communication workshops, with the intention to equip scientists of all disciplines with the skills necessary to effectively communicate the importance of their science to the public. These workshops were formed not long after the addition a section regarding societal impacts on all funded projects through the NSF. The National Academy of Science (2009) prepared a report, A New Biology for the 21st Century, in response to the National Institutes of Health (NIH), Department of Energy (DOE), and NSF request to “examine the current state of biological research and recommend how best to capitalize on recent technological and scientific advances that...predict the behavior of complex

biological systems.” The committee of scientists recommended, among other things, that a national initiative is needed to “achieve solutions to societal challenges in food, energy, environment, and health.”

Despite the controversies and uncertainties surrounding the science of climate change, it is slowly moving from abortion to tornado politics. Regardless of one’s personal beliefs on environmental hazards and risks associated with weather and climate, we all share the collective desire to protect the health and prosperity of ourselves, fellow humans, and offspring. There is an increasingly vocal group of citizens, scientists, and policy makers that are raising concerns for the need to apply current climate science knowledge to appropriate behavior, decision making, and policy implementation. Climatologists could help society, and the agricultural sector in particular, by reconsidering their current patterns of communication, and recognizing their potential dual roles of proving scientific information and outlining impacts, hazards, and risks associated with currently available knowledge.

As observed in our scatterplot, climatologists vary in their location within each typology, suggesting that there are overlap roles and behaviors that are likely to be context and situation specific. The context of agriculture is just one situation in which climatologists would communicate information to public data users. It would be interesting to explore alternative contexts of conveying information to determine if climatologists fall into the same idealized roles. Some of the climatologists demonstrate characteristics of multiple idealized roles, which may be expressed more or less in different contexts. The role of communicating science in contexts beyond agriculture would be an interesting avenue for further exploration. Further, this study was limited to climatologists in the North Central Region, and would be interesting to examine all climatologists in the United States and also other important agriculture regions of the world.

Ideal types as patterns of communication provide important theoretical constructs as we consider the perceived role of scientists. However, these constructs also obscure the concrete social phenomenon which we are investigating—the intersection of climate science communication and agricultural management. As a result, it may be beneficial to focus specifically on a two-pronged approach to climate science communication. In this case, climatologists will continue their roles of collecting and disseminating information, which encompasses translating all potential societal impacts of scientific findings. By highlighting that

effective patterns of communication contain two necessary components, both scientists and decision makers will be clear on the expected roles of scientists. This could greatly assist scientists in more effectively conveying information, and society in responding to the information to help mitigate hazards and manage risks.

CHAPTER 5.

GENERAL CONCLUSION

“We have a research role, and that’s trying to understand temporal and spatial trends of climate within the state and...also projected climate in the future—that’s been a hot topic in the last decade or so. And we also have an educational mission, and that is to try and incorporate pieces of what we do in educational opportunities for students but also in terms of public outreach and educate the public on climate science and climate-related issues” (1204200901, 1).

Climatologists provide weather and climate science information to public data users in their state. In the North Central Region (NCR) of the United States, this encompasses a large group of farmers and other stakeholders in the agricultural sector. Climatologists are therefore tasked with actively communicating climate science to agriculture because the agricultural audience constitutes a significant portion of NCR climatologists’ constituents.

The main recognized role of the climatologists is that of scientist—to develop and test research questions utilizing the scientific method. Other roles involve data and technological management, including maintaining weather observation equipment. Climatologists often interact with one another and regional climate centers to exchange information. Public service is also a role recognized by climatologists within the land grant institutions, encompassing the presentation and communication of scientific information to the public.

Many of the state climate offices in the North Central Region interact extensively with agriculture. However, this varies somewhat by state. For instance, in Michigan there is a large fruit sector, which requires different types of information than typical in the corn-belt. In the far western part of the NCR, irrigation agriculture also requires different types of information than rain-fed regions. Information for agricultural livestock producers is also important in dairy regions such as Wisconsin.

Climatologists largely recognize that there are gaps in the ability to collect information. When asked about what information would be helpful to the agriculture sector but is not currently available, common responses included soil moisture, solar radiation, and evapotranspiration. Communication challenges are also recognized, and many climatologists

noted that even though science is advancing, it does not mean that the public realizes what is available or will apply it in decision making.

There is recognition that farmers do utilize weather and climate information, however there are social, cultural, and political factors that moderate application of currently available scientific knowledge. As has been indicated by the Intergovernmental Panel on Climate Change, the National Climate Assessment Federal Advisory Committee's Draft Climate Assessment Report, and the Iowa Climate Change Impacts Committee, we recognize the climate is an environmental risk. These reports also suggest that agriculture is particularly sensitive to climate change and variability because of its reliance on the environment.

While agriculture is at risk to extreme weather events and climate variability, there is recognition that science can assist individual and collective decision making to help agriculture adapt to changes and remain resilient and profitable (Likens, 2010). As individuals tasked with creating and communicating climate-related science, climatologists are at the fore-front of helping agriculture and society address potential problems associated with increasingly unpredictable environmental risks.

This study provides insights into understanding how climatologists can more effectively assist agriculture and society in adapting to and mitigating risks associated with extreme weather events and variable climate patterns. Climatologists are key actors in helping farmers understand environmental uncertainties that influence agricultural production. Therefore, climatologists must embrace roles beyond the production of scientific information, to also encompass the translation and dissemination of this information to public audiences.

Fischhoff's (1995) seven stages of uncertain risk communication provide a valuable framework to understand how climate-related risks are communication by climatologists. As main themes emerged during the interview analysis, we found it helpful to collapse these stages into three main elements (See Table 3.2). Our findings indicate that the majority of climatologists are focused on the first element (objective and accurate). However, social and decision theory suggests that it is also necessary to embrace communication techniques of the second and third elements, by providing information that is relevant and important, and communicating it in a way in which the audience is engaged and the messenger is trusted. By engaging farmers in citizen science programs such as the Community Collaborative Rain, Hail, and Snow Network, as well as providing information that is agriculture and location specific,

climatologists may more effectively communicate to farmers and other stakeholders in the agriculture sector.

Pielke's (2007) four idealized roles of science in society are also an important framework to understand climatologists perceived roles as scientists. Results indicate that the majority of climatologists are focused on the role of producing science as pure scientists (See Figure 4.3). However, some climatologists did recognize the need to arbitrate information when requested. A few climatologists mentioned the need to communicate information to society, in line with the role of honest broker. These findings indicate the importance of a two-pronged approach to climate science communication for agriculture, in which science is first produced and then actively disseminated to the needs of farmers and other stakeholders. Further, the communication of current knowledge should be framed in terms of risk management and hazard mitigation, as a positive option to benefit society and public health.

