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THE DIFFUSION OF NEW MEDIA AND RADAR TECHNOLOGY AND THE ROLE OF BROADCASTERS' PRIOR EXPERIENCE AND PUBLIC PERCEPTIONS IN TELEVISION SEVERE WEATHER COVERAGE

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RACHEL E. BUTTERWORTH
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THE DIFFUSION OF NEW MEDIA AND RADAR TECHNOLOGY AND THE ROLE OF BROADCASTERS' PRIOR EXPERIENCE AND PUBLIC PERCEPTIONS IN TELEVISION SEVERE WEATHER COVERAGE

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BY

[redacted]

Dr. Kevin Kloesel, Chair

[redacted]

Dr. Shari Veil

[redacted]

Dr. Eve Gruntfest

[redacted]

Dr. Dan O'Hair

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Table of Contents

List of Tables

List of Figures

Abstract

Broadcast meteorologists are the top source of information for people during severe weather in the U.S. (Hayes, 2009; Legates & Biddle, 1999; Schmidlin & King, 1997; Sherman-Morris, 2009) and play an important role in disseminating life-saving information to the public. However, few studies have looked at their role as a communicator, the challenges they face when covering severe weather, and gathered their input on research topics pertaining to public understanding that are salient to them. Twenty broadcast meteorologists from various sized TV markets and positions in the central U.S. were interviewed in the summer and fall of 2009. Semi-structured interviews were used to gather insight on three topics: 1) How do broadcasters use experience to cover severe weather? 2) How are innovations such as new media, dual-polarimetric (dual-pol) radar and 3DVar (a small-scale wind analysis tool) being diffused in the broadcast industry? 3) How do broadcasters understand public perceptions and what questions would they like researchers to address related to public understanding, interpretation, and action during severe weather? Results were analyzed thematically and according to the theories of sensemaking (Weick, 1995) and diffusion of innovation (Rogers, 1976).

Various conclusions are derived from the results. First, broadcasters use insight gained from experience to make decisions during many severe events. However, their coverage is based on aspects of sensemaking when an unusual event occurs. Second, the use of new media in severe weather coverage varied

from station to station, although the National Weather Service (NWS) Chat, internet simulcasting, and radio simulcasting were the most popular new tools. Some of the participants looked forward to the benefits of dual-pol radar, but were waiting for the NWS to lead a training initiative. Some broadcasters also found 3DVar to be useful but cautioned that it would have to be suitable for TV in order for them to show it on-air. Diffusion of innovation applied to the broadcasters' adoption of these tools. Relative advantage was the most common innovation attribute for an innovation that was farther along in the diffusion process (i.e. new media) whereas opinion leaders played a very important role for an innovation in the beginning stages (i.e., dual-pol & 3DVar). The data reveal a unique double-diffusion process. Not only were broadcasters concerned that the innovations were useful to themselves (i.e. user), but they were also concerned that the innovations were useful to viewers (i.e. customer). Resource limitations and lack of awareness of the benefits for the user, and complexity for the customer, were the most common barriers to adoption. Finally, most of the participants said there is a need to research topics related to public understanding and interpretation of weather information. Broadcasters would like specific feedback from viewers pertaining to topics ranging from the terminology they use, to radar and graphics, to overall coverage preferences. They would also like answers to the following questions: *who* is taking action, *when* do people take action, and *why* do they take action. Broadcasters are relying on the research community to address these questions.

Chapter 1: Introduction

Severe weather is a relatively common phenomenon in much of the United States as well as a societal threat. Weather[1] killed an average of 546 people each year between 2000 and 2009 (NWS, 2010) and it impacts decision-making in economic sectors such as the airline industry, outdoor recreation businesses, food packaging and distribution companies, and others. Droughts, hurricanes, tornadoes, floods, and wildfires cause an estimated $11 billion in damages each year in the U.S. according to the National Oceanic and Atmospheric Administration (NOAA, 2010). Meteorologists have tried to mitigate the destruction caused by severe weather by predicting storms and tornadoes since the late 1940's. Their understanding of the atmosphere has improved and computer models continue to advance. For example, tornado warning lead times increased from five minutes in 1986 to 13 minutes in 2004 (Erickson & Brooks, 2006), and a 5-day temperature forecast in 2010 is just as accurate as a 2-day temperature forecast in 1970 (D. Young, personal communication, July 19, 2010).

Despite improvements in the physical science understanding of weather in the last 60 years, little attention has been given to the socio-economic factors (e.g., income, race, gender, experience) that may inhibit safety. Broadcast meteorologists communicate to a variety of audiences during severe weather, and studies have shown that they are the top source of severe weather

[1] Direct fatalities from floods, lightning, tornadoes, hurricanes, heat, cold, winter storms, and wind. Does not include indirect weather fatalities such as car accidents.

information for people in the U.S. (e.g., Hayes, 2009; Legates & Biddle, 1999; Schmidlin & King, 1997; Sherman-Morris, 2009). However, aside from studies regarding narrow topics such as forecast uncertainty (Demuth, Morrow, & Lazo, 2009) and radar (LaDue, Newman & Heinselman, in press), broadcast meteorologists have been an untapped resource for understanding the societal impacts of severe weather.

A recent report by the National Research Council (NRC) states "The most innovative and risky research [in integrating social science and weather] will combine cutting-edge social science with cutting-edge meteorology, advancing science and knowledge in both fields" (NRC, 2010, p. 32). This study combines relevant meteorological issues with social science methods and theory to advance knowledge in both fields. Specifically, this study looks at how broadcasters' experience covering severe weather influences the type and content of their coverage. It also focuses on the role of technology in severe weather coverage including the use of new media and the potential uses of dual-polarimetric radar ("dual-pol" from here on out for brevity) and a small-scale wind analysis tool called 3DVar.

Finally, the focus turns to the broadcasters' knowledge of the public pertaining to weather information and the questions they would like answered. Scientists understand that there is not a single "public" (Drobot, Benight, & Gruntfest, 2007) and that people react differently to weather information based on their economic status, location (work, school, home), prior experience, and other factors. Thus, research related to the public should focus on a particular sector. However, because this is a broad study that lays the groundwork for understanding broadcast meteorologists and their role in disseminating severe weather information, "public" is used and includes anyone who is not a broadcast meteorologist or National Weather Service (NWS) or private sector forecaster. The realization that "public" is not a singular term also creates a challenge for broadcast meteorologists and will be discussed in the following pages.

This study aims to inform those involved in the severe weather warning partnership (e.g., the NWS, broadcast meteorologists, and emergency managers) and may help them better understand the socio-economic factors that influence TV severe weather coverage. In addition to practical implications, this study also has theoretical implications as it adds to the theories of sensemaking (Weick, 1995) and diffusion of innovation (Rogers, 1976). Chapter 2 provides an overview of the sensemaking and diffusion of innovation literature. Background information on the changing technological nature of broadcast meteorology is included in Chapter 3. The methodology of the study is described in Chapter 4, and results and discussions regarding experience, new media and radar technology, and broadcasters' perceptions of the public can be found in Chapters 5 through 7. The conclusions are reported in Chapter 8. Implications for industry and academia and a reflection on the interdisciplinary nature of the project are located in Appendices A and B, respectively.

Chapter 2: Literature Reviews

2.1 Sensemaking

Some broadcast meteorologists have been in the business for over three decades and can easily recognize storm patterns and radar signatures. However, despite their ability to forecast somewhat accurately, the dynamic nature of the atmosphere always provides an element of uncertainty. While experience has been shown to positively influence unprogrammed decision-making (Perkins & Rao, 1990) such as that during severe weather, broadcasters often face situations that are unrecognizable and must use sensemaking to make decisions and communicate with their audience. Choo (1996) notes that people are limited by their knowledge and skills to be able to take appropriate action in every situation they encounter. Thus, when experience is insufficient to make sense of a situation, another cognitive process must take a dominant role.

Sensemaking describes how people make sense of unfamiliar situations. Weick, Sutcliffe, and Obstfeld (2005) say, "Sensemaking involves turning circumstances into a situation that is comprehended explicitly in words and that serves as a springboard into action" (p. 409). It can also be thought of as "a way station on the road to a consensually constructed, coordinated system of action" (Taylor & Van Every, 2000, p. 275) and "at the crossroads between action and interpretation" (Weick et. al., 2005, p. 409). Sensemaking is used when a person does not have enough prior experience to make sense of a situation and make a decision. Although some weather patterns and storm systems are quite predictable and some severe weather is predicted a week ahead of time, broadcasters never know the exact impact(s) of a storm until it happens.

Much of the sensemaking literature focuses on how organizations, as one entity, make sense of a situation. Choo (1996) states that an organization often has to make sense of "changes and developments in its external environment" (p. 330), the premise behind the sensemaking framework. While broadcast meteorologists are part of an organization (a TV station), they often operate on an individual or small team basis during severe weather. Most severe weather events only require a small production crew (one to two people) along with other broadcast meteorologists. The entire news department does not usually get involved unless the incident evolves into a significant, newsworthy event. Yet, Choo's definition can be taken quite literally in the context of weather since the "environment," which is usually perceived as an organizational environment, can be thought of as the atmospheric environment. The nature of severe weather and uncertainty of atmospheric conditions allow this theoretical framework to apply to this context.

Weick (1995) describes sensemaking as being comprised of seven aspects including identity construction, retrospect, enactment of sensible environments, social, ongoing, focused on and by extracted cues, and driven by plausibility rather than accuracy. In a more recent paper however, Weick et al. (2005) break up sensemaking into descriptive, conceptual, and prospective categories, and identify subtopics under each of those categories. This study focuses on the descriptive properties of sensemaking, some of which overlap with the aspects discussed in Weick (1995). These properties include organizing flux, noticing and bracketing, labeling, retrospect, presumption, social and systematic, action, and organizing through communication. Each property and its applicability to weather are discussed below.

2.1.1 Organizing Flux

Weick et al. (2005) note that sensemaking begins with a chaotic situation and the first step to making sense of it is organizing the flux. In the midst of confusion and chaos, a person must consider the elements of flux as the first step to creating meaning. Broadcasters may encounter situations in which they have to process "a million things" during a severe weather event. This overwhelming feeling may occur during an event in which they have not yet experienced or when the atmosphere does not behave in a predictable manner. A broadcaster may search for organization throughout moments of uncertainty and flux during their coverage of the event.

2.1.2 Noticing and Bracketing

Another property of sensemaking is noticing and bracketing. People notice departures from normal and will bracket those differences. Weick et al. (2005) say experience and mental models guide a person's ability to notice and bracket differences. Bracketing involves classifying a process, object, or event. If a broadcaster realizes they are encountering a situation in which they have never experienced, it will help them begin to make sense of the situation. Magala (1997) also gives a description of this aspect of sensemaking in Weick et al. (2005). They say noticing and bracketing is like "inventing a new meaning (interpretation) for something that has already occurred during the organizing process, *but does not yet have a name* (italics in original), has never been recognized as a separate autonomous process, object, event" (p. 324). Broadcasters will often compare severe weather events to those they have already experienced and decide whether an event is similar or different to other events they have covered. Their action(s) may be based on this component of sensemaking.

2.1.3 Labeling

Another component of sensemaking is "labeling and categorizing to stabilize the streaming of experience" (Weick et al. 2005, p. 411). Labeling entails associating the new event, object, etc...with pre-existing notions or ideas so that one can move forward in the sensemaking process. When a person describes an event in a particular way (e.g., out of the ordinary, dangerous, unique) it is considered labeling. Labeling an event helps people manage chaos, and coordinate and distribute appropriate action among the players involved in the situation (Weick et al. 2005). If a broadcaster can identity needs to be fulfilled during coverage (e.g., radar interpretation, delivering on-air messages, monitoring NWSChat) it allows them to note that certain tasks need to be completed. A mutual understanding of needs will help broadcasters begin to make sense of the situation.

2.1.4 Retrospect

Retrospect involves using past experience to make sense of current ambiguity and is derived from meaningful lived experience (Schutz, 1967). Weick

(1995) and Choo (1996) say that people can begin to create meaning by using retrospect, and that it involves a relatively short time period between act and reflection. For example, if a broadcaster realizes that an event is similar to one they have covered in the past they may base their coverage techniques on their knowledge gained from previous events. As Klein, Moon, and Hoffman (2006) note, the retrospective function of sensemaking "clarifies the past but doesn't make it transparent (that is, completely understood)" (p. 72).

2.1.5 Presumption

According to Weick et al. (2005), presumption connects the abstract to the concrete in order to make sense of something. It can also be thought of as testing a "hunch" (p. 412). It is difficult to make sense of a situation and decide whether action should be taken when one does not have a concrete idea of what is happening. A broadcaster can make presumptions about the potential impacts of a storm if he/she recognizes how it might evolve. These impacts may be based on storm type, time of day (nighttime storms often have higher impacts because people are sleeping), or the population that lies in the path of the storm.

2.1.6 Social and Systematic

As Weick (1995) points out, sensemaking is a social process that is influenced by a variety of factors. Oftentimes one must consider the needs of others when making sense of a situation, especially in an organizational setting. In fact, Weick (1995) points out that "sensemaking is never solitary because what a person does internally is contingent on others" (p. 40). The type and amount of coverage a broadcaster gives an event may be based on management rules, population density, time of day, and other factors. Broadcasters must take a variety of social factors into consideration when determining how to make sense of a situation and employ certain actions.

2.1.7 Action

The goal of sensemaking is determining whether to take action and if so, what action(s) should be taken. Weick et al. (2005) describe this aspect of sensemaking as a person saying, "What's going on here," and, "What do I do next" (p. 412)? In this action step of sensemaking, a person tries to get a handle on the situation and determine the next steps. Choo (1996) also notes that the action step in sensemaking plays a different role than the action step in a traditional decision-making model. He says:

> Whereas the decision-making model assumes that organizational behavior is directed at the attainment of goals and is primarily concerned with uncertainty and choice in the performance of organizational tasks, the sensemaking view suggests that organizational actors have first to make sense of what is happening in their organizational environments in order to develop a shared interpretation that can serve as a context for organizational action (p. 332).

The shared interpretation may be between multiple broadcasters at the TV station, a manager and a broadcaster, and/or an NWS forecaster and broadcaster. It is plausible that broadcasters use sensemaking rather than decision-making during severe weather because they have to interpret data (physical and social) and then take action, within a matter of seconds.

2.1.8 Organizing through Communication

Communication is an ongoing process in sensemaking; a situation is discussed and subsequent actions are taken based on what is communicated and how it is communicated (Weick et al. 2005). The action of sensemaking involves some form of communication whether verbal or non-verbal. Of course, broadcasters communicate severe weather information in a variety of ways to colleagues, managers, and viewers.

2.2 Diffusion of Innovation

The second theoretical perspective used in this study is diffusion of innovation. It applies to the potential adoption of new media and radar technology in the broadcast meteorology industry. Diffusion of innovation describes how technology or information is adopted by users. Rogers (1976) says innovation is communicated through channels over time among members of a social system through the process of diffusion. Social change occurs when new ideas are developed, diffused, and adopted or rejected (Rogers, 2003). Diffusion research dates back to the early 1940s when Ryan and Gross (1943) studied how hybrid seed was adopted by Iowa farmers. They found that adoption usually occurs in an s-shaped curve, which means that some users are quick to adopt the new technology while others lag behind. However, the later adopters tend to accept the innovation in a shorter time-period than the early adopters because they have the opportunity to see the early adopters use it successfully (Ryan & Gross, 1943). When opinion leaders, or influential individuals or organizations in the field, adopt new information and technology they relay the information through their social networks. This coincides with Granovetter's (1973) theory of weak ties, which states that an innovation reaches a larger audience if passed through weaker ties rather than strong ones. For example, a weak tie may be a colleague or acquaintance, and a strong tie could be a close friend or family member. Since strong ties are usually linked to one another and weak ties are not, diffusion through strong ties will not reach as many people as it will through weak ones.

Many innovation studies are based in a marketing tradition where adopting an innovation involves the sale of a new product. For example, in their research on innovation in a scanning firm, Paulson-Gjerde, Slotnick, and Sobel (2002) found that innovation decisions are impacted by the speed of technology and that quick-paced technological movements increase the likelihood that adoption will occur. However, if innovative changes occur at a rapid pace, it can often be difficult to cope with those changes. Benamati and Lederer (1998) discovered that certain coping strategies such as education and training, new procedures showing modifications, vendor support, consultant support, and endurance can be used to manage the changes. Not only is the adoption rate related to the properties of the innovation itself however, but also to those who are adopting the technology. Rogers (2003) notes that diffusion usually occurs more rapidly when it is adopted by an individual rather than an entire organization.

There are multiple factors that affect the rate of adoption, including the type of innovation decision, the nature of the communication channel diffusing the innovation, the nature of the social system through which the innovation is being diffused, and the extent to which leaders promote the innovation. Yet, Rogers (2003) says that most of the time diffusion can be explained by five attributes: relative advantage, compatibility, complexity, trialability, and observability. While these attributes may be objectively measured, Rogers (2003) notes that the perceptions of the attributes of the innovation may affect the adoption rate more than the objectively classified attributes.

2.2.1 Innovation Attributes

One of the strongest predictors of adoption is relative advantage, or "the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers, 2003, p. 229). Sometimes described in terms of economic profitability and social prestige, Fliegel and Kivlin (1966) found that adoption is more likely with more rewarding, less risky, and less uncertain innovations. One example of relative advantage related to broadcast meteorology would be a station implementing a new graphics system that updated more quickly than the previous system (e.g., a few seconds rather than a few minutes). If the benefits heavily outweigh the costs, adoption is very likely. The chance of adoption also increases when advantages of a new product or system are demonstrated prior to replacing a current system (Veil, 2010). However, one must keep in mind that if an idea fails, the adopter is less likely to adopt future ideas. Thus, emphasis on relative advantage is imperative to the success of an innovation (Rogers, 2003).

A second attribute of innovation is compatibility, and studies have shown that compatibility is positively correlated with adoption (Cooper & Zmud, 1990; Ettlie & Vellenga, 1979). The new tool must be similar enough to the current tool that potential users have a sufficient understanding as to how it should be used. The innovation must also coincide with existing values, past experiences, and needs of potential adopters (Rogers, 2003). A potential innovator should consider past experiences when developing new technology because an individual's experience will shape their perception of the innovation. Stoller (1994) says that compatibility can be equated to acceptance, an attribute found to influence the adoption of English as a second language (ESL) programs. Furthermore, if the basis for understanding of an innovation lies outside of a cultural framework, potential adopters will not understand the need for the innovation or how it should function in society. Rogers (2003) also says that adoption will occur sooner if perceived needs are met, which again identifies the importance of perception rather than simply the objective characteristics.

Complexity is the third innovation attribute and is "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003, p. 257). This attribute may not be as important as the first two, but could be a barrier to innovation if it is perceived as too complicated. Rogers (2003) uses the example of home computers to illustrate this attribute. He says the initial adopters for home computers were technically savvy individuals such as hobbyists, scientists, and engineers. As the innovation spread throughout society, less technically inclined individuals began adopting the technology, however not without frustration. Time was needed for the home computer to be diffused throughout many sectors of society due to the complex nature of the product.

Trialability allows a potential adopter to test a new product prior to committing to its use. This attribute dispels uncertainty and increases the likelihood of adoption. So, this attribute means that the likelihood a new weather graphics system is purchased by a TV station would increase if the broadcast meteorologist has a chance to preview the system first. Gross (1942) and Ryan (1948) found trialability to be more important for early adopters than for later ones. Perhaps this is because essentially, the late adopters try the innovation vicariously through the pioneers, and by the time they decide to adopt they already know whether the innovation is worth their investment. Also, early and late adopters have different effects on their communities. Early adopters have the ability to reduce uncertainty and gain social power, whereas later adopters do not gain as much power (Burkhardt & Brass, 1990).

The final innovation attribute is observability. It is a measure of the amount of visibility the results of an innovation have on others. Increased observability increases the likelihood of adoption (Rogers, 2003) because potential adopters are more likely to use the innovation when they see it working well among peers. In the case of broadcasters, this might mean, for example, that they see innovations being used by colleagues, at other TV stations, or during conferences.

2.2.2 Opinion Leaders

In addition to the innovation attributes, opinion leaders are also known to have a strong influence on the diffusion process. Opinion leaders can be from relationships based in formal or informal networks. Rogers (2003) says that opinion leaders "serve as a model for the innovation behavior of their followers" (p. 27), so they are often highly regarded individuals. Valente and Davis (1999) cite many studies that support the basic premise that new ideas and practices are often spread through contacts based on interpersonal communication. In fact, they tried to determine the impact of interpersonal conversations in government agencies or other organizations on the diffusion of information in those environments in the 1950s and early 1960s (Valente & Davis, 1999). Scholars continue to find that these contacts are an important component to diffusion of innovation (Valente & Rogers, 1995). In essence, opinion leaders are individuals or organizations who strongly affect on the rate of adoption. Prominent broadcast meteorologists, weather vendors, or the NWS could be possible opinion leaders for broadcasters.

2.2.3 Diffusion Weaknesses

While diffusion theory has been tested in many contexts, scholars agree there are some weaknesses. One weakness noted by Rogers (2003) is that many diffusion studies are completed after an innovation has already been adopted (pro-innovation bias), so there is limited knowledge as to why some innovations are *not* adopted. Rogers (1976) and Burkhardt and Brass (1990) also point out that many innovation studies are biased because they only focus on a single point in time rather than being longitudinal, and are designed to assume that the innovation is always good. In other words, researchers often forget to consider that the group, audience, or community may be better off *without* the innovation. Also, while some studies have identified adoption barriers such as awareness, persuasion, influence (Veil, 2010), and knowledge (Fichman & Kemerer, 1999) which may slow down or stop the diffusion process, they have not been documented as well as the attributes. This may also be a result of pro-innovation bias. Despite these weaknesses however, diffusion theory can shed light on the likelihood that an innovation will be adopted. Since new media has infiltrated into broadcast meteorology and radar technology continues to advance, diffusion theory provides insight into the adoption of these tools in the industry. Additionally, because broadcasters have yet to commit to adoption of new media and upcoming radar technologies that have been researched for years but have yet to be introduced operationally, this study adds to the short list of pre-adoption literature.

Chapter 3: Background

Understanding how broadcasters use new media and may use new radar technology is a major component of this paper. The following pages describe the changing role of technology in American society and provide background information on new tools available to the broadcast meteorology industry.

New forms of media are shaping the way society operates. Accessing information via the Internet has become increasingly popular in America, and wireless communications are growing at a rapid pace. An April 2009 survey found that 63% of Americans have a broadband internet connection at home (Horrigan, 2009a) and 56% have accessed the Internet through various wireless methods such as a laptop, cell phone, or game console (Horrigan, 2009b). New media such as blogs and social media allow for instant communication among people around the world. In fact, the percentage of adults on social networking sites rose from 8% in 2005 to 35% in 2008 (Lenhart, 2009). The rate at which information is exchanged continues to increase and is changing the way society functions. One industry that has been affected by this change is the news industry. As more and more people turn to the Internet for news information (Project, 2010), television stations have been forced to change their business models. For example, video streaming has become popular among local television stations (Murray, 2001). Despite these technological changes (e.g., internet streaming and blogs), TV stations have yet to determine how to implement them in the most effective manner (Chan-Olmstead & Ha, 2003; Lin, 2003).

Technology also plays a large role in the broadcast meteorology industry. Broadcast meteorologists use radar products and graphic displays to communicate weather messages to their audiences, and new tools and media are changing the way they gather and disseminate information. However, while broadcast meteorologists have been credited for saving lives during life-threatening weather events (e.g., Barnhardt, 2003; Hoffman, 2009) and weathercasts are the most important part of a newscast (Smith, 2000), there is limited research on the role the broadcaster plays in what some would call their ad-hoc severe weather partnership with the NWS and emergency managers.

One of the main tools broadcast meteorologists use when covering severe weather is radar. Radar technology allows them to track dangerous storms. While the implementation of the WSR-88D (Weather Surveillance Radar – 1988 Doppler) radars by the NWS in the 1990s provided many meteorological benefits, there are still some limitations with the system. LaDue, Newman, and Heinselman (in press) interviewed broadcasters and NWS forecasters about the strengths and weaknesses of the WSR-88D's. They found the meteorologists to have four radar needs: clean data, better spatial and temporal resolution, more low-altitude information, and more detailed precipitation information. Two of the four needs, increased resolution and low-altitude information, may be fulfilled by implementing a network of short-range, X-band (3cm) radars such as those being developed by the National Science Foundation (NSF) Engineering Research Center (ERC) for the Collaborative Adaptive Sensing of the Atmosphere (CASA) (McLaughlin et al., 2009). CASA will be implementing new radar technology and other products within a few years, and one potential use would be in TV severe weather coverage. Insight on new media in the broadcast industry, dual-pol radar, and a small-scale wind analysis tool developed by CASA called 3DVar, is discussed below.

3.1 New Media

As the news industry changes, the way broadcast meteorologists gather and disseminate weather information continues to change as well. Broadcast meteorologists are beginning to embrace new forms of media such as NWSChat (an instant messaging tool), internet and radio streaming, blogs, and social media. For example, during a tornadic thunderstorm event in February 2009, an Oklahoma City news station updated weather information via their internet blog (KOCO, 2009). In addition, the NWSChat has become a popular addition to the broadcaster's work routine. A grassroots effort developed by a university research scientist, a local TV meteorologist, and NWS forecasters (Herzmann et al., 2006), the Chat was not officially adopted by the NWS until December 2008

(D. Jones, personal communication, December 12, 2009). It functions as an online chat room and facilitates communication among NWS forecasters, broadcast media, emergency managers, and first responders during severe and hazardous weather events.

While evidence of new media in the broadcast meteorology industry continues to surface, little to no research has documented how the industry is being affected by the new tools. Because broadcast meteorologists play a vital role in communicating severe and hazardous weather information and new media may be affecting the content and quality of their message, one must understand how they are utilizing these tools. Understanding the role these new tools are playing could benefit the others in the severe weather warning partnership and facilitate efficient and effective communication. One question this study seeks to answer is: How have new media such as internet and radio simulcasting, NWSChat, blogs, and social media influenced the ways broadcast meteorologists in the central United States gather and disseminate severe weather information?

3.2 Dual-Polarimetric Radar

Many broadcasters use radar data from the NWS which currently has 165 WSR-88D radars scattered across the country (Doviak et al., 2000). While these radars help meteorologists observe the atmosphere, they only send electromagnetic waves in a single, horizontally polarized direction. As a result, various limitations are associated with them such as inaccurate precipitation estimates, beam blockage, and overshooting. Fortunately, some of the limitations will be immensely improved when the WSR-88D's are upgraded to have dual-pol capabilities beginning in the fall of 2010 (Warning Decision Training Branch, 2010). Almost all broadcast meteorologists in the United States will have access to dual-pol data in less than three years. Figure 1 shows that unlike conventional weather radars that emit electromagnetic waves in the horizontal plane, dual-pol radars emit in both the horizontal and vertical planes (Straka, Zrnic, & Rhyzkov, 2000). This technology should improve rain and snowfall estimation, hydrometeor classification, and discrimination between precipitation and non-precipitation echoes (Ryzhkov et al., 2005; Zrnic & Ryzhkov, 1999), but it is not known if and how the broadcast industry will embrace this technology, whether for analysis purposes behind the scenes, on-air, or both. This study inquires about how the broadcast meteorology industry will utilize the NWS dual-pol upgrade. The

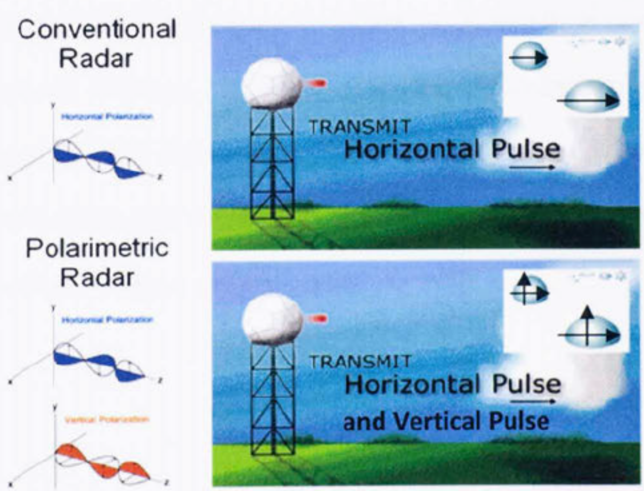


Figure 1: Conventional radar emits a single polarized electromagnetic wave in the horizontal plane, whereas polarimetric radar emits a dual-polarized electromagnetic wave in the horizontal *and* vertical plane. (Image credit: National Severe Storms Lab, http://www.nssl.noaa.gov/dualpol/)

results may be informative to CASA as well because it provides a relevant example of the introduction of new radar technology to the field of meteorology. Both CASA and the NWS can gain insight from the broadcaster's responses to the technology.

3.3 3DVar – Small-Scale Wind Analysis Tool

Another form of radar technology that may be available to broadcasters in the future is a product called 3DVar. It is a small-scale wind analysis tool that is being developed by CASA (Gao et al. 2009). CASA is developing weather radars that sense closer to the ground and have higher spatial and temporal resolution than the WSR-88D. CASA currently has a dense network of four radars in southwestern Oklahoma (Figure 2). The dense network has allowed for the development of this tool (Figure 3). 3DVar is unique because it shows low-level, mesoscale, Doppler-derived wind vectors and allows meteorologists to see thunderstorm and tornadic winds at much higher resolution than currently possible in operations (Hu et al., 2006). Broadcast meteorologists are a potential user of this product, but it is not known whether and/or how it will benefit them. This study seeks to determine whether broadcasters find 3DVar useful, either behind the scenes as a diagnostic tool, on-air, or both.

Figure 2: Map of the four CASA (Center for Collaborative Adaptive Sensing of the Atmosphere) radars in southwest Oklahoma with 40-km range rings. Also pictured are two WSR-88D radars: Twin Lakes (KTLX) in the upper right and Frederick (KFDR) in the lower left. Range rings denote 40 and 60km, respectively.

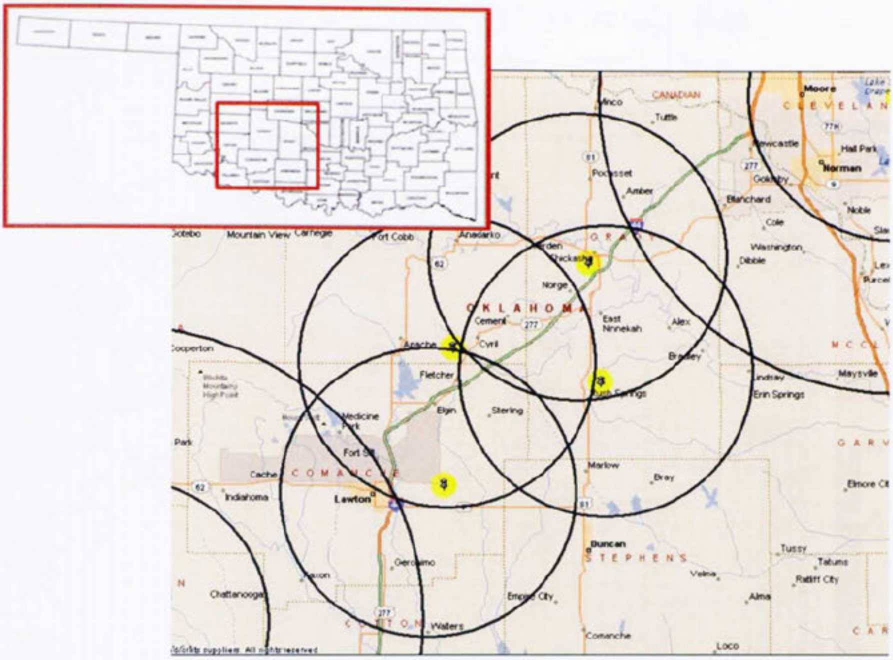
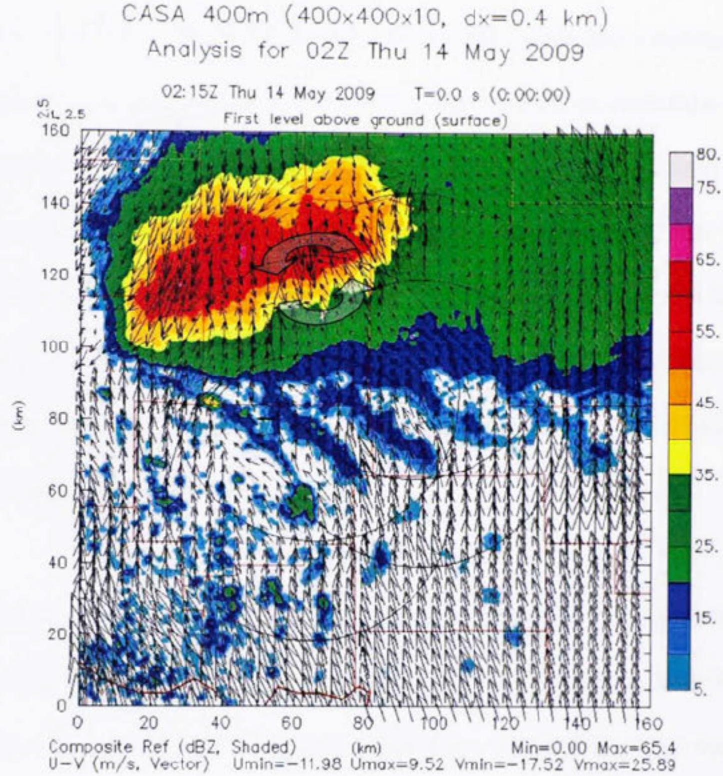


Figure 3: Example 3DVar image from May 14, 2009 with a composite reflectivity overlay showing Doppler-derived wind vectors. The two thick arrows indicate the circulation that formed an EF-2 tornado that struck Gracemont and Anadarko, Oklahoma.



Chapter 4: Methodology

Broadcast meteorologists in the central United States participated in semi-structured interviews regarding some of the factors that influence communication during TV severe weather coverage including prior experience, new forms of media, radar technology, and public perceptions. (For brevity I will use "broadcaster" to represent the broadcast meteorology participants.) One-on-one interviews were used because they allow the participant to elaborate on what they feel is important (Herbst, 1993) and develop their own frameworks (Crigler, Just, & Neuman, 1990). Interviews also enable the researcher to connect with participants, which produces familiarity and trust between them and the researcher (Kirk & Miller, 1986). While the researcher leads the interview in a particular direction, the participant also has the opportunity to verbalize messages most salient to them. Although the researcher tried to obtain responses from a diverse sample (e.g., market size, position at station, years of experience), this study is qualitative in nature and is not generalizable to the entire population of broadcast meteorologists in the United States. Nevertheless, this study provides a stepping stone to understand the role of the broadcast meteorologist during hazardous weather events.

4.1 Interview Protocol

The interview protocol was based on insight provided by Seidman (1998) and Kvale and Brinkmann (2009) and developed based on the needs of the field of meteorology as seen through literature searches, researcher prior experience, and to inform CASA. A limited number of studies focus on broadcast meteorologists so a macro approach seemed appropriate to obtain an understanding of some factors that influence the flow of communication during severe weather events. In this study, severe weather is defined as a potentially hazardous short-fuse weather event such as damaging winds, hail, or tornadoes. Of course, longer-fuse events such as flooding, drought, extreme heat, and winter weather can be dangerous and important as well, but are outside the scope.

The protocol was evaluated by several researchers in the fields of communication, meteorology and geography and aimed to answer five research questions, interpretive and descriptive. The protocol contained demographic questions, and broadcasters were asked about how they use their experience to cover severe weather and how they decide on the level of coverage to give an event. Another section of the protocol was comprised of questions about the broadcasters' use of new media, potential use of dual-pol and 3DVar data, and the positives and negatives of each innovation. (The questions pertaining to 3DVar were included in the study after about half of the interviews had taken place. While some broadcasters were asked about the tool during the interview, some responses were also solicited via email. Not all broadcasters responded to the email despite several attempts, so frequencies pertaining to this topic are lower than the other topics.) The researcher also solicited broadcasters for social science research topics pertaining to public understanding, interpretation, and action during severe weather. The results are intended to inform future studies. Finally, participants were given a chance to ask their own questions at the end of the interview.