Having demonstrated these two findings, there is one important further recommendation to address the climate science communication gap. The phrase "global warming" was often connected with climate science, and has since been phased out as a misappropriation because warming is just one factor associated with global change. However, when we are considering climate science, the phrase "climate change" may influence the audiences' willingness and ability to comprehend and accept scientific information. It is important to remember that by definition, climate is always changing. Climate change, then, often evokes perceptions of human-induced changes. However, climate science recognizes all changes of weather over time. As a result, it may be helpful when communicating climate science for climatologists to simply refer to "climate."

Implications

As public servants of the land grant universities, climatologists largely perceive their roles to remain objective providers of scientific information. However, there is much evidence in the decision and social sciences that indicate scientists' roles encompass both production and communication of research to assist individual and collective decision makers in applying modern knowledge to address social problems. Late agricultural economist and extension scholar James T. Bonnen argued for the urgent need of land grant institutions to evolve in order to meet the needs of a changing and modernizing society (Bonnen, 1996, 1998). To protect the

integrity of the land grant mission, he outlined seven potential risks of university intervention in society. Interestingly, these risks more or less follow the framework outlined by Fischhoff (1995), from letting society decide how to implement science in policy development, to suggesting or advocating certain societal responses on account of scientific consensus.

Dr. Bonnen recognized the extreme level of risk intertwined with the land grant institutions, and their affiliated employees and scientists, advocating societal and public policy response to matters of scientific consensus. As a result, he suggests that the highest level of risk involves advocating for certain societal responses to scientific consensus, specifically public policy development. However, it is argued that exceptions include “situations in which there was such great consensus in the community of the program goals and actions that the risk associated with public advocacy was nil” (Bonnen, 1998, p. 65). Further, these situations occur when a social consensus is so outstanding that any potential pushbacks to advocacy are nullified.

As a boundary between scientific knowledge and public data users, land grant institutions have tremendous potential to assist society in adapting to and mitigating environmental risks associated with weather and climate. However, institutional structures, funding mechanisms, traditions, and reward and review systems hinder the ability of universities to evolve the interface between society and science (Whitmer et al., 2010). It will be necessary to change how scientists are trained and rewarded to integrate science with society and policy (Pouyat et al., 2010).

Limitations and future research

As an investigation of scientists’ roles and responsibilities to communicate information to public data users, this particular research had several limitations. For instance, it was focused specifically on a certain audience (agriculture) in only the North Central Region of the United States. Further, it focused specifically on climatologists, and did not include other scientists who may utilize weather and climate science to communicate information for agriculture, such as agronomists, soil scientists, and agriculture engineers. Future research may consider addressing a broader area of the country, or other important agriculture regions across the globe. Investigations of scientists of differing disciplines, including agriculture, environmental, and natural resource science would also be interesting. Interview research methodology also provides a snap-shop at one point in time; longitudinal studies utilizing content analysis of public

comments from climatologists may be a helpful approach to further understand climatologists perceived roles and communication of science to the public.

Conclusions

On November 19, 2012, one hundred and eight scientists and researchers from twenty seven colleges and universities in the state of Iowa released the Iowa Climate Statement in response to the drought of 2012, declaring “we have confidence in recent findings that climate change is real and having an impact on the economy and natural resources of Iowa. We feel that it is important for citizens of Iowa to understand its implications” (Iowa Climate Statement). . This is one example in which climate science consensus has been directly connected to real-world impacts and risks. As the risks of increasingly variable climate patterns and extreme weather conditions become more certain to the scientific community, it is imperative that connections between scientific consensus and real-world impacts be addressed. In doing so, the communication of climate information to agricultural audiences will become much more effective, allowing for management operations to adapt their long term portfolios to remain productive and resilient, while assisting in the mitigation of variable climate conditions.

There are many examples of civil society demanding that individual and collective decision makers take a stance on climate. For instance, On February 17, 2013 approximately 40,000 people marched to the White House in Washington, D.C. to demand that President Obama move “Forward On Climate.” This event was held to demonstrate that citizens are concerned about the current state of energy policy in the country, and believe that appropriate policies need to be developed to address the environmental hazards associated with increasing extreme weather events and unpredictable climate conditions. The event was very timely, as President Obama declared in his State of the Union address, “We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations.” This statement strongly echoed the conclusions of United States Secretary of Energy Steven Chu, who declared in a speech to Iowa State University, “The oil and gas industries have received subsidies for the past 100 plus years—it is time to level the playing field.” Secretary Chu concluded, “I think we have a moral responsibility...The most innocent

victims in climate change are the poorest who never contribute anything to this and those yet to be born” (Chu, 2013).

Clearly, climate science is urgently needed to assist the public and policy makers in developing individual and collective decisions regarding climate. Regardless of one’s personal beliefs regarding future global change, this example demonstrates a situation in which the engagement of scientists with society is increasingly necessary for all stakeholders to potentially benefit. By remaining in the idealized role of pure scientist, climatologists are not allowing the full beneficial potential of their knowledge accumulation to be realized. It will become more important for climatologists to recognize their roles as experts in democratic society and embrace the application of their science for the betterment of society. By doing so, they will achieve the more modern balance of scientific progression between opportunity and needs.

One could argue that the climate science field greatly harmed their credibility by advocating one response to future problems: to reduce fossil carbon use. Had the scientific leaders in advocating policy response to current climate science consensus approached the issue slowly and offered potential outcomes and all potential responses, communicating this information to the public, and then stepping back and letting them decide, perhaps outcomes may have been more rapid and productive. Sometimes people know what the right thing is to do, but most people do not appreciate being told what to do, and will sometimes do the exact opposite. This is particularly evident in historically conservative social groups, such as farmers.

There is a large body of evidence to indicate that human forcings beyond carbon dioxide, particularly land cover and land use changes, are influencing atmospheric-terrestrial interactions that affect both local and global weather and climate patterns (Pielke et al., 2011; Pielke et al., 2009; McAlpine et al., 2010; DeFries et al., 2004; Diffenbaugh, 2009; Foley et al., 2003; Foley et al., 2005; Twin et al., 2004). A recent study using satellite photos demonstrated that from 2006 to 2011, 1.3 million acres of grass land were converted to corn and soybeans in the northern Great Plains (Wright & Wimberly, 2013). This is just one example of relevant interactions between climate and agriculture that scientists could communicate to public data users. Another potential avenue to make climate information important and relevant is by exploring the frame of public health (Nisbet, 2009; Maibach et al., 2008; Moser, 2006; Dilling & Moser, 2006) to avoid complications of emphasizing fear as a means to motivate individual action (O’Neill & Nicholson-Cole, 2009). By focusing on the potential human health benefits of

adapting to and mitigating a wide range of atmospheric-terrestrial interaction influences, climatologists may more effectively reach broader audiences of the public.