4.2 Participants

Twenty broadcasters in the central U.S. were interviewed for this study (Figure 4). The research focused on broadcasters in the middle of the country because it is a prominent severe weather region. Participants were contacted through email and phone; some participants were contacted twice if they did not respond the first time, and a new participant was contacted if no response was

Figure 4: Summary of the number of participants in each state. Broadcasters from twelve markets participated in the study. Specific demographic associations cannot be given to protect the identity of the participants.

Table 1: Participant demographic summary.

# of Participants in Market	3 Large	12 Medium	5 Small
Positions	7 Chiefs	7 Morning	6 Weekend
Gender	16 Males	4 Females	
Experience	1-37 yrs, *M* = 14.5 yrs		
Education	12 Mteor. Degrees	4 Mteor. Certificates	4 Other Degrees

received on the second attempt. Twenty-seven broadcast meteorologists were contacted in total. Personal network sampling was employed to recruit about half of the participants. The rest of the participants were selected based on "sampling logic" (Maxwell, 2005, p. 71) and feasibility to include broadcasters from a variety of demographics including market size, station position, age, gender, and experience (Table 1). The purpose was to garner diverse responses. Participants were located in 12 of the 210 U.S. designated market areas (DMA's)[2]. There is no official definition of a small, medium or large market, so size categories were based on Nielson (2009) rankings, participant insight, and DMA population. In this study, markets with a population greater than one million (1-30) were considered large, between 250,000 and one million (31-115) medium, and less than 250,000 (116-210) small. A couple of the broadcasters also mentioned that the DMA rankings might be different if one only considers severe weather intensity (e.g., Wichita-Huchinson, KS is ranked 69th by Nielson (2009), but one participant noted that it is probably in the top 10 in terms of weather intensity and importance of severe weather coverage). For simplicity, only Nielson (2009) rankings were used.

The broadcasters were equally representative of the various weathercaster positions at television stations (morning/noon, evening/chief, and weekend, in most cases), although one should keep in mind that the broadcast industry is very dynamic and some broadcasters change positions and/or stations every couple of years. So, the market and position classifications only reflect the situation at the time of the interview. Quotations or paraphrases from participants are followed by "(I#)" (the number corresponding to the same participant throughout the text) to provide clarity for the reader. Four female and sixteen male broadcasters participated in the study. Twelve had meteorology or atmospheric science degrees, four had a broadcast meteorology certificate, and

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[2] Although each county in the U.S. has been assigned to a DMA, cable access sometimes enables viewers to receive a local TV signal that is outside of their assigned area.

four had other degrees. While some broadcasters were more or less knowledgeable about particular topics (e.g., dual-pol radar), there appeared to be no correlation between the broadcasters who had a meteorology degree and those with a meteorology certificate or communication degree in general. The only noticeable difference corresponded to a participant with no meteorology degree who said they were not concerned with making forecasts that were different (e.g., better) than the NWS or Storm Prediction Center (SPC). Instead, they cared solely about communicating the message. The forecasting issue did not surface with the rest of the participants. The participants' experience as a broadcast meteorologist ranged from 1 to 37 years (M = 14.5 years). Additional specific demographic associations cannot be provided to protect the identity of the participants. They were informed at the beginning of the study that no information would be revealed which would allow someone to identify them.

4.3 Data Collection

Eighteen interviews were conducted from May to July 2009 during the prime spring severe weather season in hopes that hazardous weather would be fresh on the broadcasters' minds and therefore provoke thoughtful responses. The final two interviews were conducted in October 2009, which saturated the sample. This means that the researcher could predict some of the broadcasters' responses near the end of the interview process. All but one interview was conducted in person (the interview was conducted through email due to circumstances beyond the control of the researcher). Sixteen interviews occurred at the participant's TV station while the rest were in a public venue or the researcher's office. These environments provided a comfortable setting for the participants (Taylor & Bogdan, 1998) in which the researcher hoped would facilitate meaningful responses. Interviews typically started and ended with brief conversations about the study, or recent weather events. The researcher also received a tour of the station in some instances, and participants signed a consent form at the beginning of the interview. Interviews were recorded with a small digital recorder and lasted between 36 and 84 min (M = 52 min).

4.4 Data Analysis

The researcher transcribed interviews verbatim and included the recording time of the interview throughout the transcripts. Transcripts were analyzed to determine major themes and perceptions related to the appropriate theory: aspects of *sensemaking* to describe how broadcasters take action during severe weather when experience provides an insufficient means, and innovation attributes and barriers for the *diffusion* of new media, dual-pol radar, and 3DVar. The portion of the interviews pertaining to the public was coded thematically according to context.

The portion of the interviews containing information related to diffusion of innovation was coded for innovation attributes and adoption barriers. The list of codes is located in Appendix C, and the frequencies for each code are noted in parenthesis throughout the results. Scott's Pi (1955) was used to calculate intercoder reliability for the 18 questions on the interview protocol pertaining to the diffusion topics. Table 2 shows a summary of the analyses. Frey, Botan, and Kreps (2000) suggest that values 0.0-0.2 denote very low reliability, 0.2-0.4 are low reliability, 0.4-0.7 are substantial reliability, and 0.7-1.0 are high reliability. Reliability calculations were based on a sample of four interviews and compared the researcher's codes to that of another coder. Each of the additional coders analyzed one interview a piece. Some of the low accuracy values may be due to the second coders' unfamiliarity with the data (even though they received training on the topics and theory) or small sample size.

Table 2: Results of Scott's Pi (1955) coding reliability calculations.

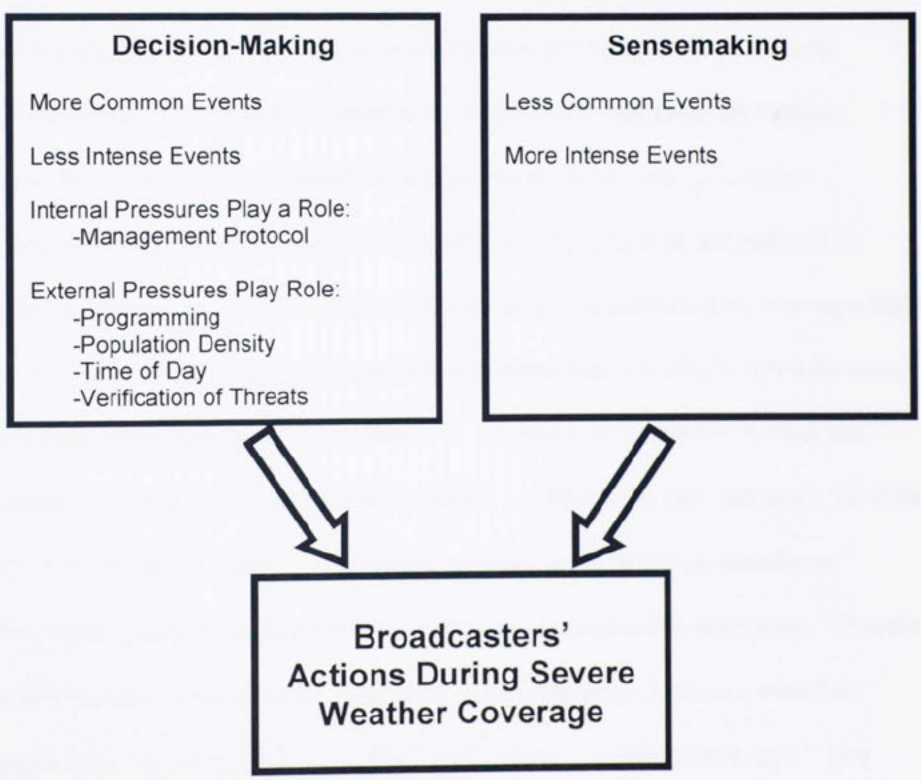
Scott's Pi Results	
Question	π
1. Internet simulcasting	0.38
2. Radio simulcasting	0.57
3. Blog	0.33
4. Storm spotters	0.06
5. NWSChat	0.74
6. Other tools	0.06
7. Greater information available	0.68
8. Better decisions	0.53
9. Changed business	0.45
10. Heard about dual-pol	0.54
11. Aware of NWS upgrade	1
12. Will stay up to date with dual-pol	0.6
13. Will Use dual-pol on TV	0.47
14. Continue to use new radar products on-air	0.38
15. 3DVar would be helpful to broadcaster	0.5
16. 3DVar would be helpful behind the scenes	1
17. 3DVar would be helpful on-air	0.75
18. 3DVar could replace SRV	0.5

Chapter 5: Severe Weather Sensemaking and Decision-Making - Results & Discussion

5.1 Results

Broadcasters' actions during severe weather seem to be based on both decision-making and sensemaking. Decision-making is used more frequently and is influenced by experience covering severe weather. When broadcasters use decision-making they follow a general protocol set by management as well as social and environmental considerations. Sensemaking is used during intense, unfamiliar events. The interaction of these variables is shown in Figure 6. Many

Figure 6: Model depicting broadcasters' use of decision-making and sensemaking during severe weather coverage.



participants indicated that each weather event is a little different so they are not always able to rely on prior experience or protocol to make decisions. The way broadcasters use prior experience to make decisions and the lessons they have learned from covering past events is discussed first, followed by a summary of the general guidelines they are expected to follow during an event. The influences of social variables on severe weather coverage are also described. This chapter concludes by showing how some aspects of sensemaking are used during severe weather coverage.

5.1.1 Using Experiential Knowledge to Cover Severe Weather

Most of the broadcasters said that experience plays a role in how they cover severe weather. Their understanding of the atmosphere and the general protocol and rules set by management improve with time. This is despite recognition that each event is different with regard to behavior and storm impacts. Broadcasters use insight and lessons learned based on prior experience to provide life-saving information to viewers, and sometimes a particularly intense event can cause a broadcaster to adapt their coverage style. In fact, one participant (I20) discussed the impact that a multiple tornado event had on their coverage style. They said, ". . . it was a huge factor in how we determine . . . When do you go wall-to-wall? . . . When do you just stay on, how severe does it have to be? . . . it helped answer a lot of those questions." Another participant (I13) agreed that coverage styles evolve with time. "There's a huge difference from the type . . . and tone and content of severe weather coverage which I do now versus what I was doing . . . nine years ago." The participants noted several different skills they have honed over the years as well as lessons learned. Some participants said that they can differentiate between storm severities more accurately than in the past. They also have a better sense of how storms evolve and are able to categorize and prioritize messages to their viewers.

Differentiate Between Storm Severities. A number of the more experienced broadcasters noted that their experience has taught them to be able to decipher between marginally severe storms and very severe storms. As one participant (I8) noted, knowing which storms are very dangerous and which do not pose much threat ". . . helps you relax . . . and not be overcome by the tension of the moment." In addition to knowing whether they should be concerned about the severe weather situations themselves, experienced broadcasters are also able to determine whether to instill a sense of urgency with the viewers. One morning meteorologist (I19) summed it up this way:

> I think just as a general rule if you haven't been on the air very long . . . you scare people more than you help people understand. . . . there's a time to be, very serious and there's a time to be [less serious and] as you get older and have looked at a lot of different storms on radar, you just know which ones are gonna be bad and which ones aren't, and, how to convey that you know is the biggest deal.

Many broadcasters have strong credentials and have a deep understanding of meteorological processes. However, being able to stand in front of hundreds of thousands of people and make effective split-second decisions is a skill that is honed over time.

Sense Storm Evolution. In addition to deciphering between very dangerous storms and storms that do not pose much of a threat, some participants said their experience has helped them understand storm evolution. One weekend broadcaster (I10) mentioned, "I usually have an idea if the trend is going to be up or down, as far as how severe things are going." Another participant (I7) noted that storm evolution is a good indicator of the threats and potential impacts associated with the storm. He said:

> You get a sense for how a severe thunderstorm might evolve, or how a tornado-producing supercell might have a lifecycle or how it's going to move . . . you can tell if it's kinda getting ready to produce wind, if it's getting ready to become a hail producer or if it *is* a tornado producer, you know that makes us really focus on it."

Understanding the lifecycle of a storm and the potential impacts of each point in time can help broadcasters communicate effectively.

Categorize and Prioritize Messages. Often times a broadcaster has so much weather information available to them that they do not have enough time to disseminate all of it to their viewers. Thus, they learn to prioritize their messages so that they can circulate the most important information to viewers in a short amount of time. One participant (I14) said prioritizing messages means asking themselves, ". . . what's the most important thing that I need to say . . . what are the things that would mean the most to our viewers?" Some participants also mentioned that it is important to remind people what to do in a life-threatening situation. "You know of course, going into the whole drill, to the interior of the house also the basement you know and whatever I'll talk you through it," a morning meteorologist (I5) said. While the style of coverage varied among broadcasters and markets, one participant (I13) said that providing a clear message is important. He noted, "It's always been my style to be very clear, um, and to not hype severe weather. . . . an authoritative and a calm delivery I think goes along way, with viewers."

Show the Big Picture. Another important element of severe weather coverage is remembering that the viewers are not in one location. Although many viewers are concentrated in a relatively small area in some DMAs, one chief (I3) said it is important to remember that viewers are scattered throughout the *entire* DMA:

> . . . you can't just be focused on a tiny little area . . . People watching you right now are saying, "What's happening in *my* area?" . . . So if you stay focused on, the southern part of [the metropolitan] county all the time, then everybody outside of that is upset because they think, "Well maybe something's coming my way?" So I always try to . . . zoom out [and] show the big picture. You [also] have to show the radar in motion because people want to, people wanna see which way it's moving.

The Human Connection. Broadcasters are in a unique position compared to other meteorologists because people associate a face with the information. Unlike other weather sources (e.g., NWS, text messages), people are able to see that another human being is telling them something. One chief was on-air for hours when a tornado devastated a small town and the station received comments from viewers about the value of having a human being disseminating the information. The chief (I9) noted:

> We had, a number of people in [the small town] tell us and other people, *about* us, "it wasn't so much what you said, as it was the tone in your voice." . . . It isn't, *just* showing the radar. It isn't just knowing your stuff as a meteorologist. But it's also being able to utilize all your skills as a communicator. As a human. To, connect with those other humans in the basement. Or, that *need* to be going to the basement . . . the qualities that you bring as a human and as a communicator, are extremely critical in those high impact situations.

Other delivery methods may be suitable for non-severe weather and even marginal severe weather events, but it appears that the human-to-human connection is important for life-threatening situations.

5.1.2 Severe Weather Protocol

Many of the participants said their managers leave coverage decisions up to the meteorologist in charge at the time of the severe weather event. Despite this freedom, however, some said their actions are based on general guidelines set by management (Table 3). One chief (I9) remarked:

> You know [at] most television stations the chief meteorologist does not have final say. If they have final say it means someone else *said* they did which means you really don't. [laughs] In the end, the Vice President and General Manager of the television station, makes the call.

The participants described the protocol they follow. The protocol for severe thunderstorm and tornado watches was similar among the participants. They said they run the crawler (scrolling message at the top or bottom of the TV screen) a few times per hour when a watch is issued but not during commercials. Some participants mentioned having crawl systems that are automatically triggered when a watch is issued.

Severe thunderstorm warnings receive more coverage than watches. They are also more subjective than tornado warnings due to varying degrees of danger. For example, one broadcaster said they will cut into programming for a storm that is producing 90 mph winds, whereas they would probably just run the crawler for 60 mph winds. If a large bow echo or derecho (a very destructive line of storms) has the potential to impact a large population, a broadcaster may go wall-to-wall (stay on the air between several minutes and several hours). Many

Table 3: The general severe weather protocol the participants in this study follow for severe thunderstorm and tornado watches and warnings. Social factors such as TV programming, population density, time of day, and verification are considerations when deciding how to cover an event.

General Severe Weather Protocol	
Watches	The protocol for severe thunderstorm and tornado watches was similar among all participants. • Run the crawler a few times per hour, never over commercials. • Some crawl systems are automated.
Warnings	Warnings receive more coverage than watches.
Severe Thunderstorm	The protocol for severe thunderstorm warnings is more subjective than tornado warnings due to varying degrees of danger. • E.g., A broadcaster might cut into programming for a storm producing 90 mph winds but just run a crawler for 60 mph winds. • The crawler and the map are run continuously during programming. • The broadcaster may go wall-to-wall for a large, intense, bow echo or derecho that has potential to impact a large population.
Tornado	The protocol for tornado warnings is more straightforward than for severe thunderstorm warnings. • Treated more seriously than a severe thunderstorm warning. • The crawler is run over commercial breaks. • Many broadcasters cut into commercial or programming for every issuance of a tornado warning. • Go wall-to-wall for a confirmed tornado (vs. being radar indicated) • Areas with greater population density receive more attention than rural areas, unless the situation is confirmed to be life threatening.

of the participants said they will run the crawler or put the small map on the screen during commercial breaks for a warning, as opposed to watches where they do not obscure commercials.

Tornado warnings are treated more seriously than severe thunderstorm warnings. One participant (I6) works at a station that has very strict rules:

> We're only allowed to, cut in once per tornado warning. Unless there's a tornado on the ground or something. . . . [A]ctually our last, tornado outbreak, [our general manager] said that even for the next tornado warning, I had to ask . . . to cut-in . . . I had to go back and ask every time a tornado warning was issued.

Another broadcaster (I1) operates on the opposite end of the spectrum and said that their management would rather have them stay on-air. They said, "Essentially we cut in, regardless of programming, regardless of timing as soon as we can for any severe warning."

Despite these two extremes, the rest of the participants seem to follow standards that are similar to one another. For most of the participants, the severe weather crawl banner is taken off the screen during commercial breaks during a thunderstorm warning. However, the crawl stays up during a tornado warning. In fact, many broadcasters cut into commercials or programming for every tornado warning that comes out and they will almost certainly go wall-to-wall for a confirmed tornado rather than just being radar indicated. This is especially true if the storm affects a large population. In fact, population is a major factor in deciding when and for how long to cover an event for most of the participants in this study. One participant (I7) also said that if meteorologists were more accurate in determining whether a tornado actually exists (as opposed to just being indicated by radar) they would probably break into programming for the rural areas more often.

Many stations follow the guidelines above, however a number of the broadcasters stressed that each event is different and decisions are not usually black and white. The amount and type of coverage depends on a variety of factors. Aside from atmospheric conditions, coverage also depends on social pressures such as TV programming, population density, time of day, and verification.

5.1.3 Social Pressures

Broadcasters must consider internal and external social pressures when deciding how to cover an event. One participant (I20) described the thoughts that go through their head during an event:

> There's so many things you gotta ask yourself. What's on the programming, is the tornado verified, is it a Doppler indicated, is it over a rural population, is it over a city? Has it been spotted, has it done damage? . . . Is the *Survivor* finale about to award $4 million dollars to somebody? You know, are you upsetting more people than helping? Those are the questions I ask. There's probably six to 10 questions I ask before I do a cut-in.

The broadcaster said that all broadcasters should consider the variables listed above when deciding whether breaking in. They said that there is an element of responsibility "that comes with just going on the air and interrupting a show, and then having nothing ever happen from it." Broadcasters have to juggle many tasks and consider multiple angles before breaking into programming. The TV program that is currently airing, population density of the affected area, time of day, and whether the storm has been verified by a spotter are variables that a broadcaster has to consider before going on-air and are discussed below.

Programming. TV programming is a big determinant in whether a broadcaster can break-in. "Whatever is on our programming, has a lot to do with the decisions made on how to cover severe weather," one chief (I20) said. Viewers get upset when severe weather coverage interrupts their programming, and the backlash is the most substantial if it is during Prime Time. The same chief described an event in which the programming was a big issue:

> One time, I cut in during an NCAA basketball championship game with a tornado warning. . . . *but*, we knew to do a split screen where on one side of the screen was me with the warning and on the other side the game was continuing so . . . you didn't miss a play . . . We did a tornado warning during a timeout in a basketball game and the viewer could clearly see it was a timeout 'cause it was on the right side of the screen and all the players were on the bench talking, and then I was on the left side, giving the tornado warning. And they *still*, called in and complained.

Several broadcasters talked about the programming issue during the course of the interview. As will be noted later, sometimes the greatest issue for a broadcaster is negative feedback from viewers. Not due to poor coverage, but because their show was interrupted. Most participants were well aware of this problem and say it is something they must take into consideration every time they want to break-in. One morning meteorologist (I13) explained:

> [If there's a severe thunderstorm warning] in the metro area, my instinct is to go on immediately. But if you cover the first minute of *CSI* when they explain the entire rest of the show then you've just tuned a bunch of viewers out that you know you could otherwise be informing if you had just waited a minute . . . that balancing act is a huge part of what we do.

Population Density. Aside from programming, the size of the population at risk also influences the coverage level. Because profits in the television industry are closely tied to ratings and ratings are based on the number of people who watch a show, the number of people affected by a storm is another area of consideration for broadcasters. Viewers tend to be selfish when it comes to severe weather coverage. One participant described a time where their station was on the air for a confirmed tornado headed toward a small town during the season finale of a popular TV show. Many angry viewers phoned the station. But, as the participant (I15) noted:

> Right after that episode of *Lost* ended, [a] tornado warning comes out for the metro. 10:03 . . . at that point, ah 60 something percent of the television sets were turned on and turned to a newscast during the tornado warning. So they were mad at you an hour ago, now you can't say enough.

This type of viewer behavior can be frustrating to broadcasters.

Whether a station will break in for an unverified tornadic storm over a rural area, for example, varies from station to station. One participant (I18) said, ". . . the people in those [metropolitan] cities don't understand that sometimes that just because it's not impacting you, that 'hey something's going on' within our coverage area and we still have to be on the air." Another participant (I16) discussed how even if they interrupt programming for a storm in a rural area, it is also important to let the people in the population center know what to expect within the next few hours. The broadcasters noted that it is not always easy to know how to handle the population variable and to know when to break in since events differ.

Time of Day. Another coverage consideration is the time of day. As previously mentioned, broadcasters usually receive a lot of backlash for breaking in during Prime Time programming. However, viewers do not usually get as angry in the early afternoon. One unique part of the day is during the overnight hours. It is very difficult to spot storms at night so it can be difficult to obtain verification. Few people watch TV at 1:00am, so some broadcasters mentioned that they are more liberal with coverage in the overnight hours. One (I10) commented, "you gotta play night a little bit different." Another participant (I9) said that if a person wakes up due to a thunderstorm they are probably going to turn on the TV to see if the storm is particularly threatening. If a broadcaster can reassure them that the situation is not that dangerous, their mind can be put at ease. On the other hand, if the situation is dangerous, the broadcaster can encourage the person(s) to take appropriate action. The participant (I9) said it is probably better to overdo the coverage at night.

Verification. Another variable in deciding whether to break into programming or just run the crawler is verification. Spotter reports are especially important for tornadoes, because some broadcasters mentioned that the difference between them breaking into commercial for a minute or breaking into programming and staying on for the duration of the warning depends on verification. As one chief (I7) notes, "The spotter report [that] there's actually a tornado is so critical because 75% of these Doppler indicated tornado warnings don't produce tornadoes." The stations whose rules are more strict about interrupting programming lean towards *not* cutting in unless they know there is a tornado on the ground.

5.1.4 Sensemaking in Severe Weather Coverage

When experience is not enough to know how to respond to a situation, broadcasters use other mechanisms to make sense of the situation. Severe weather coverage is often fast-paced and impromptu, so sometimes broadcasters do not have time to think about what they are going to say on-air. One weekend meteorologist (I1) said that during an event in which a deadly tornado struck a small town, they, "probably ran about three miles back in the weather center between the printer and the phones and the radar and the. . . NWSChat product . . . it's a crazy time during severe weather. . ." A chief with 20 years of experience (I9) spoke about a recent deadly tornadic event saying it was a "pounding heart, stomach churning" situation. In fact, sometimes broadcasters have to cover multiple tornadoes at one time, which makes coverage very intense. Storms do not have to be tornadic, though, for the situation to be dangerous and intense. One chief (I7) described a straight-line wind event that impacted a metropolitan area and the resulting unusual situation that occurred:

> [There was a] straight-line wind event that came across the city, 80 to 100 mile per hour winds for many of our population. So it's rare to get something that most people [in the viewing area] experience . . . it was . . . probably as a strong of a straight line wind event as we've seen across the area *and* for it to have hit right through the middle of the metro area you know made it particularly extreme and unusual . . . [there was so much hail hitting our building] such that . . . I couldn't even hear myself talk.

Broadcasters are unable to rely on the lessons they have learned from experience and the guidelines set in place by management for events like these. The unique, evolving, nature of the atmosphere means that broadcasters use aspects of sensemaking to understand, make decisions, and communicate during intense events. Examples of individual aspects of sensemaking during severe weather are provided below, followed by two examples of multiple aspects of sensemaking in action from participants who describe their experiences covering an intense event.

Organizing Flux. Some broadcasters are very familiar with the weather conditions in their DMA. However, broadcasters will often relocate every couple of years, especially at the beginning of their career. Thus, sometimes they are unfamiliar with the weather conditions they face. One morning meteorologist moved from the east coast to the upper Midwest and found out that there was a great difference in forecasting techniques. "[The coast was] completely different. You know [here, in the central plains] it was just learning by the seat of your pants," they said (I5). The same broadcaster went on to describe a tornadic event that was difficult to get a handle on. He (I5) continued, ". . . everything just lit up, the whole thing went crazy. We basically had a line of warnings. . . I think eleven confirmed [tornadoes] when it was all said and done . . . three hours it was wall to wall. . . . so many storms . . . *you couldn't even get your ducks in a row* . . . (italics added)." The broadcaster was forced to take the information they had and organize it into something that could be understood and support relevant action.

Noticing and Bracketing. Broadcasters may get used to how storms evolve in their area and feel like they have a pretty good handle on severe weather. One morning meteorologist (I2), however, pointed out that it was clear that one deadly tornadic storm was different from the others they had experienced. ". . . to see that devastation…to *see* it on radar and then to *see* what it can do…makes you well aware of what is bad and what's not bad. It just put it in perspective," she commented.

Oftentimes severe thunderstorm warnings do not get as much attention as tornado warnings because they are usually less threatening. However, one participant (I4) said there was a time where they realized the situation was worse than normal. He stated, ". . . before this last week my most memorable event was a derecho event that, moved through [with] 80 mile per hour winds. I was on solid for that one, because I thought it needed it." The broadcaster deviated from normal protocol due to the intensity of the event.

Labeling. A broadcaster has access to a lot of information during severe weather, and it can be overwhelming for stations that are short-staffed. In addition, the amount of time allocated to broadcasters for coverage can be short (30 seconds to 2 minutes), so they have to determine the most important messages to disseminate to viewers. One broadcaster (I14) said that she ". . . prioritize[s] and categorize[s] you know, in my mind, what's the most important thing that I need to say [and] what are the things that would mean the most to our viewers." In addition to sleuthing through information, another time, as previously noted, where a broadcaster may realize the need to treat the situation a certain way, is at night. Labeling the event as "night time" helps the broadcaster adjust their understanding accordingly. They try to give people more constant reassurance and more warning information at night.

Retrospective. The broadcasters did not give explicit examples of an event in which they compared it to an event in the past, but several participants indicated that they evaluate the event and the effectiveness of their coverage afterwards. One chief (I11) noted, "Every experience gives me a chance to evaluate what worked and what didn't work." Another chief (I9) said they "maintain a learning atmosphere" at their station. After an event they ask themselves, ". . . did that work, how did it work, were we effective? Did we do a good job? . . . What else could we have done?"

Presumption. Although the evolution of some storms can surprise broadcasters, there are also trends they recognize and make presumptions about the impact of a storm. One chief (I7) noted that after several years covering the weather ". . . you get a sense for how a severe thunderstorm might evolve, or how a, tornado-producing supercell might, have a lifecycle, or how it's going to move." A morning meteorologist (I19) said along similar lines, "You just know which ones are gonna be bad and which ones aren't . . ." When making split-second decisions broadcasters must rely on the past to decide what actions to take.

Social and Systematic. The evidence suggests that the amount of TV coverage an event receives depends on several social factors including management, programming, and population density. Although many broadcasters are passionate about the weather and would not mind discussing it for hours, they also have to consider the viewer's perspective during severe events. One chief (I3) noted that he tries to "think like a viewer" when breaking in because it seems that most people would rather watch their TV show than the weather (especially if it is not directly affecting them). Another chief (I20) also commented about how the airing TV program significantly influences the type of coverage they provide. Thus, broadcasters cannot only think about *their* needs and the information *they* would like to provide, but rather they must also consider the wants and needs of viewers.

Action. During and after data interpretation, broadcasters have to decide what messages to convey and how to convey them. As previously noted, one participant (I20) said he asks himself several questions before going on-air such as whether the storm had been verified and what program is currently airing. Another participant described a coverage decision during an event in which a tornadic storm was impacting a fairly rural area in their viewing area. Her action (i.e. coverage) took population density into consideration. “My, mission had to be, tell people what they need to know, do it quickly, and don’t forget about the fact that most of these people are not in the [metro area]. . .” (I14). Broadcasters must decide whether to break into commercials or programming for a few seconds, or stay on the air for an extended time period. When the decision is “Yes”, the broadcaster takes action and decides on the level of coverage, the words to describe the event, and the tone of voice to use.

Organizing through Communication. Communication and action usually go hand in hand in severe weather coverage. Since communication is a large component of a broadcaster’s job, there is some overlap in these sensemaking aspects. Broadcasters communicate with the audience with more than one medium (e.g., TV, internet simulcasting, cell phone) depending on the event. In fact, they may communicate with viewers for several hours. One participant described an instance when a major metropolitan area was impacted by a tornado outbreak and every county in their DMA was under a warning at one point. “So we were very busy that night. And *constantly on the air* (italics added) at certain points once the weather really started going downhill. . .” Communicating to viewers through extended coverage was crucial in disseminating life-saving information.

Sensemaking in Action. Individual aspects of sensemaking are apparent at various points during severe weather events. However, two participants described events in which several aspects of sensemaking were evident in real-time. First, a weekend meteorologist (I6) described a time when dangerous storms and technological failure combined to create a chaotic situation. The aspects of sensemaking are italicized in parentheses:

> . . . we were in the process of finding a new chief. . . . I called [the other meteorologist] in because . . . we were under a moderate risk [for severe weather]. And, [I] knew it was going to be a crazy day (*label*), but he just wasn't answering his phone. So, I believe I ended up having . . . eleven tornado warnings, at one time . . . [I was] all by myself. . . . our engineer, he came in to help me, he was manning. . . the warning updates (*organizing flux*) and so when I'd be cutting in he'd say "oh we've got another one" so I'd go back and check, 'cause he really couldn't give me much information. . . so I, I had to do a moderate risk day all by myself cutting-in, doing the crawl (*communication*), and then of course the crawl crashed and I had to, reboot the crawl (*action*). . . . it was a scary, freaky, situation 'cause it was my first big severe weather event [and] I had to handle it by myself and, you know, people's lives were potentially, in danger . . .

Another weekend meteorologist (I4) described an event where a tornado struck their town, creating power outages at the station:

> A week and a half ago. Ah, we had a tornado about a half-mile from the station [and it] knocked out power to the town and we were able to get back up on air primitively with our live truck. We don't have a backup generator so we were using our little gas generator to power our live truck (*organizing flux*) and we had no internet, no computers, just a camera [and] two lights set on a tripod and we were sitting there with a microphone (*communication*). Reporters were coming in with what they knew. . . . I actually wasn't here at the start of it but I booked my butt back home. Really quick (*label*). . . . And, started helping cover and the entire next day from, 5am till 3pm I was doing cut-ins (*action*) ah, during commercial breaks because . . . we couldn't fill the spots because our master control wasn't running so we had to fill it somehow so we filled it with just me and the morning guy by doing what we could. By then we actually had some computers and we had our backup weather graphics computer going so we could at least do some sort of a . . . real, cut-in type thing . . .(*communication*).

5.2 Discussion

The decision whether and/or how to cover a severe weather event depends on several factors. Although the atmosphere is very dynamic and meteorologists have difficulty accurately pinpointing exact impacts (e.g., the town that will be struck by a tornado and what time it will be struck, down to the minute), many storm patterns are recognizable and certain types of events can be covered effectively by using past experience to understand how the storm system will evolve. Broadcasters often use their knowledge of how storms behave in their DMA to decide how to cover an event. Experience allows them to be able to tell which storms are more dangerous on radar and how storms may evolve over time. They can base their coverage decisions on this knowledge. They also learn how to use the short amount of time they are usually given to communicate the most important messages (e.g., most dangerous threat) effectively to their viewers.

Internal and external social pressures also play a significant role in their coverage and may compete with their own opinions about how an event should be handled. Some of the participants mentioned that their station managers trust them to be the weather experts and to use their best judgment as to when to break-in, however, a few stations have very strict rules to which broadcasters must adhere. Furthermore, as one participant mentioned, even the broadcasters who work at stations with general protocols are obligated to follow management rules if presented. The TV program airing at the time of the event, the size of the population who may be affected by the event, time of day, and whether the storm threats have been verified are also important social factors. The broadcaster has to consider the interests of the population at large since station revenue is closely tied to the number of people who tune in at a particular time. (On the other hand, some TV stations in the central U.S. are very competitive about severe weather so they may cover the event more thoroughly if they think it will boost their ratings). The conflict of interest between management and the broadcaster is certainly an issue at times, but many of the participants in this study appear to have a trustworthy relationship with management. That is, many of the broadcasters say that their managers trust them to make the best decisions based on the meteorological information. Of course, broadcasters still have to take all of the external social pressures into consideration.

Many broadcasters feel they have a good handle on events, especially the longer they work in the industry. Most severe weather situations are routine for them. However, no matter how much experience one has, there can still be "surprise" events and events in which a broadcaster lacks experience. These events, although rare, are usually the most impactful events and create the highest threat to life and property. When experience and management protocol are not enough to handle the situation, broadcasters use properties of sensemaking to make decisions and take action to provide the most effective coverage possible to keep the most people safe. Sensemaking may not be an active component of every severe weather situation, but it plays an important role when seconds count.

Chapter 6: Diffusion of New Media & Radar Technology – Results & Discussion

Aside from experience being an influential factor in coverage, another important factor is technology. The broadcasters' use and/or potential use of new media, dual-pol radar, and 3DVar are discussed in the following pages. The diffusion of these innovations into the broadcast industry is analyzed according to the theory of diffusion of innovation. This study offers a unique perspective on the diffusion process because it gains perspective about current, near future, and future innovations. New media is a current issue, dual-pol radar will be available very soon, and the infrastructure that the 3DVar product is based on will not be available operationally for a number of years.

6.1 New Media Diffusion

Table 4 provides a summary of the new media being used by the participants during severe weather. The most common new tool was the NWSChat (95%). Some participants were very active in the NWSChat whereas others simply used it as an information-gathering source. Internet simulcasting has also become a popular method for disseminating severe weather messages. While industry-wide adoption has yet to occur, the broadcasters who use the technology (60%) only do so during "wall-to-wall" events where coverage can last anywhere from 15 minutes to several hours. Of the participants whose stations simulcasted on the Internet, all had only been doing so for a couple of years. Radio simulcasting is actually not a new tool (some have been using it for over a decade), but just over half (55%) of the participant's stations used the

Table 4: Summary of the participants' use of new media in severe weather coverage.

Medium	Number of participants (%) who use the medium
NWSChat	19 (95%)
Internet Simulcasting	12 (60%)
Radio Simulcasting	11 (55%)
Designated Storm Spotters (paid and unpaid)	9 (45%)
Social Media	8 (40%)
Blog	1 (5%)
Other (e.g., digital sub-channel, GR2 Analyst, sky cams, ham radio, text messages, Skype, helicopter)	Varies

technology.

About half (45%) of the broadcasters said their stations have designated storm spotters, some paid and some unpaid by the station. Again, although people have been spotting storms since the early 1940s (Doswell, Moller, & Brooks, 1999) and it is not necessarily a new idea, participants were asked about it because real-time communication with the studio via cell phone, web cam, etc… is only possible using recent technology. A question pertaining to the use of social media was not on the original protocol, but 40% (n = 8) of the broadcasters mentioned using Twitter to disseminate severe weather information to viewers. They had only been using the tool for a couple of months, however. One participant mentioned using Facebook. Of the broadcasters who mentioned having used Twitter during severe weather, all said they had only been using it for a couple of months. Only one broadcaster said their station had blogged during a severe weather event, although several broadcasters mentioned that their stations have general weather blogs. The main reason for not blogging during severe weather was not having enough people on staff.