In closing, I would like to briefly return to the topic of public engagement in science, democracy, and public health. This study has indicated that climate is a risk the agricultural sector, which influences the production of food and environmental wellbeing. Results indicate that climatologists could benefit from actively communicating scientific information, and enlarging all potential impacts of current scientific consensus for public data users to make individual and collective decision, as well as appropriate public policy. In this process, it is of utmost importance to consider the public's input on issues dealing with individual values systems and beliefs, such as "ecosystem health." As society increasingly demands that the natural environment provide services which support human health, such as clean air and water, science must actively address these concerns in developing research methodologies to inform decision making and public policy. A scientific communication strategy that encompasses hazard mitigation and risk management will help society remain food secure and healthy for generations to come, regardless of uncertain future weather extremes and climate variability.

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APPENDIX A. CONTACT FORM.

Dear *****,

I am a graduate student on two USDA-NIFA funded projects, Climate Change Mitigation and Adaptation in Corn-Based Cropping Systems (<http://www.sustainablecorn.com>), and Useful to Usable: Transforming Climate Variability and Change Information for Cereal Crop Producers (<http://drinet.hubzero.org/u2uproject>). These two research groups are gathering information that will help them to develop agriculture management decision support tools in the Midwest Corn-Belt.

For my Master's thesis, I am investigating perceptions of risk associated with increasing weather variability between groups of scientific experts and agriculture producers. State Climatologists **Dennis** Todey of South Dakota and Pat Guinan of Missouri have helped me to prepare a methodology to better understand the role of State Climatologists in providing information to farmers.

My goal is to interview all the State and Extension Climatologists in this Midwest region. Would you be available to talk with me for approximately 45 minutes about your work? I will be calling you in the next couple days to set up an appointment.

If you have questions feel free to contact me, [\(320\) 583-7351](tel:3205837351) or awilke@iastate.edu

Thank you, I look forward to talking with you soon.

Kindest regards,

Adam K. Wilke

MS Graduate Research Assistant
Iowa State University
Department of Sociology
310 East Hall
Ames, Iowa 50011
[\(320\) 583-7351](tel:3205837351)
awilke@iastate.edu

APPENDIX B. CONSENT FORM.

INFORMED CONSENT DOCUMENT

Title of Study: Differences in Risk Perception between Climatologists and Farmers

Investigators: Adam K. Wilke, Graduate Student, ISU Department of Sociology
Lois Wright Morton, Ph.D., Professor, ISU Department of Sociology

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

INTRODUCTION

The purposes of this study is to understand perceptions of climate change between groups of climatologist and farmers, specifically investigating how increasing weather variability may affect agriculture production in the future. This knowledge will assist in the development of agriculture management decision making support tools for use by farmers in the Corn-Belt. You are being invited to participate in this study because you are a Climatologist in the North Central Region of the United States.

DESCRIPTION OF PROCEDURES

If you agree to participate in this study, your participation will consist of an interview conducted by Mr. Wilke which will last for approximately 40 minutes. You will also be asked to complete a mini-questionnaire prior to the interview. The types of questions asked will revolve around your perceptions of farmer's use of climate data in developing agriculture management plans. You may view the questions prior to the interview. Our conversation will be audio recorded and then transcribed. You will not be identified by name, and all transcripts will be assigned a random number for analysis. The tape recording will be destroyed after this project is completed.

RISKS

There are no foreseeable risks from participating in this study.

BENEFITS

If you decide to participate in this study you may request a copy of the case study/technical report that summarizes our findings. A desired outcome of this project is to advance the knowledge of farmers' needs of weather and climate data while making agriculture management decisions. Your contribution to this study will assist in the development of decision support tools for agricultural producers to ensure productivity in the face of increasing extreme weather events and variability.

COSTS AND COMPENSATION

You will not have any costs from participating in this study other than your time, about 45 minutes. You will not be compensated for participating in this study.

PARTICIPANT RIGHTS

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled. You can skip any questions that you do not wish to answer.

CONFIDENTIALITY

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken: interviewees will be assigned a unique code that will be used on forms and names will be removed from transcripts. Study records will only be available to the research team, and will be locked in Dr. Morton's office and destroyed after the project is completed. If the results are published, your identity will remain confidential.

QUESTIONS OR PROBLEMS

You are encouraged to ask questions at any time during this study.

- For further information about the study contact Dr. Lois Wright Morton, Iowa State University Department of Sociology, 317C East Hall, Ames, Iowa 50011. Tel: 515-294-2843 or lwmorton@iastate.edu.
- If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

PARTICIPANT SIGNATURE

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant's Name (printed) _____

(Participant's Signature)

(Date)

IRB ID: []

**INSTITUTIONAL REVIEW BOARD (IRB)
Application for Approval of Research Involving Humans**

Title of Project: Useful to Usdale (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers

Principal Investigator (PI): Lois Wright Morton		Degrees: 0592PhD
University ID:	Phone: 515-294-2643	Email Address: lwmorton@iastate.edu
Correspondence Address: 317C East Hall Ames, Iowa 5011-1070		
Department: Sociology		College/Center/Institute: Agriculture and Life Sciences
PI Level: <input checked="checked" type="checkbox"/> Tenured, Tenure-Eligible, & NTER Faculty <input type="checkbox"/> Adjunct/Affiliate Faculty <input type="checkbox"/> Collaborator Faculty <input type="checkbox"/> Emeritus Faculty <input type="checkbox"/> Visiting Faculty/Scientist <input type="checkbox"/> Senior Lecturer/Clinician <input type="checkbox"/> Lecturer/Clinician, Ph.D. or DVM <input type="checkbox"/> P&S Employee, P37 & above <input type="checkbox"/> Extension to Families/Youth Specialist <input type="checkbox"/> Field Specialist III <input type="checkbox"/> Postdoctoral Associate <input type="checkbox"/> Graduate/Undergrad Student <input type="checkbox"/> Other (specify:)		

FOR STUDENT PROJECTS (<i>Required when the principal investigator is a student</i>)		
Name of Major Professor/Supervising Faculty:		
University ID:	Phone:	Email Address: @iastate.edu
Campus Address:		Department:
Type of Project (check all that apply): <input type="checkbox"/> Thesis/Dissertation <input type="checkbox"/> Class Project <input type="checkbox"/> Other (specify:)		
Alternate Contact Person: Jean McGuire		Email Address: jmcguire@iastate.edu
Correspondence Address: 317B East Hall Ames, Iowa 5011-1070		Phone: 515-294-3383

ASSURANCE

- I certify that the information provided in this application is complete and accurate and consistent with any proposal(s) submitted to external funding agencies. Misrepresentation of the research described in this or any other IRB application may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.
- I agree to provide proper surveillance of this project to ensure that the rights and welfare of the human subjects are protected. I will report any problems to the IRB.
- I agree that modifications to the originally approved project will not take place without prior review and approval by the IRB.
- I agree that the research will not take place without the receipt of permission from any cooperating institutions, when applicable.
- I agree to obtain approval from other appropriate committees as needed for this project, such as the IACUC (if the research includes animals), the IBC (for research involving biohazards), the Radiation Safety Committee (for research involving x-rays or other radiation producing devices or procedures), etc.
- I agree that all activities will be performed in accordance with all applicable federal, state, local, and Iowa State University policies.

Signature of Principal Investigator Date

Signature of Major Professor/Supervising Faculty Date
(Required when the principal investigator is a student)

- I have reviewed this application and determined that departmental requirements are met, the investigator(s) has/have adequate resources to conduct the research, and the research design is scientifically sound and has scientific merit.

Signature of Department Chair Date

For IRB Use Only	Full Committee Review: <input type="checkbox"/>	Review Date:
	EXPEDITED per 45 CFR 46.110(b): Category Letter	Approval/Determination Date:
Approval Not Required: <input type="checkbox"/>		Approval Expiration Date:
<i>Not Research:</i> <input type="checkbox"/>	EXEMPT per 45 CFR 46.101(b):	
<i>No Human Subjects:</i> <input type="checkbox"/>	Not Approved: <input type="checkbox"/>	Risk: Minimal <input type="checkbox"/> More than Minimal <input type="checkbox"/>
IRB Reviewer's Signature		

Research Involving Humans Study Information

Please provide answers to all questions, except as specified. Incomplete forms will be returned without review.

Part A: Key Personnel

List all members and relevant qualifications of the project personnel. Key personnel includes the principal investigator, co-principal investigators, supervising faculty member, and any other individuals who will have contact with the participants or the participants' data (e.g., interviewers, transcribers, coders, etc.). This information is intended to inform the committee of the training and background related to the specific procedures that each person will perform on the project. For more information, please see [Human Subjects - Persons Required to Obtain IRB Training](#).

NAME	Interpersonal contact or communication with subjects, or access to private identifiable data?	Involved in the consent process?	Contact with human blood, specimens, or other biohazardous materials?	Other Roles in Research	Qualifications (i.e., special training, degrees, certifications, coursework, etc.)	Human Subjects Training Date
Lois Wright Morton	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		Professor PhD	10/09/2000
Jean McGuire	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		Doctoral Student	05/07/2008
Adam Wilke	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		Masters Student	08/29/2011
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
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	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			

Please complete additional pages of key personnel as necessary.

Part B: Funding Information

<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No	1. Is the project federally funded? If Yes , please provide the complete name(s) of the source(s); please do not use acronyms. Please attach a complete copy of the federal grant proposal from which the study is funded.
United States Department of Agriculture -- National Institute of Food and Agriculture (Appendix H)		

Part C: General Overview

2.	Study Objectives – Briefly explain in language understandable to a layperson the purpose and specific aim(s) of the study.
<p>The goal of the Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers project is to improve the resilience and profitability of farms in the 12 state North Central Region (See Appendix A) amid variable climate change through the development and dissemination of decision support tools. Social scientists representing 9 of the 12 states in the region, will address these critical issues through these five broad objectives:</p> <ol style="list-style-type: none"> 1. Use existing data to develop a knowledge base of potential biophysical and economic impacts related to climate changes and consider the relative risks they pose. 2. Understand how producers make decisions under uncertain climate projections, what type of information they need to make better decisions, and what are effective methods for disseminating usable knowledge to them and larger agricultural networks. 3. Develop tools, training materials, and implementation approaches that lead to more effective decision-making and adoption of practices associated with farms resilient to climate variability. 4. Evaluate the effectiveness of the tools, training materials, and implementation approaches for corn/soybean producers in four pilot states (Indiana, Iowa, Nebraska, and Michigan). 5. Broadly disseminate validated training materials, tools, and extension programs to ensure increased usefulness and usability of climate information. <p>More specifically the Human Dimension portion of this project will explore the use and value of climate information and projections among cereal crop producers in the North Central Region by examining the role of networks and iterative modes of science and decision making and working with those stakeholder to help them incorporate climate-information driven decision support tools into their farming decision process. This “coproduction” of science is increasingly being called for by groups such as the National Academy of Scientists (NRC, 2009, 2010). We use the term producers to mean people growing corn/soybeans on their own or rented land. We use the term advisors to mean people who work with producers and help them make decisions including bankers, crop advisors and others; a special type of advisor group is extension.</p>	
3.	Benefits to Society and Participants – Explain in language understandable to a layperson how the information gained in this study will advance knowledge, and/or serve the good of society.
<p>Agricultural crops contribute about \$150 billion annually to the U.S. economy, most of which comes from the intensely cultivated Midwest. This level of production relies on favorable temperatures and appropriate</p>	

precipitation patterns. Variation in either, including fewer frosts and earlier warm days for temperature and increased occurrences of extreme variability in rainfall, limit season-to-season predictability and lessen the ability of producers to maintain viable farm operations. This presents significant challenges to the corn economy in the North Central Region where farmers grew approximately 88% of U.S. corn in 2009. The potential for this project to lead to long-term improvement and sustainability of cereal crop production in the North Central Region is very high as climate change and climate variability greatly impact corn production. The Region's long-term economic viability requires better information predictive resources regarding climate.

4. Describe the direct benefits to research participants; if there are no direct benefits to participants, indicate that. Note: Monetary compensation cannot be considered a benefit to participants.

At the end of the project the participants will have access to better tools and mechanisms to inform corn production decisions with critical economic impact under current conditions of climate change.

Part D: Anticipated Enrollment

Estimated number of participants to be enrolled in the study		Total: 24,000	Males: 23,000	Females: 2,000
Check below if you intend to include persons from the following groups: <input type="checkbox"/> Minors (Under 18) Age Range of Minors: <input type="checkbox"/> Pregnant Women/Fetuses <input type="checkbox"/> Cognitively Impaired <input type="checkbox"/> Prisoners	Check below if this project includes: <input checked="" type="checkbox"/> Adults, non-students <input type="checkbox"/> Minor ISU students <input type="checkbox"/> ISU students 18 and older <input type="checkbox"/> Other (explain)			
List estimated percent of the anticipated enrollment that will be minorities <i>if known</i>:				
American Indian: 100		Alaskan Native:		
Asian or Pacific Islander:		Black or African American:		
Latino or Hispanic:				

Part E: Participant Selection and Recruitment

Please use additional space as necessary to adequately answer each question.

5. Explain the procedures and rationale for selecting participants, including the inclusion and exclusion criteria (e.g., where will names come from, what persons will be included or excluded and why, etc.).

Three groups of participants will be involved in this project.

The first group is state climatologists from the 12 states in the North Central Region. This group is limited to those individuals who hold the title of state climatologist for their state and other climatologists from land grant universities who are serving as principal investigators on this project.

The second group is corn producers in the North Central Region who will participate in a survey that is being issued in conjunction with the Climate Change, Mitigation, and Adaptation in Corn-Base Cropping System project (Appendix B). The details on how those individuals were chosen can be found in the approved Exempt Study

Review submitted by J. Gordon Arbuckle Id 10-599. A copy of that approved form has been attached to this application (Appendix C). In addition, focus groups of corn producers will be held in Iowa in 2013. Focus group member selection procedures and questions will be developed and submitted to Iowa State University IRB at a later time and are not attached to this application.