The use of new media has played an important role in broadcast meteorology, and some innovation attributes have influenced the adoption of the new tools. An in-depth look at the attributes related to each form of media and the tools is provided below. Table 5 shows a summary of the frequencies and barriers associated with each innovation. Before looking at the diffusion of individual media in the broadcast industry, one must also consider how the Internet as a whole has changed the way broadcasters gather and present severe weather information. After all, most of the new media would not exist without the Internet. All of the broadcasters commented that much more information is available today than in the past. A chief in a medium market (I20) summarized how the industry has changed since the adoption of the Internet and use of new tools. He enthusiastically stated:

> Yeah, it's been so different [within the last] 10 years . . . it's been a lot different in 20 years but when you just think of the past 5 to 10, that Internet, that Chat, storm spotters . . . There's so many more eyes out there looking at storms. . . So yeah that information . . . has tripled.

Another chief from a medium market with 37 years of experience (I12) said the industry has changed considerably since he started, and will continue to do so. "Yes [the industry is] dramatically changing rapidly. . . The business, in eight, five years, is not, is not even going to look the same." One of the most dramatic changes is that the availability of information has increased significantly. A large market morning meteorologist (I16) commented on the impact the Internet has had on his job:

Table 5: Summary of new media, dual-polarimetric radar, and 3DVar innovation attribute and barrier frequencies. Relative advantage was the most common innovation attribute and limited resources was the biggest barrier. While opinion leaders were not very influential for the adoption of new media, they will be very influential for the adoption of dual-polarimetric radar.

New Media Attribute Summary (Broadcaster)	
Relative Advantage	59
Compatibility	19
Complexity	4
Observability	7
Trialability	14
Opinion Leaders	5
Competition	1

New Media Barrier Summary (Broadcaster)	
Limited Resources	37
Information Overload	8
Competition	2
Weather Forecast Office Differences	2
Liability (storm chasing)	2
Logistics (poor cell coverage)	2

New Media Attribute Summary (Viewer)	
Relative Advantage	46
Compatibility	0
Complexity	0
Observability	7
Trialability	0

New Media Barrier Summary (Viewer)	
Limited Resources	4
Information Overload	2
Complexity	1
Awareness	2

Dual-Pol Attribute Summary (Broadcaster)	
Relative Advantage	14
Compatibility	1
Complexity	1
Observability	1
Trialability	0
Competition	5
Opinion Leader	32

Dual-Pol Barrier Summary (Broadcaster)	
Limited Resources	12
Information Overload	1
Awareness	17
Complexity	1

Dual-Pol Attribute Summary (Viewer)	
Relative Advantage	10
Compatibility	0
Complexity	7
Observability	0
Trialability	0

Dual-Pol Barrier Summary (Viewer)	
Complexity	7
Information Overload	1

3DVar Attribute Summary (Broadcaster)	
Relative Advantage	15
Compatibility	1
Complexity	2
Observability	0
Trialability	1
Opinion Leaders	0

3DVar Barrier Summary (Broadcaster)	
Limited Resources	1
Information Overload	0
Awareness	1
Complexity	3

3DVar Attribute Summary (Viewer)	
Relative Advantage	2
Compatibility	0
Complexity	7
Observability	0
Trialability	0

3DVar Barrier Summary (Viewer)	
Complexity	8
Information Overload	1

> . . . probably the first, two or three years [of my career] I rarely used internet and I [would] just get the old Difax charts [...that] just pipelined all sorts of data. . . . And it wasn't really, I think until 2000, 2001 that I started using the Internet . . . to look at more and more information. And now it's . . . what I use. I don't wait even for the products that [our weather vendor] sends out. It's all on the Internet that I can find.

The Internet has been the foundation of technological change. Relative advantage, from the broadcaster's perspective and the perspective of the viewer, was the main attribute in the adoption of the Internet in the broadcast industry. Improved accuracy can lead to better decisions. A weekend meteorologist in small market (I4) also said the information helps him make better decisions. "Absolutely [more information helps me make better decisions]. Ah, cuz we're stuck inside a building, while all this stuff is happening. [We] really don't get a chance to look at [the weather]." While many broadcasters said the Internet has had a positive impact on *their* job performance, they also discussed the advantages of the technology from the viewer's perspective. Although many of their comments were speculative in nature, they were also very informative.

Viewer. New media enable broadcasters to provide more precise information to viewers. One weekend meteorologist in a small market (I6) noted, "With better technology, I think you have more capability of *showing* people how dangerous the situation can be. . . .So I think with today's technology, people can maybe trust us more, and can . . . *see* what's actually going on." A weekend meteorologist in a medium market (I15) also commented about the benefit of the Internet to viewers. "We can tell them . . . with far better certainty, [what's going to happen]." In addition to certainty, one broadcaster (I12) also mentioned that viewers benefit because they "can get their forecast anywhere [e.g., TV, internet, cell phone] today" instead of waiting for the evening newscast. Timeliness has also improved. Since broadcasters are able to gather information more quickly, they can disseminate it in a swift manner as well. A chief in a medium market (I20) commented, "Where the viewer gets served . . . is with getting the information out quickly. Like, 'tornado destroyed a neighborhood, here.' . . . We can get that out in a minute or two, where versus 10 years ago it might take 10 or 20 minutes to get that out." A medium market morning meteorologist (I2) added that improving forecast accuracy is advantageous for the viewer. "Yeah I think our forecasts are getting more and more accurate and more and more specific and I think that's what people want," they commented. While the advent of the Internet has played a tremendous role in the availability of information in general, this study focused on the impact of the changing forms of individual media as a result of the Internet, not the Internet as a whole. The innovation attributes related to each medium are presented below.

6.1.1 NWSChat

Aside from the Internet itself, the NWSChat was the only new medium that broadcasters used to *gather* information. Broadcasters used the other new media to *disseminate* information. The NWSChat has certainly impacted the industry in a positive way. Broadcasters raved about the NWSChat. The dominant attribute pertaining to broadcasters is relative advantage (25). Complexity (4), observability (3), compatibility (2), and trialability (1) seem to have little adoption influence. All but three comments related to NWSChat pertained to the broadcaster's perspective. (The comments related to a news director wanting the broadcaster to mention that they were talking directly with the NWS during severe weather coverage – observability - and that it gives them "heads up" before the warning comes out – relative advantage.)

Relative Advantage - Broadcaster. The broadcasters were overwhelmingly positive about NWSChat, making comments such as "[it is] one of the best things we have during severe weather coverage (I1)" and that "it is the quickest way of communication right now" and "the best thing since radar (I3)." One morning meteorologist in a small market (I5) said the NWSChat is "invaluable" and that it is "almost like the invention of the telephone" in the way it has revolutionized how broadcasters communicate with everyone else in the warning partnership. He continued:

> Pity the meteorologists who aren't using it . . . one of those things guys who have been in the business thirty years [are probably saying] "how did we do this before?" [laughs] . . . You know . . . "I don't even know how we did this before."

Participants also likeds the NWSChat because it sometimes allowed them to get advanced warning notification from the NWS, something previously impossible. A weekend meteorologist in a small market (I6) described a time when advanced notification was helpful. "[The NWS] gave us [the warning notification] in advance so we could get our graphics ready to do a cut-in, we could tell our production staff to 'get ready we're gonna do a cut-in,' and then when they issued it we'd be right on-air, at the same time, and we could be prepared." A weekend meteorologist in a medium market (I10) also spoke highly of the benefits of NWSChat. He stated:

> I *love* the fast communications. I mean when you can get storm reports like that, you can get the, severe wind gust reports off the ASOS [Automated Surface Observing Network] network [snaps] like that. Ah, warning decision updates by the Weather Service, those discussions, just being able to click on them and, pull up the bulletins instantly. It's the fastest circuit there is. I mean it beat everything in the house.

In addition to relative advantage, the broadcasters said NWSChat is relatively easy to use.

Complexity - Broadcaster. Examples of complexity (or lack thereof) were also found in the interviews. Aside from a couple of broadcasters being slightly irritated about having to change their passwords every 60 days, participants did not have any complaints about their ability to understand and use the NWSChat. "I think Chat has simplified [all of the information]," one chief from a small market (I18) said. They also commented, "I think it is probably . . . one of the best communication advancements that the Weather Service has done. It's so instant, it's so quick, it's so easy." Other participants agreed about the relative simplicity of the NWSChat and said it is "fast [and] it's immediate" (I2) and that it is "automated where it needs to be automated and you get a live person too who you can chat with" (I16).

Observability - Broadcaster. Although observability was not a prominent attribute, a few broadcasters were influenced by seeing others use the tool. A couple of broadcasters commented about seeing their competitors using the NWSChat. In one case, a large market morning meteorologist (I13) did not use the NWSChat, but knew of others who did. "I know [an NWS Weather Forecast Office (WFO) has a chat room because] I have a friend that works at the TV . . .

station in [a city within the WFO] and he uses it quite often. But, I haven't done it yet."

Observability – Viewer. The adoption of NWSChat was influenced very little by its observability to viewers. While TV viewers are most likely unaware of the details of the NWSChat, one participant (I16) said they actively mention their station's relationship with the NWS. He noted:

> I know our news director likes for us to mention [the NWS Chat] as often as we can, and that we're in constant, live communication with the National Weather Service. You know and we've mentioned before, you know, 'hey we're chatting with the Weather Service it looks like they're gonna issue a warning on that storm that's over [large city].'

Aside from the NWSChat, internet simulcasting is another new form of media being used by some broadcasters during severe weather. It is one way in addition to traditional TV that broadcasters are using to disseminate severe weather information. The diffusion attributes of internet simulcasting are discussed next.

6.1.2 Internet Simulcasting

Internet simulcasting has become a popular method for disseminating severe weather messages. While industry-wide adoption has yet to occur, the broadcasters who use the technology only do so during wall-to-wall events. Some stations had simulcasted on the Internet for over a decade while others had yet to present their first simulcast. Trialability (6), relative advantage (5), compatibility (2), and observability (1) were diffusion attributes that influenced the broadcasters' adoption of the technology.

Trialability - Broadcaster. One benefit of internet simulcasting is that it does not have to be used during every weathercast or severe weather cut-in to be effective. Whether a station simulcasts their severe weather coverage on the Internet varies depending on the severity of the weather event, staffing, and resources. Stations are not committed to simulcasting every time they go on-air. "It's not necessarily a scheduled thing but if there are bodies there and there is somebody up there [in the control room] they will stream that coverage," a chief in a medium market (I7) said. A medium market weekend meteorologist (I15) also noted that they only stream during "major events." He continued, "I mean yeah, if it's a severe thunderstorm warning we'll just put our latest cut-in somewhere on [our webpage]."

Relative Advantage - Broadcaster. Internet simulcasting is also beneficial to broadcasters because it is another way to get the station's brand out to viewers, which can increase ratings and hence, increase advertising revenue. A large market morning meteorologist (I13) commented about this benefit of simulcasting:

> There's been a lot of research done by the PEW research center about people who, go to your website almost exclusively watch, your newscast. And people who watch your newscast almost exclusively go to your website. So there's a lot of interplay. If you can hook them on the Internet chances are you can hook them on television later that night when they're home.

A chief in a medium market (I12) had a similar understanding as the previous participant and noted, "I think [internet simulcasting is] positive [because] we're all in the business to make money, and increasing hits on the website, theoretically leads to higher [advertising] rates." A morning meteorologist in a different large market (I16) also made a comment about the positive side of internet simulcasting and said, "We don't feel like we're taking anything, or any eyeballs really away from us on TV if we point people to the website." Thus, internet simulcasting could potentially provide monetary benefits to TV stations.

Complexity - Broadcaster. In addition to trialability and relative advantage, complexity was another diffusion attribute that applies to internet simulcasting. Streaming coverage is not very difficult for a station to do as long as the appropriate staff is present and the station has enough bandwidth to host the service. One chief in a medium market (I20) said that, ". . . Somebody up there [in the control room] flips the switch and we're on the web." Another participant (I16) said that their web team is used to streaming news stories, so streaming severe weather coverage is not much of a change. He said, "our web team . . . is really adept to getting it live. They do a lot of live streaming anyway so, it's not an arduous task for them so it's pretty . . . standard if we go wall-to-wall it will be, on the website."

While diffusion attributes were apparent from the broadcaster's perspective, the biggest advantage of the technology seemed to be to the viewer. Fifteen examples of relative advantage and two examples of observability pertaining to the viewer perspective surfaced in the interviews.

Relative Advantage – Viewer. One of the major advantages to internet simulcasting is that people can watch severe weather coverage at work, where most of them do not have TV access. A chief in a medium market (I9) said, "Particularly when people are at work, they really love that, because hardly anyone has a television at work but everyone has a computer." Internet simulcasting also allows a person to take shelter in their basement or other safe place but remain informed about the weather (assuming their power does not go out). A participant from a large market (I13) thought highly of the technology and said, "With laptops and wireless internet now you can be in your basement while there's a tornado bearing down on your house and still watch our coverage if we're streaming it. And I think that that's, huge." Many broadcasters made similar comments.

Another benefit is that people outside the viewing area can watch the coverage. As one medium market weekend meteorologist stated, simulcasting is "good because it lets relatives be aware of the weather." Lazo, Morss, & Demuth (2009) and Paul, Brock, Csiki, & Emerson (2003) have shown that one way people get severe weather information is through a phone call from a relative. If the power goes out and the person in harm's way has no information, an out-of-town relative can see the coverage and keep them informed.

Observability – Viewer. One way viewers can know whether a station is streaming is by going to the TV station's homepage. One broadcaster (I18) made a few comments about their streaming being "bold at the top of . . . [their] webpage." This small market chief also said that sometimes they will plug it during newscasts or severe weather coverage. Although observability was not a prominent attribute of internet simulcasting, it may play a small role in whether a station adopts the innovation.

6.1.3 Radio Simulcasting

Radio simulcasting is another avenue to disseminate severe weather information. While radio is not a new medium, radio simulcasting is one relatively new tool that some broadcasters are able to use. Some stations have been simulcasting on the radio for a decade, while some do not simulcast at all. For the participants in this study, whether a station simulcasted on the radio depended on whether they had a contract with a radio station. Sometimes a single TV station will dominate the market by having an exclusive contract with all the radio stations in town. In one instance, a morning meteorologist in a small market (I6) said that while her station does not simulcast another station in town does. From the broadcasters' perspective, compatibility (9) was the most prominent attribute. There was also one example of relative advantage where a participant said simulcasting on the radio is free advertising for the TV station. The same participant (I19) also said his station only simulcasts in "extreme circumstances," an example of trialability.

Compatibility - Broadcaster. The main attribute of radio simulcasting applicable to the broadcaster was compatibility. If a TV station has a contract with a radio station it is very easy to stream severe weather coverage on the radio. It does not take any effort on the part of the meteorologist who is already strapped for resources. One chief in a medium market (I20) explained, "You know . . . I don't need to know [when the radio station takes us] But . . . they do try to let us know, 'by the way we're carrying you all live right now.'" Another chief (I9) noted, "we don't have any bi-play or any interaction with the radio people, we're not actually conscious of when they actually take us." Similarly, a medium market morning meteorologist (I19) said the radio station they work with will "hit our coverage for a period of time. And sometimes they don't even tell us they're doing it." Since the radio station is responsible for initiating the simulcasting, it requires very little effort from the broadcaster and is compatible with their system.

Relative Advantage - Broadcaster. Only one broadcaster (I19) spoke about the advantages of radio simulcasting from their perspective. They said that radio simulcasting is "getting our signal, our branding as a good severe weather station out on a pretty powerful radio station," which may indirectly increase their television ratings.

Trialability - Broadcaster. The example of trialability surfaced when a broadcaster (I19) mentioned that their station might stream their coverage on the radio in "extreme circumstances," such as when severe weather threatens the metropolitan area. However, similar to internet simulcasting, radio simulcasting is more advantageous for viewers than it is for broadcasters. Because it does not require any extra work on the part of the broadcaster, it is an excellent way to disseminate critical information. Eight examples of relative advantage and two examples of observability from the viewer perspective surfaced in the interviews.

Relative Advantage – Viewer. Similar to internet simulcasting, the radio can provide backup coverage when one does not have access to a TV. A weekend meteorologist in a medium market (I15) provided an example to illustrate this point:

> Ah, I gotta tell you to me [radio is] . . . still the bigger deal than the computers . . . And you really can't get a lot of streaming information on

> this [cell phone] so radio to me is still battery powered, still works, people driving down the road . . . [for example let's say] I live in [a northern city] but I'm going to Six Flags in [a southern city and] I'm driving through [a central city] at the wrong time. Well, they can [listen to the radio]. To me it's more vital than streaming on the air.

A chief in a small market (I18) also talked about the advantages of the radio for viewers. He told a story about a woman being able to hear the station's coverage when her power went out:

> . . . I remember a lady called and said you know 'We were without power,' I think she was out in [a town]. Um and their cable . . . went out. I mean they didn't know what was going on but they were able to listen to [the radio station] and [hear] . . . what was up. So you know that makes me feel better. Like people still . . . have a way to listen to us.

Many broadcasters cited examples of the advantage of radio simulcasting pertaining to a power loss. One morning meteorologist in a medium market said, "If people lose their signal . . . [and] they're in their basement listening to the radio and it's just one advantage we have . . . we can give people, ah, an idea of where the storms are."

Observability – Viewer. Similar to internet simulcasting, a couple broadcasters commented about letting viewers know about their radio simulcasting. One participant said they "promote it every day throughout our newscast" (I18). Another participant (I19) said their producer asks them to mention the radio station on which they are simulcasting during severe weather coverage.

6.1.4 Social Media

Social media such as Twitter and Facebook are also beginning to influence the way broadcasters communicate during severe weather. Because these media (especially Twitter) were so new at the time of the interviews, the original protocol did not ask about their use. However without being solicited one broadcaster mentioned posting messages on Facebook during severe weather, and several broadcasters said they had disseminated information via Twitter. Of the broadcasters who mentioned having used Twitter during severe weather, all said they had only been using it for a couple of months. However, because the spring 2009 severe weather season was relatively inactive, the broadcasters did not have many opportunities to use the tool and were unable to provide many examples of its positive or negative aspects.