The last group that will be studied are advisors to corn producers. This group includes extension staff from Iowa State University, Michigan State University, University of Nebraska-Lincoln and Purdue. Other members of this group include crop advisers, insurance agents, equipment dealers, financial advisers, bankers and others in Indiana, Iowa, Michigan and Nebraska. The selection criteria is quite broad and includes any individual or groups of individuals who advise corn producers in the North Central Region. Focus group questions for the corn producer advisers will be developed and submitted to Iowa State University IRB at a later time and are not attached to this application.

6. Describe the procedures for contacting participants (e.g., letter, email, flyer, advertisements, phone call, etc.). Attach copies of any letters, scripts, flyers, or advertisements that will be used.

The state climatologists will be contacted directly by e-mail and telephone in the Spring 2012 for in-person interviews. Procedures and protocol are attached to this application and include the consent form, mini survey and interview prompts.

Contact procedures for corn producers in the North Central Region who will participate in the survey being performed by social scientists on this project are available in the approved Iowa State University Exempt Study Review forms submitted by J. Gordon Arbuckle Id 10-599. A copy of that approved form has been attached to this application as Appendix B. The survey instrument is attached to this application as Appendix C. In addition, focus groups of Iowa corn producers will be held in 2013. Focus group selection contact procedures will be developed and submitted to Iowa State University IRB at a later time and are not attached to this application.

Contact protocol for the advisers of North Central Region corn producers will include e-mails for the survey portion and phone calls for the focus group portion of the project. Documents and procedures for corn producer adviser survey and focus groups will be developed and submitted for review and approval once they are complete and are not attached to this application.

Part F: Research Plan

Include sufficient detail for IRB review of this project independent of any other documents.

- | | | |
|---|-----------------------------|--|
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 7. Does this project involve using existing data or records? If Yes , describe the data/records in the Research Plan, question 9. |
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 8. Does this project involve secondary analysis? If Yes , describe the source of the data in the Research Plan, question 9. |

9. **Research Plan** – The information needed here is similar to that in the “methods” or “procedures” sections of a

research proposal—it should describe the flow of events that will occur during your interactions with subjects. Please describe in detail your plans for collecting data from participants, including **all** procedures, tasks, or interventions participants will be asked to complete during the research (e.g., random assignment, any conditions or treatment groups into which participants will be divided, mail survey or interview procedures, sensors to be worn, amount of blood drawn, etc.). This information is intended to inform the committee of the procedures used in the study and their potential risk. **Please do not respond with “see attached” or “not applicable.”**

Interviews with state climatologists will be performed in Spring 2012. Those interviews will be recorded and transcribed. Interviews will then be coded for themes and analyzed amongst the total group of interviews for emergent themes. The interview questions are provided in Appendix D. Climatologists will also complete a brief survey, which will be analyzed quantitatively (Appendix E).

Two surveys will be performed in this project. The first is a survey of corn producers in the North Central Region. This survey is being done with the Climate Change, Mitigation, and Adaptation in Corn-Based Cropping Systems (CSCAP). Dr. J Gordon Arbuckle has already applied for and received approval to exempt this particular study through the Iowa State University Review Board. The IRB ID is 10-599. A copy of this survey is attached (Appendix C) Following analysis of the survey, focus groups with corn producers will be held throughout the North Central Region. The procedures and questions for those focus groups will be developed and submitted to IRB in 2013 and are not attached to this application.

The second survey will be e-mailed to those who advise corn producers. Most of the questions will be identical to or slightly modified the questions in the corn producers. A draft of that survey (Appendix F) is attached to this application. This survey will cover only the states of Indiana, Iowa, Michigan and Nebraska. The ISU team will be responsible for dispersing and collecting the data for Iowa. Following analysis of the advisor survey, focus groups will be held to add qualitative explanations to the quantitative data collected in the survey. Questions for those focus groups will be submitted to the IRB upon development and are not attached to this application.

10. For studies involving deception or where information is intentionally withheld from participants, such as the full purpose of the study, please explain how persons will be deceived or what information will be withheld. Additionally, a waiver of the applicable elements of consent will be needed. Please complete the [Waiver of Elements of Consent](#) form. If this question is not applicable, please type N/A in the response cell.

Not applicable

- Yes No 11. Does your project require the use of a health care provider’s records concerning past, present, or future physical, dental, or mental health information about a subject? The Health Insurance Portability and Accountability Act established the conditions under which protected health information may be used or disclosed for research purposes. If your project will involve the use of any past or present clinical information about someone, or if you will add clinical information to someone’s treatment record (electronic or paper) during the study, you must complete and submit the [Application for Use of Protected Health Information](#).

- Yes No 12. Does this project involve an investigational new drug (IND)? Number:

- Yes No 13. Does this project involve an investigational device exemption (IDE)? Number:

- Yes No 14. Does this project involve DEXA/CT scans or X-rays?

Yes No

15. Does this project involve pathology or diagnostic specimens? If **Yes**, indicate whether specimens will be collected prospectively and/or already exist “on the shelf” at the time of submission of this review form. If prospective, describe specimen procurement procedures, indicate whether any additional medical information about the subject is being gathered, and whether specimens are linked at any time by code number to the participant’s identity. If this question is not applicable, please type N/A in the response cell.

Part G: Consent Process

A copy of any translated informed consent documents and an English version should be submitted with the application. Provide the name of the individual who translated the consent documents and their qualifications for translating consent documents below.

If the consent process does not include documented (signed) consent, please request a [Waiver of Documentation of Consent](#). If any information about the study is intentionally withheld or misleading (i.e., deception is used), a [Waiver of Elements of Consent](#) must be requested. Links to the forms for requesting waivers are also available at the IRB website.

16. Describe the consent process for adult participants (those who are age 18 and older). Include information about who will obtain consent from participants; how/when consent will be obtained in relation to actual data gathering; whether someone other than the subject will provide consent (e.g., a legally authorized representative); etc.

Consent will be obtained prior to the interviews with the state climatologists. The consent form is included as Appendix G.

Consent will be obtained for the survey of the North Central Region corn producers at the beginning of the survey. This process was approved in ISU IRB 10-599 in Appendix C of the application. Once the focus group protocol is developed a specific consent form will be developed and submitted for review to Iowa State University IRB at a later time and are not attached to this application.

Consent will be obtained for the survey of the advisers of North Central Region corn producers at the beginning of the e-mail survey. The specific language of that consent is being developed and will be submitted for review to Iowa State University IRB at a later time and is not attached to this application. The focus groups planned for this group, a specific consent form will be developed and submitted for review to Iowa State University IRB at a later time and are not attached to this application.

17. If your study involves minor children, please explain how parental consent will be obtained prior to enrollment of the minor(s).

No minors involved

18. Please explain how assent will be obtained from minors (younger than 18 years of age) prior to their enrollment.

Also, please explain if the assent process will be documented (*e.g., a simplified version of the consent form, combined with the parental informed consent document*). According to the federal regulations **assent** "...means a child's affirmative agreement to participate in research. Mere failure to object should not, absent affirmative agreement, be construed as assent."

Part H: Data Analysis

19. Describe how the data will be analyzed (*e.g., statistical methodology, statistical evaluation, statistical measures used to evaluate results*).

Quantitative data (surveys) will be analyzed using statistical software programs such as SAS, SPSS, and MPlus. Qualitative data (interviews and focus groups) will be analyzed using NVIVO software and by hand coding by Dr. Morton or her graduate students. No personally identifiable information will be present in either the quantitative or qualitative analysis.

Part I: Risks

The concept of risk goes beyond physical risk and includes risks to participants' dignity and self-respect as well as psychological, emotional, legal, social or financial risks.

Yes No 20. Is the **probability** of the harm or discomfort anticipated in the proposed research greater than that encountered ordinarily in daily life or during the performance of routine physical or psychological examinations or tests?

Yes No 21. Is the **magnitude** of the harm or discomfort greater than that encountered ordinarily in daily life or during the performance of routine physical or psychological examinations or tests?

22. Describe any foreseeable risks or discomforts to the participants and how they will be minimized and precautions taken. **Do not respond with N/A.** If you believe that there will not be risk or discomfort to participants, *you must explain why.*

There will be no risk or discomfort to the participants because no personally identifiable information will be released and their identities will not be connected to any of their statements or information they provided.

23. If this study involves vulnerable populations, including minors, pregnant women, prisoners, the cognitively impaired, or those educationally or economically disadvantaged, what additional protections will be provided to minimize risks?

Not applicable

Part J: Compensation

 Yes No

24. Will participants receive compensation (including course credit/extra credit) for their participation? If **Yes**, please describe compensation plans below.

Note: Do not make the payment an inducement—only a compensation for expenses and inconvenience. If a person is to receive money or another token of appreciation for their participation, explain when it will be given and any conditions of full or partial payment. (For example, volunteers will receive \$5.00 for each of the five visits in the study or a total of \$25.00 if they complete the study. If a participant withdraws from participation, he/she will receive \$5.00 for each of the visits completed.) It is considered undue influence to make completion of the study the basis for compensation.

Part K: Confidentiality

25. Describe below the methods that will be used to ensure the confidentiality of data obtained. For example, describe who will have access to the data, where the data will be stored, security measures for web-based surveys and computer storage, how long data or specimens will be retained, what (if any) identifiers will be retained, etc.

Records identifying participants will be kept confidential to the extent permitted by applicable law and regulations and will not be made publicly available. However, federal government regulatory agencies (USDA as project grantor) and the Iowa State University Institutional Review Board may inspect and /or copy records for quality assurance and data analysis. These records may include private information. To ensure confidentiality to the extent permitted by law, the following measures will be taken: Interviewed subjects will be assigned a unique code that will be used on forms instead of their names. Study records will be available to the research team -- Dr. Lois Wright Morton and trained graduate students. Tape recordings of interviews and focus groups will be locked in Dr. Morton's office and destroyed two years after completion of the project (April 1, 2018). If the results are published, all personally identifiable information will be excluded.

Part L: Registry Projects

 Yes No

26. Does this project establish a registry? If **Yes**, please provide the registry name below.

Note: To be considered a registry: (1) the individuals must have a common condition or demonstrate common responses to questions; (2) the individuals in the registry might be contacted in the future; and (3) the names/data of the individuals in the

registry might be used by investigators other than the one maintaining the registry.

Checklist for Attachments

Listed below are the types of documents that should be submitted for IRB review. Please check **and attach** the documents that are applicable for your study:

- Federal grant application (only for federally funded research)
- A copy of the informed consent document or letter of introduction containing the elements of consent
- A copy of the forms requesting waivers of elements of consent or documentation of consent, where applicable
- A copy of the assent form if minors will be enrolled
- Data-gathering instruments (including surveys)
- Recruitment fliers, phone scripts, or any other documents or materials participants will see or hear

The original signed copy of the application form and one set of accompanying materials should be submitted for review.

ENVIRONMENTAL HEALTH AND SAFETY INFORMATION

PART M: HUMAN CELL LINES

Yes No

1. Does this project involve human cell or tissue cultures (primary OR immortalized cell lines/strains) that have been documented to be free of bloodborne pathogens? If the answer is **Yes**, please answer question A below and attach copies of the documentation.

A. Please list the specific cell lines/strains to be used, their source and description of use.

CELL LINE	SOURCE	DESCRIPTION OF USE

B. Please refer to the ISU *Bloodborne Pathogens Manual*, which contains the requirements of the OSHA Bloodborne Pathogens Standard. Please list the specific precautions to be followed for this project below (e.g., retractable needles used for blood draws):

Anyone working with human cell lines/strains that have not been documented to be free of bloodborne pathogens is required to have Bloodborne Pathogen Training annually. Current Bloodborne Pathogen Training dates must be listed in Section I for all Key Personnel. Please contact Environmental Health and Safety (294-5359) if you need to sign up for training and/or to get a copy of the [Bloodborne Pathogens Manual](#).

PART N: HUMAN BLOOD COMPONENTS, BODY FLUIDS OR TISSUES

Yes No

2. Does this project involve human blood components, body fluids or tissues? If **Yes**, please answer all of the questions in the "Human Blood Components, Body Fluids or Tissues" section.

A. Please list the specific human substances used, their source, amount and description of use.

SUBSTANCE	SOURCE	AMOUNT	DESCRIPTION OF USE
<i>E.g., Blood</i>	<i>Normal healthy volunteers</i>	<i>2 ml</i>	<i>Approximate quantity, assays to be done.</i>

B. Please refer to the ISU *Bloodborne Pathogens Manual*, which contains the requirements of the OSHA Bloodborne Pathogens Standard. Specific sections to be followed for this project are:

Anyone working with human blood components, body fluids or tissues is required to have Bloodborne Pathogen Training annually. Current Bloodborne Pathogen Training dates must be listed in Section I for all Key Personnel. Please contact Environmental Health and Safety (294-5359) if you need to sign up for training and/or to get a copy of the [Bloodborne Pathogens Manual](#).

APPENDIX D. PRE-INTERVIEW MINI-QUESTIONNAIRE.