Compatibility - Broadcaster. One possible attribute of social networking sites is their compatibility with current infrastructure. Since Twitter and Facebook are just fairly simple websites, they are available to anyone on the Internet. There was only one instance where a broadcaster described their station's use of Facebook and Twitter and the compatible nature of the system. "We do keep a pretty close update on Facebook and Twitter. . . Jamie[3] will sit in here with both of my Facebook pages open, and Twitter. . . and she'll just listen and sometimes I'll say, 'Tornado, approaching [town], going south' [and she'll type it in]" (I12). One thing to note is that the person updating the pages in this case was not a meteorologist but had been hired to help with the weather department. If this individual were not present, updating Twitter and Facebook would not

[3] name has been changed

be possible for this station. Limited resources were one adoption barrier, and will be discussed in a later section.

Relative Advantage - Viewer. Since Twitter was so new at the time of the interviews and participants had little experience with the tool, there was not much data pertaining to its use. However, using social media to disseminate severe weather information could be advantageous to viewers. One participant told a story about a viewer who was very thankful their station used Twitter to disseminate severe weather messages. The broadcaster (I16) said, "There was an event that . . . someone . . . lost their power . . . but they were getting the Twitter updates on their phone. . . So they kind of knew what was going on even though, they weren't able to see it on TV." The viewer's story epitomizes the definition of relative advantage. A morning meteorologist in a large market (I16) also noted one advantage of using the social networking giant. "[We] basically use [Twitter] as a tool for helping people that have their cell phones and check Twitter for the latest warnings or that kind of thing, kind of as another way of reaching out," they said. Like internet and radio simulcasting, it could be another severe weather information source for people.

Observability - Viewer. One participant noted that she tries to market their use of Twitter to viewers. The broadcaster (I14) commented, ". . . one of the things that we have on our website is a little link that says, right here [points to link], 'be sure to follow us on Twitter.'"

6.1.5 Other Tools

In addition to the new forms of media above, some participants mentioned using other tools such as a web cam, Skype, and digital sub-channels to gather or disseminate information during severe weather. Some stations had a weather blog, but none of the participants utilized it during severe weather. A couple participants mentioned having used it once or twice but that they were unable to keep up with the workload as soon as the NWS issued severe thunderstorm and tornado warnings. A few participants mentioned that blogs can be useful for post-event analysis, however.

The use of all of these tools seemed to be dependent on the fact that broadcasters do not have to commit to using them and that they can use them on a trial basis. Trialability is the most prominent attribute of these tools, at least at this stage in the adoption process.

Trialability - Broadcaster. One station was considering using a web cam during severe weather. A broadcaster from a large market (I13) said, "We are toying with putting a web cam in the, weather center . . . with a microphone. Um, so that during a severe weather event we could be streaming live and you could hear what the meteorologists were talking about." A weekend meteorologist in a small market (I17) mentioned the possibility of using Skype, a free online video chat tool, to relay information. He noted, ". . . we've been trying to do some ah, video from the field as well . . . We've been trying to use Skype and, I think we've had some success but . . . we're not utilizing like we could be." The final tool broadcasters mentioned was utilizing the digital sub-channels that have been available since the digital conversion. While a few participants mentioned putting severe weather coverage on their sub-channel from time to time, it was not clear how the industry as a whole plans to utilize the technology. One participant said his station only uses the sub-channel during the most dangerous events. He (I7) stated, "[It is] only [used] in the extreme events. I mean [if there's] one tornado warning no, we're not gonna go on [our digital sub-channel]." The digital sub-channel may allow broadcasters to cover severe weather extensively without angering viewers (many stations get angry calls from viewers when they interrupt programming); those who need the coverage can watch it on the sub-channel and those who do not need it can watch regular programming.

6.1.6 Adoption Barriers – Broadcaster

Broadcast meteorologists were using many new forms of media to gather and disseminate severe weather information and examples of innovation attributes were evident, yet there were substantial barriers to adopting these media. The biggest barrier to adopting new media for the broadcaster was limited resources (37). Information overload (8) was also a prominent barrier. Competition (2), differences in NWS weather forecast offices (2), liability (2) and logistics (2) were minor barriers.

Limited Resources. The biggest barrier to adoption was limited resources, both physical and financial. The broadcaster's time and station's money are being stretched in order to cover many forms of media. Failure to adopt is due to either the broadcaster not having enough time (and the station cannot afford to hire another person) or the station not having enough money to support the technology. For example, some stations in this study did not have enough bandwidth to support internet simulcasting. In addition, most stations did not have enough money to employ their own storm spotters and pay for the equipment required to support that type of operation (live radar, video feed, etc...). Limited resources were especially prominent in smaller markets where stations have smaller staffs. Some larger stations have four, five, or even six meteorologists, but that is rare. Most have three, which often means that during severe weather coverage only two people are present at the station because one has to be ready for the morning newscast the next day. One weekend meteorologist from a small market (I17) commented on this issue:

> . . . in severe weather like, we're now expected to update the crawls, update Twitter, update our website, go on to TV, call radio stations in our, our network, and then send out other forecasts to other radio stations . . . It is too much, for a staff as small as we have.

A morning meteorologist from a medium market provided similar sentiments. They noted, "[doing all these things] gives us less time for everything, less time for forecasting. Your, whole day is just busier. Gotta get on the radio, you gotta get on the Internet and update that site, you know that's, 30 minutes gone out of your forecasting." Keeping up with technological changes takes time away from one of the major duties of a broadcaster: forecast.

Of the original media this study was designed to investigate, severe weather blogs were the only form not being used during severe weather. While some broadcasters had blogs, they said they do not update them during severe weather because they do not have time. One chief from a medium market (I20) said:

> I do not do a weather blog. I know one station in town does one and his is pretty successful. Um, but we have not been asked to, nor do I really have the time to. If they ask me to, I don't know where I'll fit it in my day.

Another chief (I7) says they are not a "fan" of blogging because "people want that when there's weather happening. And unfortunately when there's weather happening, I'm busy doing, television." Blogging during severe weather was more of a hindrance to the broadcaster than it is helpful. Although Twitter and Facebook may not require as much of a time commitment as blogs, some broadcasters did not have enough time to keep them updated either. A morning meteorologist in a medium market (I8) put it this way. ". . . it's just one more thing for us to do. [laughs] I mean, there's already internet and radio and television. And now there's Twitter, too. And so it, it's possible to stretch yourself too thin."

Information Overload. Aside from limited time and money to support all of the new media, it can be difficult for the broadcaster to process all of the information. This is especially true during severe weather coverage when they have many things to monitor (radar, NWSChat, multiple storms, etc…). While new media have the potential to increase efficiency, the amount of information available to a broadcaster can also be overwhelming. Sometimes it is difficult for the broadcaster to sort through, process the information, and know on which information to focus. A morning meteorologist in a large market (I13) explained, ". . . the more data I have available to me the more I look at and maybe sometimes the more confused you make yourself." A chief from a medium market (I12) made a similar remark. He stated, "There's a lot of information available [and] at times it feels like too much." Despite these negative comments, both of these meteorologists also acknowledged that the positive aspects of information availability outweigh the negatives. In addition, they preferred the current situation to that of the past, because technology has improved forecast accuracy and made severe weather coverage easier.

Competition. A couple of broadcasters mentioned competition as a barrier, but it did not appear to be affecting the actual adoption of media. The comments applied to the NWSChat in that there is the potential for stations with more resources to withhold information from those with fewer resources. Another broadcaster noted however, that if broadcasters' ultimate goal is to save lives it should not be an issue.

While the aforementioned issues can prevent broadcasters from adopting new media, broadcasters also made a few comments pertaining to audience barriers. While these issues were not as prominent as the issues affecting the broadcasters, they were still noteworthy. Limited resources (4), information overload (2) and awareness (2) are three audience barriers perceived by the broadcasters.

6.1.7 Adoption Barriers – Viewer

Limited Resources. Not only do broadcasters have limited resources, but viewers do as well. In 2009, 60% of American adults used broadband internet at their home and 46% owned a laptop (83% of which connected wirelessly) (Rainie, 2010). Nineteen percent of internet users were using Twitter or another status update service in October 2009 (Fox, Zickuhr, & Smith, 2010). So, while new technology allows broadcasters to disseminate life-saving information through multiple internet platforms, broadcasters have to keep in mind that there are still millions of Americans who do not have access to the technology. A chief in a medium market (I9) illustrated this point:

> The downside of this [internet streaming] of course is that not everyone has broadband, and in fact the populations that are least . . . likely to have it are among the most vulnerable. Obviously those who are on the lower end of the economic stratus are least likely to have broadband, and on the other hand the rural population, is the least likely to have broadband.

Thus, many people are unable to reap the benefits of new technology, and TV stations need to take that into consideration when deciding what tools to use to disseminate severe weather information.

Information Overload. The broadcasters were also concerned that the viewer can be overloaded with information. When asked about whether the amount of available information affects a viewer's decision one broadcaster (I9) commented, "Yeah, absolutely. Information overload, um, I think is a very real concern." This participant went on to describe how broadcast meteorologists in their area pushed to raise the severe thunderstorm warning criteria to decrease the number of warnings and hence, the amount of information that viewers have to process.

Awareness. Another viewer barrier might be that the audience is unaware of the information sources available to them. Some people may be more or less likely to adopt solely because of their age. A chief in a medium market (I9) brought up the issue:

> You've gotta take into account . . . generational differences. I think we're seeing, much greater differences generationally, then we were 10 years ago. And part of that is the proliferation of new technology, which has

been adopted more readily by younger people, less readily by older people and so that, generationally there's a, a growing gap.

There is potential for new forms of media to be adopted in the broadcast meteorology industry, although the aforementioned barriers may slow the process. New media are not the only innovations available to broadcasters, though. Data from NWS dual-pol radar will be available to DMA's beginning in spring 2011.

6.2 Dual-Polarimetric Radar Diffusion

6.2.1 Knowledge and Understanding of Dual-Polarimetric Radar

Participants were also asked about their knowledge of dual-pol radar and whether they plan to use the information behind the scenes or on-air. Their knowledge ranged from not having heard of it to having fairly extensive understanding of the topic, but the majority had heard of it and were aware of the horizontal and vertical polarizations (Table 6). While some broadcasters were somewhat aware of the benefits, many were unable to provide specific examples.

Table 6: Broadcasters' knowledge pertaining to dual-polarimetric radar. *These categories were compiled qualitatively. ** h = horizontal polarization, v = vertical polarization

Dual-Polarimetric Radar Knowledge	# of Participants
Unaware of it*	2
Had heard of it, knew about h & v**, but not aware of benefits*	7
Knew about h & v, aware of some benefits*	8
Extensive knowledge*	3
Aware of NWS Upgrade	16

In a few instances, some broadcasters stated inaccurate benefits. Only a couple broadcasters seemed very comfortable with the subject. Sixteen out of 20 broadcasters (80%) were aware of the NWS upgrade.

6.2.2 Innovation Attributes - Broadcaster

Broadcasters' comments reflected their uncertainty about using dual-pol products in the future, but some facets of innovation attributes were apparent in their responses. Unless the TV station owns a dual-pol radar, the technology is not yet available to them. Since the participants have yet to use any of the data they often had to make assumptions to answer the interview questions. Only one example of compatibility, complexity, and observability was found. The compatibility example came into play when one broadcaster discussed the need to have ready-made graphics during severe weather coverage that explain dual-polarization. A morning meteorologist in a large market (I16) spoke of complexity when he mentioned that one reason for using the technology may depend on its simplistic nature. A small market weekend meteorologist (I6) showed an example of observability when she spoke of her knowledge of one station already having their own dual-polarimetric radar and the benefits it has given them. Despite these examples, relative advantage (14) was overwhelmingly the most common innovation attribute of dual-polarimetric radar from the broadcaster's perspective.

Relative Advantage. Although the broadcasters in this study did not have a complete understanding of dual-polarimetric technology, some understood there will be some benefits over the current, single polarization, and that might motivate them to use the technology. A weekend meteorologist in a small market

(I6) commented on the benefits of the radar, saying "it can show you so much more than the regular radar can just because it's got the horizontal and vertical, and you can get so much a better idea of the storm." The same broadcaster continued to show enthusiasm for the topic, stating, ". . . having another tool like that to work with would be just awesome and, I think it would expand . . . knowledge, especially of systems that are passing through and you have a better idea of what's going on." The broadcaster perceived the technology to be beneficial over the current system. Another weekend meteorologist in a small market (I4) agreed that improvements on the WSR-88D would be helpful in their job. They noted, ". . . anything new, that expands on the addition of the previous radar . . . would be helpful, on-air, 'cause we're already showing it [the radar], so, any of the ways to make it better, the better we'll be." One chief commented about how this advantage might play a role in the likelihood of broadcasters adopting the technology. He (I7) said, "TV stations are in the business of…trying to…um have the latest technology and then have viewers care about seeing that technology." Dual-polarimetric radar will be the latest radar technology.

Aside from the advantages of being able to identify details in a thunderstorm, dual-polarimetric radar should also increase the accuracy of snow forecasting and snowfall estimates. One morning meteorologist in a medium market (I8) noted the advantage by saying, "Anything that can improve the whole snow forecasting game, will be helpful." The "game" this participant refers to is the fact that forecasting snow amounts for specific areas is very difficult, so any details the radar can provide would be very helpful to meteorologists.

Competition. Another attribute that may influence whether and how quickly dual-pol is adopted is competition. Five broadcasters said the competitive nature of the business may push the adoption process forward. One chief (I3) said, "everybody wants to look like they know the most or have the most." Another chief (I7) noted that his TV station is always looking to show new radar products on-air, and a morning meteorologist (I6) said that if they were the first to have a dual-pol radar in their market it would set them apart from the competition.

6.2.3 Innovation Attributes – Viewer

Overall, the biggest theme for the broadcasters' use of the dual-polarimetric data was that it will have to be in a format that is simple and valuable to the viewer. There were 10 instances of the perceived need for the technology to be advantageous for the viewer. In addition, broadcasters mentioned the need for the technology to be simple enough for viewers to understand seven times. Since it is not yet available, all of the broadcaster's comments pertaining to the viewer were about the *need* for dual-polarimetric radar to be advantageous and not complex, not necessarily the fact that it will or will not possess those characteristics.

Relative Advantage. Many broadcasters spoke of the need for dual-polarimetric information to provide added value to the viewer if it is to be used on-air. This is another form of relative advantage. One chief (I9) was very adamant about the need for dual-polarimetric radar to be useful for the viewer. He had many questions about this innovation. "What is dual-pol gonna *look* like on TV?

How will we take that data and repackage it to make sense to people? I think [those] questions are still out there I think the vendors are still looking at these issues."

Broadcasters gave examples of how they would like to show dual-polarimetric information to viewers and the benefits it will provide. A weekend meteorologist in a small market (I1) had a clear understanding of some of the benefits of dual-polarization:

> Here we would have a way, a radar product . . . to say, "Okay, this color, is hail, and on the outside of this color is small hail, and on the outside of that is, you know, heavy rain." And being able to identify, very specifically, what the different regions in the thunderstorm are doing would be a good thing.

A chief in a medium market (I12) described the kind of information he needs that in turn, would benefit viewers. "What I want to do is come on there and say, 'Okay, we *know* we have *heavy*, marble sized hail falling at this location.' Or, 'we have rainfall rates falling at six inches per hour. That really *is* six inches per hour.' Right now it's a guess." Being able to give viewers very specific hail or rain rate information may help them make better decisions. A morning meteorologist in a large market (I13) gave their opinion on what the products will look like. "I think that most frequently it would be utilized in just a color table sense. And we can paint different colors to show sleet versus freezing rain. Rainfall rates and stuff like that."

Complexity. Another innovation attribute that surfaced for viewers was complexity. Although there was a lot of uncertainty among the broadcasters as to how they will be able to use the product behind-the-scenes (discussed as an awareness barrier in the section below), most of the responses pertaining to the complex nature of the product were focused on the audience's understanding rather than that of the broadcaster. Because the broadcasters were uncertain about how the dual-polarimetric information would be visualized, it was sometimes difficult for them to describe how they would use the data or educate their viewers about the technology. One chief in a medium market (I13) noted, "I think [I would educate the viewers] if it's just a simple display and the concept is, 'is it rain or hail,' that's a simple thing. The velocity becomes more of...an issue because the velocity, it's going to and from the radar." Another chief in a medium market (I7) agreed that dual-pol products need to be in a format that is relevant to viewers. "I mean show it so viewers can understand that," he said. A weekend meteorologist in a medium market concurred. He commented, "Yes [I would show it on-air], but it depends on the simplicity of it." While some innovation attributes were present in their responses, many of the broadcaster's remarks focused on barriers to adoption.

6.2.4 Adoption Barriers – Broadcaster

Several barriers to adoption emerged in the responses of the broadcasters. The most common barrier was awareness (17) of what the dual-pol product(s) will look like and how they would be able to be used on television. Limited resources were another barrier (12), followed by one instance of information overload where a chief (I12) thought there would be too much information available for the broadcaster to have enough time to decipher all of it in the amount of time available to them.

Awareness. Some broadcasters were very excited about the potential analysis benefits of dual-polarimetric radar, on-air and behind the scenes, but their limited knowledge hindered them from giving specific reasons for using the data once it becomes available. Lack of knowledge and uncertainty about the data and its usefulness seemed to be the biggest obstacle to adoption. Prior to using the information on-air, broadcasters will need to learn how to analyze and interpret the data accurately themselves. A weekend meteorologist in a small market (I6) said:

> Ah [whether I would utilize the dual-polarimetric information], depends on the situation and how comfortable I am . . .initially it might be a little tough and I'll probably still use it on-air but use it sparingly until I felt comfortable enough explaining what exactly that, the people are seeing, what I'm showing.

The lack of awareness of the technology led some broadcasters to discuss the importance of being educated about the topic. One weekend meteorologist in a medium market (I15) said, "So for a while, especially the TV guys are gonna have to, 'Okay, what are we seeing with this thing?' You know, 'What is this?' There's gonna be this big educational things that's gonna have to be done." A chief in a medium market (I9) also commented about the need for education on the subject.

> …I am dying to know everything I can about this. Do I know what it is? Yes. Do I know what it's supposed to do? Yes. But analyzing it, in real-time? On television? In front of an audience? Man I need all the information I can get.