Pre-Interview mini-questionnaire

1. In your opinion, what proportion of farmers in your state believes that climate is changing? _____ 0 - 33% _____ 33 - 66%
_____ 66 – 100%

2. From your experience, how much do the following types of information influences farmers' decisions?

	<u>Low</u>		<u>Medium</u>		<u>High</u>
a. Past Climate Data	1	2	3	4	5
b. Weather Forecasts 3 Days	1	2	3	4	5
c. Weather Forecasts 7 Days	1	2	3	4	5
d. Climate Forecasts 1 – 3 Months	1	2	3	4	5
e. ENSO-based Forecasts	1	2	3	4	5
f. Inter-annual Variability 2 – 10 Years.....	1	2	3	4	5
g. Climate Change 30 – 50 Years.....	1	2	3	4	5

3. Based on your interaction with farmers in your state, please provide your opinions on the following statements. *(Please circle one number on each line.)*

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
a. Farmers believe their farm operation will likely benefit from climate change.....	1	2	3	4	5
b. Farmers believe there's too much uncertainty about the impacts of climate change to justify changing their agricultural practices and strategies	1	2	3	4	5
c. Farmers believe climate change is not a big issue because human ingenuity will enable them to adapt to changes.....	1	2	3	4	5
d. Farmers believe their farm operation will likely be harmed by climate change.....	1	2	3	4	5
e. Farmers are willing to use seasonal climate forecasts to help them make decisions about agriculture practices.....	1	2	3	4	5
f. Farmers are confident in their ability to apply weather forecasts and information to crop related decisions	1	2	3	4	5

5. We are interested in when you think corn producers typically carry out farming practices. Based on your work with farmers, how do you think they would answer the following questions?

Please check all of the months in which you think corn producers in your state typically carry out the following practices related to corn production. If you are unsure when they typically carry out a practice, check “Not Sure.”

Farmers typically...	...in (please check all months that apply)												Not Sure	
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec		
a. apply anhydrous	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. apply liquid fertilizer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. apply dry fertilizer.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. apply manure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. irrigate corn.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. apply fungicides.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g. apply insecticides.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h. apply herbicides.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
i. till fields	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
j. plant cover crops	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. For each decision related to corn production listed below, please circle the one primary month in which you think corn producers typically make that decision. If you are unsure when an activity typically occurs, circle “Not Sure.” (Please circle one number on each line.)

Farmers typically make decisions about the following in...	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Not Sure
a. crop rotations and field assignments	1	2	3	4	5	6	7	8	9	10	11	12	13
b. seed purchases	1	2	3	4	5	6	7	8	9	10	11	12	13
c. seeding rate selection.....	1	2	3	4	5	6	7	8	9	10	11	12	13
d. fertilizer purchases.....	1	2	3	4	5	6	7	8	9	10	11	12	13
e. pesticide purchases.....	1	2	3	4	5	6	7	8	9	10	11	12	13
f. propane purchases	1	2	3	4	5	6	7	8	9	10	11	12	13
g. purchasing crop insurance	1	2	3	4	5	6	7	8	9	10	11	12	13

h. whether or not to till in fall	1	2	3	4	5	6	7	8	9	10	11	12	13
i. fuel purchases for irrigation	1	2	3	4	5	6	7	8	9	10	11	12	13
j. use of cover crops	1	2	3	4	5	6	7	8	9	10	11	12	13

7. Please indicate how influential you think the following groups and individuals are to producers when they make decisions about agricultural practices and strategies. *(Please circle one number on each line.)*

	No contact/ They don't talk to	They talk to, and they have...			
		No Influence	Slight Influence	Moderate Influence	Strong Influence
a. Family	0	1	2	3	4
b. Other farmers	0	1	2	3	4
c. Non-farming friends or neighbors.....	0	1	2	3	4
d. Landlord/farm management firm.....	0	1	2	3	4
e. Crop/livestock consultant/adviser (independent or with an agribusiness).....	0	1	2	3	4
f. Custom operator	0	1	2	3	4
g. Seed dealer	0	1	2	3	4
h. Farm chemical dealer (e.g., fertilizer, pesticides)	0	1	2	3	4
i. Banker, insurance agent, or lawyer	0	1	2	3	4
j. Farm organizations (e.g., Farm Bureau, Corn Growers, etc.)	0	1	2	3	4
k. NRCS or county Soil and Water Conservation District staff	0	1	2	3	4
l. FSA office staff	0	1	2	3	4
m. State Climatologist	0	1	2	3	4
n. University Extension (e.g., local staff, campus staff and faculty, on-line info.).....	0	1	2	3	4
o. Conservation NGO staff (e.g., Pheasants Forever, etc.).....	0	1	2	3	4
p. State Department of Agriculture..	0	1	2	3	4

8. There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change. (*Please circle one number.*)
- a. Climate change is occurring, and it is caused mostly by natural changes in the environment..... 1
 - b. Climate change is occurring, and it is caused mostly by human activities 2
 - c. Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities 3
 - d. Climate change is not occurring 4
 - e. There is not sufficient evidence to know with certainty whether climate change is occurring or not 5

APPENDIX E. INTERVIEW PROMPTS.

Face to face interviews with Climatologist in the U.S. Corn-Belt (~40 Minutes)

Interview Prompt

Introduction

Prior to asking the interview questions below, give the interviewee the mini-questionnaire to complete

- (1) Tell me about your role and responsibilities as a [Climatologist] for _____ (state).
- (2) How do you interact with other members of the weather and climate community?

Our projects are particularly interested in the relationship and connections among climatologists and farmers.

- (3) How involved is your office with the agricultural sector? Do you have any personal experience with agriculture? If yes, please elaborate.
- (4) Do you offer any products or information that is specifically tailored to the agricultural community for either long-term agriculture planning or short-term production decisions? If yes, what types of products or information do you offer?
- (5) What products or information might farmers, or others in the agriculture sector, typically request from a climatologist?
How has the relationship changed over your time as state Climatologist, or how have products/requests changed? Or has it?
- (6) What products or information do you think would be helpful to farmers that are not currently available in your state?

Communicating information

- (7) When you talk to the general public about climate and its effect on the environment and people, what terms do you use to convey climate and weather concepts? And why?
[For example “climate change,” “global warming,” or just the word “climate?” (i.e. “long-term weather data” instead of “climate data”, or “climate variability” instead of “climate change”)]
- (8) Does it matter which public you are talking to? Would you use a different set of terms with the agricultural public than with community leaders such as mayors, town councilpersons, departments of public works? Does it matter if it is an urban public versus a rural public?
- (9) How do you feel about what you can and cannot say about climate change in your state?
Do you feel any constraints about making public comments regarding climate change?

Have you ever been told specifically to modify what you say by someone inside or external to your organization?

Agricultural decision making based on climate information

- (10) In what ways do you think climate data, weather/climate forecasts, or other weather/climate information influences farmers' decision making?
- (11) What other kinds of influences interact with climate/weather information that you think affect an agriculture producer's decision making process?
- (12) What factors do you think limit the use of climate data and weather/climate forecasts?

Climatologists & farmers/advisors

- (13) To what extent do you think that those who directly advise farmers in your state believe that climate change is occurring? Specifically, to what extent do you think that extension educators, crop advisors, seed distributors, and/or bankers believe that climate change is occurring?
- (14) In what ways do you think SCs (as a group) can help farmers understand the uncertainty and risks of climate variability?
- (15) In what ways do you think SCs can help farmers adapt to climate variability?