Limited Resources. Another prominent potential barrier to adoption was limited resources. Time and time again, broadcasters brought up the poor economy and general status of the television industry as reasons that might keep them from embracing the new technology without the help of the NWS. As one broadcaster (I3) noted, "We, contemplated trying to get [a dual-polarimetric radar] here . . . to be the first, or the only people to have dual-pol, in [this state]. But, the economy being what it is . . ." Unlike the 1990s where many TV stations were able to purchase their own Doppler radars, stations today are probably going to have to rely on the NWS for dual-polarimetric data for quite some time. As one weekend meteorologist (I15) put it, "you know, I think [the NWS or vendors] were expecting TV stations to line up for [dual-pol radars] and . . . I don't know if that's gonna happen [because of] budgets." One chief (I20) also noted that some stations are privately owned whereas other stations are a part of a chain which can sometimes be an issue. If one station in the group wants to upgrade, they have to wait until there is enough money for the rest in the group to upgrade as well.

In addition to money, time was also a limited resource that may affect the adoption rate of dual-polarimetric radar. As one participant in a medium market described, there are so many tasks that broadcasters must complete everyday (e.g., forecast, prepare graphics, visit schools, call into radio stations) that it can be difficult to find time to learn about new technology. They said the best way to diffuse the information would be to have local NWS forecasters visit broadcasters at their stations. A morning meteorologist in a medium market (I13) also noted that time may not allow them to do the detailed analysis that is necessary to utilize the dual-polarimetric information to its full capacity:

> We are somewhat limited by the amount of time we have on a given day to actually put stuff together... I know that my news director is not gonna

> give me an extra 30 seconds for every weathercast because we have this cool, new dual-pol radar, ah network set up.

One chief (I12) summarized the state of the industry, saying, "[the NWS has] the people, *they* have the resources to evaluate dual-polarization. Individual television stations do not, at all." Broadcasters were looking toward the NWS to lead the initiative.

6.2.5 Adoption Barriers – Viewer

In addition to barriers on the broadcaster's end, there was also a perceived barrier on the viewer's end. Seven instances of complexity were apparent in the interviews regarding dual-pol information and the fact that it may be too complicated for viewers to understand.

Complexity. If dual-polarimetric data is not provided to viewers in a way they can understand, complexity will be a barrier to adoption. A morning meteorologist in a large market (I16) said one of their biggest questions is how the information is going to be displayed in a way that makes sense to the viewers. Another chief (I20) stated, ". . . it's gonna be a great tool to have. . . . [but] you don't want to confuse the viewers." When asked about how they would educate their viewers, broadcasters had varying responses and some comments related to the ability of the viewers to understand the information. One participant (I10) commented that it will be difficult to educate because the audience is not "scientific minded." Another participant (I18) compared the introduction of dual-polarimetric data to the introduction of velocity with the addition of the WSR-88D's almost two decades ago. "People don't even understand velocity," they said. They continued, "I think it's gonna take some time [to educate]. The public's not gonna understand it." If dual-polarimetric information is too complex for viewers, it will probably not be shown on TV.

6.3 3DVar Diffusion

6.3.1 Potential 3DVar Usage

The operational implementation of dual-polarimetric radar will occur in the near future, but a product like 3DVar that is based on an infrastructure of a dense radar network will not be available for many years. Despite the time lag, participants offered their opinions as to whether and how they might use the product. There was a general consensus among the broadcasters that 3DVar would be helpful to them behind the scenes and that they could use it as a diagnostic tool. There were differing opinions however, as to whether the product, at least in its current form, was simple enough or too complex to be shown on-air.

6.3.2 Innovation Attributes – Broadcaster

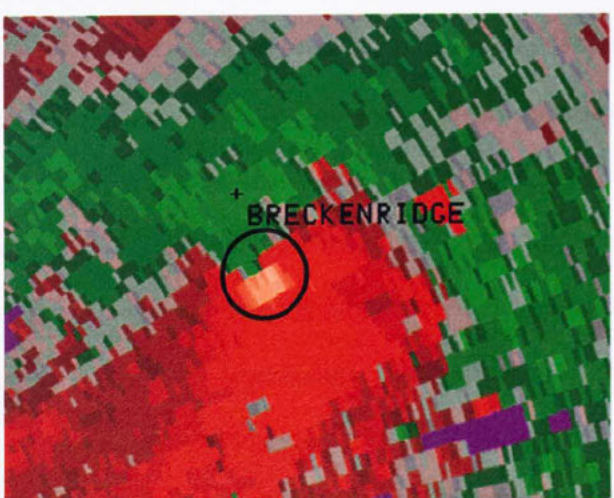
There were two instances of complexity and one instance of compatibility and trialability attributes from the broadcaster's perspective. Compatibility was addressed when one broadcaster (I10) noted that a product like 3DVar should be incorporated into weather vendor software. Another broadcaster (I3) honed in on complexity when the said the product would be "rather easy to explain." The same broadcaster also addressed an element of trialability because he noted that the product would only be used in "strong wind or meso[cyclone] development." The most prominent attribute, however, was relative advantage (15).

Relative Advantage. Some broadcasters said 3DVar could be advantageous in identifying mesoscale boundaries (assuming a dense radar network) compared to the current NEXRAD infrastructure. One chief in a medium market (I7) said:

> Sure, [3DVar] would be extremely helpful in looking at severe storms. We are always looking for the boundary and if storms are getting ready to cross a boundary to see if a tornado circulation will spin up. Sometimes fine lines will show up on our radar or NEXRAD [the WSR-88D network], but sometimes not . . . [3DVar] certainly defines boundaries with the wind vectors.

In addition, some broadcasters felt the product would be better to show on TV than the traditional storm relative velocity (SRV) products (Figure 5) with red and green pixels because small-scale circulations are more easily identifiable. One morning meteorologist in a small market (I5) noted:

Figure 5: Example of the storm relative velocity (SRV) product showing a couplet indicating tornadic circulation in Texas. (Image credit: National Weather Service Weather Forecast Office-Dallas/Fort Worth http://www.srh.noaa.gov/fwd/?n=april 09102008)



> It could easily replace SRV. In a case where we have a good couplet to show on-air the met must take time explaining what a couplet is. [3DVar] more or less shows graphically with the wind vectors what a couplet cannot, circulation.

So, from this broadcaster's perspective, using 3DVar could potentially save precious on-air time because they would not have to explain SRV.

6.3.3 Innovation Attributes – Viewer

Similar to new media and dual-polarimetric radar, broadcasters not only considered the impact of the 3DVar product on themselves when evaluating it, but to viewers as well. Two attributes were noted, complexity (7) and relative advantage (2).

Complexity. Some broadcasters felt that viewers would be able to understand the product. A chief in a medium market (I3) said they would consider showing the product to the public because it "is a much easier way to understand the winds in and around a storm." Another chief in a medium market (I7) agreed. "I think we could show it on-air…it's pretty normal looking reflectivity with wind vectors, you should be able to explain that to average folks." "People understand very simple lines like arrows," said another chief (I18). Broadcasters had differing opinions as to whether the product could replace the need to show SRV on-air. One broadcaster (I7) thought that 3DVar would be easier for the public to understand. "It might be good in place of the storm relative velocity product...folks don't always get the green/red toward/away. This gives them colors that they are more familiar with, yet pinpoints the area of the tornado," he said.

Relative Advantage. In addition to some broadcasters believing 3DVar would be easy for viewers to understand, a couple broadcasters also thought it would be advantageous for the audience. One advantage would be indirect. As a weekend meteorologist in a small market (I6) explained, using 3DVar might lead to more detailed information for viewers:

> [The product] does get a bit busy, but as an analytical tool, it would assist me in . . . being able to see where some stronger areas of rotation are *and therefore be able to inform the public where I think the more dangerous areas of the storms are* (emphasis mine).

Thus, not only could the product be beneficial for the broadcaster, but also the viewer.

6.3.4 Adoption Barriers - Broadcaster

No overarching themes emerged from the broadcaster's comments pertaining to adoption barriers however some participants did mention reasons why they might not use the product. For example, one broadcaster in a large market (I14) said she does not always have the time to complete in-depth analysis during a severe weather outbreak, so analyzing 3DVar may not always be feasible. The same participant said 3DVar might contain too much information to absorb during a major event. Another broadcaster in a large market (I13) agreed, saying that since TV meteorologists are providing a service to an audience across a wide geographic area, they do not have time to analyze each storm so intensely. 3DVar may provide more detail than they can handle.

Two broadcasters also brought up the issue of resolution differences between computers and TV. One of them said, "I can see it being used on-air if the arrows were thick enough, two or three pixels wide, where they would look good on a home television screen. Computer monitors are much higher resolution than TVs in most cases." Thus, while 3DVar provides excellent detail, it may not be possible to show that detail on TV.

6.3.5 Adoption Barriers – Viewer

Complexity. Aside from one instance of information overload, the only consistent barrier that surfaced in the broadcaster's perception of the viewer was complexity (8). As previously mentioned, there are differing opinions among broadcasters as to whether the 3DVar product would be appropriate for television use. One morning meteorologist in a large market (I16) said the product "might be a little complicated . . . for the viewer with all the arrows." Another large market meteorologist (I13) said that the graphic is "just way too busy" and most viewers would not understand the image.

3DVar could have the potential to replace the traditional SRV products on-air because it shows wind vectors. However, one weekend meteorologist from a small market (I6) thought 3DVar would confuse the viewer more than SRV.

> I don't believe this product would be a good thing to swap out in place of SRV simply because with SRV, there's only green and red. People can grasp the "towards the radar, away from the radar" concept because there are only two colors and thus less going on. This product has 360 degrees of possible wind direction and thus it looks like a more complex image, and if motion was added into it, it'd be even harder to explain on air *and harder to understand as a viewer* [emphasis added].

The conflict between the innovation attributes of relative advantage and complexity and it being *too* complex make it difficult to know whether 3DVar would be an appropriate tool to use on-air.

6.4 Opinion Leaders

While this study was not explicitly designed to focus on the influences of opinion leaders on the diffusion process, some interview evidence suggests that opinion leaders have played and will play a role in the diffusion of new media and radar technology in the broadcast industry. For example, the NWSChat was developed by a group of individuals (the leader was not associated with the NWS) prior to being managed by the government. The researcher's experiential knowledge also suggests that individual broadcasters may influence one another's adoption patterns because the broadcast meteorology field is relatively small. Some broadcasters, while on TV may appear to be total strangers, actually know each other quite well. For example, one broadcaster mentioned hearing about a colleague in a different market placing a webcam in his station's weather center during severe weather so that viewers could see what was happening when the broadcaster was not interrupting programming.

6.4.1 New Media

Based on the interviews, opinion leaders have not had much of an influence on broadcasters adopting new forms of media. There were only five instances where the participants implied that an opinion leader influenced their decisions to use new forms of media. In the case of NWSChat, one broadcaster (I9) described a "summit meeting" held with other broadcasters and NWS forecasters to discuss the use and understanding of the tool to utilize it most effectively. If the meteorologists who came up with the idea had not initiated it, the relationship among those in that part of the country may not be as good as they are now.

Another broadcaster (I3) discussed the importance of their weather vendor in their ability to communicate during severe weather. The participant said he is more dependent on his weather vendor for information than in the past. Most, if not all stations have contracts with weather vendors that provide weather information for them, sometimes in paper form and even more so now on the Internet. Thus, sometimes broadcasters look to their weather vendors to determine the "next best way" to communicate their messages.

6.4.2 Dual-Polarimetric Radar

Opinion leaders may, however, play a very large role in whether and how the broadcast industry adopts dual-pol radar. Participants referred to the influence of an opinion leader in 32 instances while discussing dual-pol. The biggest opinion leader was the NWS. The NWS is playing a major role in the implementation of the dual-pol radars, and without their network most broadcasters will be unable to access that type of data. Most broadcasters do not have their own resources to gather dual-pol information, so they are counting on others to provide the information to them. Broadcasters are relying on the NWS to educate them on the topic. One chief in a small market (I18) commented on the need for training:

> I mean I think every single, ah Weather Service office needs to provide it. . . You're gonna have to have one person out at these Weather Service offices that holds a workshop . . . for all the meteorologists that want to come, especially the TV meteorologists there. So make sure . . . everyone's on the same page. You know because really, truly like I mentioned earlier, the TV folks are the ones that get the Weather

> Services' name out there. So I think . . . you're gonna have to work together . . . to make sure we all get what's going on.

Many broadcasters spoke highly of their relationship with their local NWS offices. A few broadcasters cited instances where their local NWS office had invited them out for a visit for other topics and they expected them to do something similar for dual-pol. A chief in a medium market (I7) also noted that the American Meteorological Society (AMS) often provides useful information about new concepts or technology, but hands-on learning is the most effective method. He said:

> The Weather Service here does a pretty good job of inviting people ah to come out. They usually have, training sessions on things and then we invite ourselves out there or they'll invite us . . . You know the AMS has put a lot of stuff out there now that ah, is good. Online tutorial kinda things. [But] there's nothing that's, as good as sitting with a Science Operations Officer. . . of the Weather Service, talking to 'em.

Private industry organizations such as weather vendors may also be an opinion leader because broadcasters use their graphics and radar data during severe weather. Some participants assumed that weather vendors will be in charge of processing dual-polarimetric data to make it suitable for TV. One morning meteorologist in a large market (I16) noted:

> I'm assuming [our weather vendor is] . . . working on algorithms to be able to display Weather Service data. Yeah. And I'm sure they're working with the National Weather Service. Whatever they come up with to display on their AWIPS [Advanced Weather Interactive Processing System] and on the Internet, then I'm sure [our weather vendor] will try to do something similar for their algorithms.

A few participants said they will also be looking to colleagues, conferences and specialty magazines for information on dual-pol radar.

6.4.3 3DVar

The participants did not provide any direct evidence about the role of opinion leaders in the potential adoption of a product like 3DVar, perhaps because of the way the questions were structured. However, the comments surrounding the other innovations show that weather vendors, and the NWS if applicable, will probably play an important role in adoption.

6.5 Diffusion Discussion

One of the most noteworthy findings of this study was a double-diffusion process. While some diffusion studies have focused on diffusion from the perspective of the user *or* the customer, little to no studies have documented diffusion from *both* perspectives simultaneously. Not only were the broadcasters concerned that the innovations were useful to them, they were also concerned that the innovations were useful to their viewers. Part of this concern may be influenced by the fact that ratings increase when viewers watch their coverage, and higher ratings lead to increased revenue. An innovation might be beneficial to the broadcaster but something that benefits the viewer has a better chance of being adopted because it is more advantageous to the TV station overall. The pressure of high ratings is even more apparent in a day of declining television ratings and where people can receive severe weather information from multiple sources. Broadcasters are constantly competing for viewers and some are trying to get them in any way possible. This study shows that diffusion of innovation can be a very complex process.

Despite the competitive nature of the business, most of the broadcasters in this study are also concerned about providing the most accurate, informative coverage to their viewers to keep them safe, and possess a team mentality when a potentially deadly situation presents itself. Aspects of diffusion theory are playing a role in the adoption of new media and radar technology in the broadcast industry. This study shows that for an innovation that was further along in the diffusion process, relative advantage was the most important attribute. Although compatibility, complexity, trialability and observability were also influential, relative advantage had the greatest influence on the broadcasters' adoption of new media. For an innovation that had been almost or fully adopted, limited resources were the biggest barrier.

Opinion leaders were very important for innovations that have not yet been adopted. These leaders provide the potential adopter an example to follow and help dispel uncertainty, something that may stunt the diffusion process. Aside from opinion leaders, relative advantage and complexity were also influential in the adoption process for innovations that have not been fully diffused. Awareness of the benefits of the innovation was the main reason for slowing the diffusion process, followed by limited resources and complexity. Complexity barriers were especially influential for the customer. If the user felt the product was too difficult for his/her customer to understand, it limited the adoption of the innovation.

6.5.1 New Media

Relative advantage was by far the most prominent innovation attribute of new media from the broadcasters' perspective of themselves and viewers. While the amount of information available on the Internet can sometimes be overwhelming, the positive aspects of the media outweighed the negative. The ability to access more precise weather information and communicate more effectively with other meteorologists during severe weather was advantageous to broadcasters. Compatibility was the second most prominent attribute. Although the use of new media requires more of the broadcaster's time and energy, the media, for the most part, are compatible with their systems and require little training. Complexity, observability and trialability of new media were less important to broadcasters, but that does not mean they are not part of the diffusion process. The limited number of comments regarding complexity may be a result of the broadcasters rarely discussing the technical aspects of the media in addition to proof that they are farther along in the adoption process. The broadcasters' might not have discussed observability because they assumed their competitors were using the same tools. Trialability had some influence on the broadcasters' adoption of new media, perhaps because, aside from bandwidth costs, it is relatively inexpensive to use the innovations. Thus, it automatically provides an opportunity for broadcasters to use the media on a trial basis.

The new medium that seemed to have the greatest impact on the broadcast industry was the NWSChat. According to the broadcasters interviewed, NWSChat is the best communication tool that has been introduced in the industry in a while, has simplified the warning process, and gives broadcast meteorologists more direction for their severe weather coverage because they can receive behind the scenes information from the NWS. Another benefit of NWSChat is that it is easy to use and does not require much training. In an environment where broadcasters are already strapped for time, it helps them provide better information to viewers.

As long as a station has enough bandwidth and someone to oversee the streaming, internet and radio simulcasting are fairly simple processes that require little brainpower from the broadcaster. The biggest advantage of internet and radio simulcasting is actually to viewers. The mediums provide an additional information source for people, which is advantageous over the traditional TV-only severe weather coverage model. Simulcasting provides viewers with an opportunity to watch the coverage at work or listen in their cars. This is especially helpful if they have children in school and are concerned about their safety. Simulcasting also allows people to watch coverage when taking shelter. Instead of having to rely solely on audio information from a radio, for example, it is possible that they can bring their laptop to their safe place and continue to stay informed in a life-threatening situation.

Few instances of innovation attributes were apparent in the context of the mediums that were not being used by the majority of the participants such as social media, storm spotters, and blogs. It makes sense that if a broadcaster does not use the medium they are not going to be able to talk about it very long or give examples about its use. So, while it may appear that this shows a lack of support for diffusion theory, it may not necessarily be an accurate assumption.

Despite the new media innovation attributes, there were also barriers to adoption. Limited resources and information overload were the most common barriers to adopting new media. Lack of financial resources and personnel hinder some broadcasters from disseminating severe weather information in any way they see possible. The amount of information they have available to process can be overwhelming, yet the competitive nature of the business and their genuine desire to inform people as best as they can when severe weather is imminent motivates them to seek information. Opinion leaders did not play much of a role in adopting new media for the participants in this study.