APPENDIX F. QUALITATIVE ANALYSIS CODEBOOK.

Coding Instructions for Climatologist Interviews

Unit of Analysis

Responses to 16 questions from typed transcript of 22 climatologist interviews conducted between March and June 2012 in the North Central Region of the United States (representing 11 states). Interviews conducted by a graduate student at Iowa State University to help understand the communication of scientific climate information for developing resilient and profitable agriculture management plans in the face of increasingly variable weather events.

Procedure

Read transcript question to question. Audio recordings of the transcript may also be important to detect hesitance or emphasis in word choice.

Enter participant information, including demographics and number of references for each question, into provided Excel spreadsheet.

Directions

Count the number of references to a conceptual idea (listed below) in each question. Highlight these references in the transcript. For each question, enter the number of references to the conceptual idea in the spreadsheet.

An important consideration is to note if a concept is negated by the interviewee. For example, stating that “accuracy is not important for communicating climate” would not receive a count for component 1 for addressing the cue word.

Background Information

Interview ID Number

Correlate Interviewee ID number between cover sheet and transcript. Enter under column A

State

Enter State ID under column B.

- 1 = Ohio
- 2 = Illinois
- 3 = Missouri
- 4 = Minnesota

- 5 = Iowa
- 6 = South Dakota
- 7 = Nebraska
- 8 = Wisconsin
- 9 = Michigan
- 10 = Kansas
- 11 = NOAA
- 12 = Indiana

Role

Enter climatologist's job role under column C.

- 1 = State Climatologist
- 2 = Extension Climatologist
- 3 = Assistant State Climatologist
- 4 = Climatologist (Other)

Years in position

Enter approximate years in position under column D. Information gained from transcript or on web. Categorized into:

- 1 = Less than 20 years
- 2 = Greater than 20 years

Approximate Age

Enter approximate age of interviewee under column E. Information gained from cover sheet or on web. Categorized into:

- 1 = Less than 30 years
- 2 = 30 – 50 years
- 3 = Greater than 50 years

Gender

Enter gender of interviewee under column F. Information gained from cover sheet.

- 1 = Male
- 2 = Female

Farm Background

Does the interviewee have a farm background? Enter under column G. Information gained from transcript.

0 = No
1 = Yes

Interview Format

Enter format of interview under column H. Information gained from cover sheet.

1 = In-person
2 = Telephone

Survey

Did interviewee respond to optional survey? Enter under column I. Information gained from cover sheet.

0 = No
1 = Yes

Public Comments

Does interviewee feel any constraints making public comment about climate change? Information gained from question # 9.

0 = No
1 = Yes
2 = uncertain

Personal Experience

Does interviewee have any person experience with agriculture? Information gained from question #3.

0 = No
1 = Yes

Past Data

Does interviewee think that past weather data is important for farmers? Information gained from comments in transcripts.

0 = No
1 = Yes

Transcript Analysis

Coder will be analyzing the transcript text to detect occurrences of mentions to communication techniques outline by Fischhoff (1995) and adapted by Wilke. Each of the following conceptual ideas may represent a stage of communication outlined by Fischhoff.

As you read the transcript question by question, count the number of occurrences of mentions to each concept for each question.

At the end of all questions, totals will be tallied. In this method, references to a certain communication technique may be compared across interviews, as well as across questions.

It is important to note that follow-up questions shall be combined with the original prompted question.

Illustrative quotations and important statements should be highlighted and marked.

Accurate and objective

1. **Accuracy and objectivity** refers to the communication technique of providing accurate and objective information. This component may be operationalized in any reference to accuracy and objectivity. Cue words and phrases include peer reviewed, scientific, rigorously tested, empirical, credible, accurate, objective, accuracy, and objectivity.

Agricultural management relevance

2. **Management relevance** refers to framing of climate information for agricultural management planning. This could be anything that might help a farmer manage land. Cues include planting, tilling, pollination, harvest, grain drying, nutrient management, conservation management, pest management, insects, disease, inputs, outputs, yields, nitrogen, phosphorous, manure, anhydrous ammonia, pesticides, herbicides, insecticides, fungicides, lime, fertilizer, tillage, no till, conservation till, succeed, achieve, accomplish, execute, carry-out, conduct, carry-on, operate, guide, and direct.

Agricultural economics and marketing

3. **Marketing relevance** refers to framing of climate information for marketing of agricultural commodities. This could be anything that might help a farmer market a crop. Cues may include global weather (specifically Brazil, China, and other main grain growing regions of the world), commodities, economics, monetary value (numerical values), price, price per bushel, bushels, charge, cost, rate, sell, profit (profits, profitable, profitability), market (markets, marketed, marketing, marketable), unmarketable, saleable, unsalable, purchase, buying, trade (traded, trading, trades), supply, demand, purchase, futures, forward-contract, speculate, hedge, auctions, and promote.

Agricultural decision timing relevance

4. **Timing relevance** refers to framing of climate information for assisting with timing

of agriculture decision. This could be anything that might help a farmer time a decision. Cues may include discussion of seasonality of trends, annual variations, seasonal variation, dates, months (Jan., Feb., etc.), morning, afternoon, mid-day, dew, rain, snow, temperature, wind speed, humidity, precipitation, seasonal..

Location relevance

5. **Location relevance** refers to the communication technique of providing information that is locally relevant and site-specific. This component may be operationalized in any reference to location of information gathering or dissemination. Cue words and phrases may include weather station proximity, field-specific, site-specific, County/State/National, climate zone, weather observatory, airport, campus, experiment station, rural/urban, population, local, watershed, city, state, Midwest, near river, approximate to stream, creek, lake, city, town, municipality.

Format

6. **Format** refers to the communication techniques' various methodologies for directing information and framing messages. This component may be operationalized in any reference to the format or display or information presentation. Cue words and phrases may include media, website, smart phone, social media, news, weathercaster, print, television, TV, radio, personal communication, blog, fact-sheets, books, magazines, newspaper, presentation, PowerPoint, slides, pictures, graphs, talk, discuss, read, write, listen, apps, online, Internet, phone.

Engagement (Trusted source)

7. **Engagement** refers to the communication technique of directing information to be disseminated by a local and trusted source. This component may be operationalized in any reference to the source of climate information and format of dissemination. Cue words and phrases may include experts/peers, job titles/social roles, recognition of expertise/knowledge, trust, extension, citizen observers, citizen science, community collaboration, CoCoRaHS, and faith-based.

Conservation management relevance

8. **Conservation relevance** refers to the communication of information about agricultural management practices for reasons other than production. This component may be operationalized in any reference to conservation management techniques. Cue words and phrases may include cover crops, no-till, minimal till, drainage management, conservation, wildlife, water quality, soil quality, ecosystem, ecosystem services.