6.5.2 Dual-Polarimetric Radar

The most prominent innovation attribute in the potential adoption of dual-pol radar was relative advantage for both broadcasters and viewers. The new radar technology will provide more detailed information about precipitation type, size, and amount, which should benefit both parties. Broadcasters also found complexity to be a very important attribute for the viewers. If the information is too confusing for the layperson, broadcasters will not be able to show it on-air or will only use it sparingly. One reason why compatibility may not have been explicitly mentioned by the broadcasters may be due to the fact that they assumed their weather vendors are going to incorporate the products into their systems, so there would be no need for an additional system. If this assumption was true, broadcasters would be less likely to discuss compatibility concerns.

Since dual-pol technology has yet to be released into the field, a lot of training is necessary for broadcasters to be equipped to use it accurately and effectively. The biggest barrier for broadcasters to adopt dual-pol radar was awareness, which was consistent with one finding in Veil (2010). Broadcasters need to be educated about how to interpret the data because many were unsure about the exact benefits of the radar and/or how they could incorporate it into severe weather coverage. Another significant barrier was limited resources, such as the broadcaster's ability to have time to learn about dual-pol as well as the station to have money to purchase their own radar. The broadcasters stated that they do not see their stations purchasing their own radars anytime soon, so they will have to rely on data from the NWS.

Opinion leaders will likely play a much larger role in the adoption of dual-pol technology than they do for new forms of media. Broadcasters are relying on the NWS to provide dual-pol data. Although a few of the participants were very interested in the topic, time and financial barriers will hinder them from studying the topic extensively. Most of them were very eager to work with their local NWS Weather Forecast Office (WFO). Many said they have great relationships with their WFO and look forward to any information that will be provided to them. Weather vendors were another opinion leader, as broadcasters will rely on them to incorporate the data into their radar and graphic systems. Some of the coping strategies (education and training, vendor support) were consistent with the coping strategies found be Benamati & Lederer (1998).

6.5.3 3DVar

Consistent with new media and dual-pol, the most important innovation attribute related to 3DVar was relative advantage. Many broadcasters were very enthusiastic about being able to see such small-scale features (realizing that the dense radar network must be in place). A few participants felt that 3DVar would save them time in trying to identify small-scale meteorological features. The product could also help the viewer understand where very small circulations are (e.g., tornadic), which might be more effective then showing them SRV. However, a couple broadcasters disagreed that 3DVar would be easier for viewers to understand than SRV. Opinions regarding the complexity of the product were almost split between whether the product was easy to understand or too complex for the viewer.

There was no prominent barrier to adopting 3DVar, although some broadcasters appeared to be in the mindset that the tool is "just one more weather product they would need to look at." The coding scheme does not show that opinion leaders would be an important part of the adoption of this product, however, the knowledge gained from the rest of the study may lead one to think that weather vendors would play an important role. Most broadcasters are not going to have time to use a completely separate system to look at the data so it would be necessary for the vendor to incorporate it into their system.

There were many factors that influence severe weather coverage. The broadcasters' experience, internal and external social pressures, and technology play a role in when they break-in and how long they stay on the air. Another factor that has not been studied very much is the influence of the public. Since the broadcasters are providing information to whomever is watching their station, they want to know how their viewers understand and interpret severe weather information. The participants were asked about their knowledge of their viewers' understanding and the questions they have regarding their understanding and interpretation. The results are presented in the next chapter.

Chapter 7: Broadcasters' Perceptions & Questions of the Public – Results & Discussion

7.1 Results

7.1.1 The Need to Research the Public

Sixteen of the participants said there is a need for researchers to study how people interpret severe weather coverage. Half of these (n = 8) participants were very enthusiastic about the topic. The remaining participants said they are interested but are not sure any information would change their job performance or did not answer the question as intended by the interviewer. One broadcaster mentioned that the most applicable research would be that which focuses on a particular DMA. Audiences are very diverse and a dissemination technique that works in one market may not work in another. Despite this predicament, most of the broadcasters acknowledged the need to research the public and their understanding and interpretation of weather information. One broadcaster in a large market (I13) explained the need by describing the gap between improving the science of meteorology and improving the understanding of people during severe weather:

> . . .while our understanding of how the atmosphere works, and our ability to predict it with a greater degree . . . of accuracy has improved, we're still using largely the same methods to get that forecast out to the public as we always did. We're still using things like "partly cloudy", and "scattered showers" and isolated "this." . . . there's gotta be sociologically, and psychologically, a better way to get that information across.

A small market morning meteorologist (I5) said that research on how people interpret TV severe weather coverage would help broadcasters "better identify with them." Broadcasters could communicate more effectively if they had a better understanding of the needs of their viewers. The need to research viewers also stemmed from the fact that broadcasters rarely receive constructive feedback from them. In fact, most participants noted that almost all of the feedback they receive is negative and usually has nothing to do with weather. One chief illustrated the point, saying:

> . . . you know what direct feedback we get? Negative. "Why'd you interrupt my show?" *That's* our feedback. Very rarely do I get, "That was a cool thing you had on radar. That helped me see exactly where the storm was." They don't call you or write you with good . . .advice.

A number of participants made similar remarks about their only feedback being viewers complaining about program interruptions. They rarely receive constructive feedback.

7.1.2 Broadcasters' Experiential Knowledge of the Public

In addition to asking broadcasters about the need to research the public, the participants were also asked about their understanding and knowledge of their viewers. The questions probed at their experiential knowledge to gain an understanding of severe weather concepts that are difficult to explain to people, messages that get people to take appropriate action, and the messages that broadcasters believe are most important to communicate during an event.

7.1.2.1 Difficult Concepts to Explain

The participant's responses pertaining to severe weather concepts that are difficult to explain were divided into three categories: vague severe weather, specific severe weather, and radar. A summary of each is below.

Severe Weather – Vague. Three participants responded to the question by noting some general severe weather concepts that are difficult to explain. A morning meteorologist in a medium market (I8) said that it is difficult for people to understand the meaning of "severe weather *potential* [italics added]." For example, meteorologists are able to narrow down the area of risk during a typical severe weather day, but there is room for error despite sophisticated forecast models. It can be difficult to pinpoint exact risks and/or impacts to particular cities and towns. The broadcaster said that people do not grasp this concept. "I think in some ways the public, expects too much accuracy as far as where the thunderstorms are going to be . . . several hours in advance," (I8). The public may have difficulty grasping the fact that although forecasts have improved and meteorologists are able to pinpoint threats more accurately, it is still hard to know exactly where the threat will occur, hours in advance. A small market weekend meteorologist (I1) also said that the public does not understand the *conditional nature of severe weather*. All but one ingredient can be in place, but if the last ingredient does not happen, storms may not ignite. ". . . you can have storms on a day when it's *50* degrees outside and you can have storms on a day when it's *100* degrees outside, and, it's very conditional. It's very complex. Another concept some broadcasters said is difficult for people to understand is *probabilities*. This issue has been heavily documented in the literature (e.g., Lipkus, Samsa, & Rimer, 2001; Peters et al., 2006). As a weekend meteorologist in a medium market pointed out, some people do not understand that even a low severe threat can be dangerous. The tornado threat may be "real low but it ain't zero," (I15). Although tornadoes may not be the main threat on marginal severe weather days, it only takes one tornado to destroy a town.

Severe Weather – Specific. Participants also gave specific examples of severe weather concepts that are difficult to explain. One participant (I6) said that people do not understand why a tornado warning can be issued even when a tornado has not actually been spotted. Another participant (I9) noted that people are unable to grasp how severe winds can cause damage just like tornadoes and that the presence of damage is not necessarily indicative of a tornado. He commented, "People do not understand . . . the threat [that] straight line winds produce."

In addition to tornadoes, one participant (I5) said that people do not understand the *meaning* of a severe thunderstorm. Lightning, heat bursts, and flooding were also topics of discussion. One participant (I9) said, ". . . I still think that people don't understand the power of water. . ." Another (I15) said that people do not understand the difference between a flood and a flash flood.

Radar. Several broadcasters discussed concepts related to radar in which they believe are difficult for people to grasp. A few broadcasters said they are not sure that people understand velocity data, let alone any radar mode other than reflectivity. A weekend meteorologist in a medium market (I10) said that the height of the radar beam is an issue because people do not understand that the radar looks higher into the storm the farther it is from the radar. They said they try to explain to the audience what the radar is really showing:

> During major tornado events I always try to say, "we are showing winds 50 miles per hour, 3,000 feet off the ground. It's hard to know if these winds are making it to the ground but this is what we know 3,000 feet up what the radar is seeing."

The same participant also commented that people also do not understand why a storm may look more intense on a radar that is closer in comparison to a radar that is farther away; again, the beam height issue arises.

Some TV stations have the capability of showing three dimensional volume scans of radar images, but one participant (I10) did not think people understand that type of image. A weekend meteorologist in a small market (I4) also noted that it is difficult to explain a hail shaft on radar because a two dimensional image is not conducive to showing the dropping hail shaft in the core of the storm. He mentioned that trying to explain it "might start to get a little too technical for people." A two dimensional image may also be problematic when trying to visualize a tornado.

7.1.2.2 Getting People to Take Appropriate Action

When asked about the kinds of verbal or graphical messages that get people to take appropriate action, 11 participants responded with verbal messages and 6 responded with graphical. One participant (I20) also mentioned that people seem to be more likely to take shelter when a storm has negatively impacted their town or family in the past, otherwise they might be complacent. Another participant (I15) thinks tornado sirens are still effective in getting people to take action. "Until the sirens are going off, people don't care"

Verbal. The most common verbal message the broadcasters said is important to convey when trying to get people to take appropriate action was *tone of voice*. Having a "calm but authoritative presence" and "conveying a sense of urgency through your voice" (I16) may be critical if warranted by the situation. One participant cautioned, however, that a broadcaster should not use the same tone for all events because it could lead to a cry wolf effect. He (I3) noted, "I don't want to say the same thing for every event because that just . . . waters down the big events. . . You want to save your most important, your *strongest* phrases, for your strongest events."

Using simple phrases like "you need to take cover now" may also be effective in getting people to take action. One broadcaster (I16) said they give viewers very specific actions to take, such as telling them to go to a "closet . . . a bathroom . . . or whatever room in your home is farthest away from the windows." Some broadcasters also said that noting specific towns, communities or subdivisions can also get people to take action, and repeating information should be standard procedure. Finally, a few broadcasters think that saying "tornado warning" or "tornado on the ground" is an effective message that conveys a sense of urgency.

Graphical. Broadcasters said that one of the strongest graphical messages can be showing video or pictures of a tornado or storm damage. Another participant (I7) said, "Seeing their county shaded in red" is a way to get them to take action because red is an alarming color. One participant (I14) also noted the importance of color and says that a "really red and really dark" radar image "speaks volumes." Using a storm track to show the cities that will be impacted by the storm as well as the time of arrival is also important because it lets viewers know who will be impacted and when. Finally, one chief in a small market (I18) said their station shows a simple graphic describing what people should do during a dangerous event. "But you can't show it all the time," they cautioned. "Because if you do I think it just totally neglects the urgency when you really, really need it."

7.1.2.3 Most Important Message to Viewers

The broadcasters made it clear that there are two main messages to communicate during severe weather: the *threat,* and *safety*. In fact, half of the participants responded to the question with messages pertaining to the level of danger. "What is it, where is it, and where is it going" one broadcaster (I10) said? For example, broadcasters said they need to tell people whether the hail is dime-sized or the size of baseballs, or whether the winds are 60 mph or 100 mph. Another participant (I5) stated that the message should be, "What is it, where is it, who is going to be affected, and for how long. If you can get all that out you can shut your mouth and your audience can go back to, watching their show." A morning meteorologist in a medium market (I19) also noted that it is important to tell people when they need to take the situation seriously and when they do not have to worry about it anymore. "I think when the storm passes people *still* don't realize that they're kind of in the clear," they said.

In addition to the danger at hand, broadcasters also said the most important message is to tell people what they need to do to keep themselves safe. "I mean when it comes down to it, we're providing a public service," a large market morning meteorologist (I13) responded. One small market meteorologist (I17) also noted that it is important to tell people when they do not need to do anything, either because the dangerous part of the storm will clearly miss them or the threat is not that substantial. If the main threat is 60 mph winds, for example, there is not much a person can do aside from pulling the patio furniture into the garage and staying away from windows. Two broadcasters also noted that it is important to encourage people to have a plan before the storm hits so they do not have to make potentially life or death decisions in a matter of minutes.

7.1.3 Salient Research Topics

Broadcasters use their experiential knowledge to provide coverage they think is beneficial to viewers. However, the lack of feedback they receive can hinder them from communicating effectively. Most broadcasters do not have the resources to research their viewers' understanding. The participants were given an opportunity to provide research topics pertaining to public understanding, interpretation, and action that are salient to them. Table 7 lists a complete record of topics, and a summary is provided below. Some broadcasters provided specific questions, while others covered broad areas. For example, three broadcasters wanted to know how technical they can be on-air. One chief wanted to know the most effective way to present a forecast, and a weekend meteorologist would like specific feedback on phrases they use during weathercasts or severe weather cut-ins. Three broadcasters were interested in whether people understand what slight, moderate, and high risk means. Four broadcasters wondered whether people understand the watch/warning terminology and one participant says that if people do not understand the current terminology perhaps it should be changed.

7.1.3.1 Viewer Preferences

The most common interest of broadcasters was understanding what viewers want out of their coverage. Nine broadcasters responded this way. Two participants (I16, I18) would like the know the 1st, 2nd and 3rd thing people want to hear during coverage as well as the last thing they want to hear. Two others (I8, I10) were interested in knowing how much coverage to give an event. A morning meteorologist in a medium market asked, "Do they want their show to be interrupted when there's a tornado in the next county, does it have to be in their county does it have to be in their town . . . anywhere in the state do they want to know about it?" A small market chief (I18) asked about the *kind* of coverage they want. They said, "Do they want people out in the field, do they want to hear those people? Um, do they like to see tower cams?" Two broadcasters (I5, I13) also asked about thresholds for severe thunderstorms. One of them said, "Do they care if the wind gusts are going to be 60 mph versus 90 mph?"

Table 7: List of questions salient to broadcasters regarding the public's knowledge of severe weather phenomena and their preferences in TV severe weather coverage.

Broadcasters' Questions about Viewers' Knowledge and Preferences
Vague Questions: • What words does the public understand and/or how technical can you be? (A debate between broadcast meteorologists and TV station management) • What does the public want to know about a storm? What aspects of the storm do they not care about? • What do people like or dislike about severe weather coverage? • What is the most effective way to present information? • What is the most effective way to write a forecast? (Meteorological vs. lay terms) • Broadcasters would like specific feedback on phrases used during a weathercast or cut-in.
Specific Contextual Questions: • Does the public understand what slight/moderate/high risk means? At what point does the risk level matter to them? • Does the public understand the watch/warning terminology? If not, does it need to be changed? • Does the public understand why there can be a tornado warning without a tornado having actually been spotted? • Does the public understand scud vs. a funnel cloud? • How do we get people to understand that straight-line winds in severe thunderstorms can produce just as much damage as tornadoes? • Does the public understand the difference between partly cloudy and partly sunny?
Viewer Preferences: • What's the 1st, 2nd and 3rd thing they want to hear during coverage? What's the last thing they want to hear? • In what means or method do people prefer to receive the warning (e.g., TV, radio, cell phone)? • How *much* coverage should a severe weather event be given? E.g., "Do they want their show to be interrupted when there's a tornado in the next county, does it have to be in their county does it have to be in their town. . . anywhere in the state do they want to know about it?" • What *kind of* coverage do they want? Do they like to see tower cams? People out in the field? Do they like hear those people?" • At what threshold of a severe thunderstorm warning (e.g., 60 vs. 85 mph winds) do people actually care? • "Do they care if we're two minutes off on the time of arrival?" • Do they want to just be *told* something will happen or do they want to be *taught why* something will happen (e.g. "it's going to rain tomorrow" vs. "why it is going to rain tomorrow)?
Radar/Graphical Topics: • Do they understand radar? Do they understand where the most intense area of the storm is when looking at radar? • Do they care if we show certain radar products? Do they just want to see reflectivity or do they want to see velocity as well? If so, do they understand it? • Do they know what hook and bow echoes look like and the dangers associated with them? • Do they like street tracking? • Do they want to see a 2D or 3D radar perspective? Do they understand what the 3D volume is showing? • Are the heavy thunderstorm maps useful? Does it matter if it's day or night?

7.1.3.2 Radar and Graphics

The most common *subject* of interest was radar and graphics. Five broadcasters asked questions pertaining to the topic. The responses ranged from very basic questions such as, "Do they care if we show certain radar products" (I18) to specific questions including whether most people can pick out a tornadic signature (I6, I10). One broadcaster (I6) also wished to know if people know what a bow echo looks like. Whether people like street tracking, tilted or 3D radar images were also areas of interest.

One weekend meteorologist pointed out that viewers' interpretations and understanding of severe weather can produce disagreements between broadcast meteorologists and station management. He (I17) commented, ". . . that's been the source of debate, as to how technical you can be, what they understand, what words they may or may not understand, and every news director, every chief meteorologist has a different opinion about that." Finding answers may be good, but as one chief (I12) noted, future researchers need to keep in mind that "viewers are a moving target." Their understanding of weather information may change frequently. In addition, a chief in a medium market noted that research should be addressed according to specific DMA's because the demographic make-up of populations probably influences their understanding of weather. He (I20) commented, "Based on the economic background of the state you're in . . .and the topography, [the broadcaster's] needs would be different." Another medium market chief (I11) said information would help them provide more effective coverage but to keep in mind that, "we're not talking to one viewer...we are talking to millions." So while information about people's understanding, interpretation and action may be helpful to broadcasters, one should also understand that the results will probably not apply to every viewer, as people have varying levels of meteorological knowledge. Despite this reality, however, most of the participants felt these issues are worth studying.

7.1.3.3 How People Make Decisions

The participants were also asked whether they are interested in knowing how people make decisions during severe weather. Twelve participants said yes, two said they are interested but it probably would not change the way they do anything, and two said they are not interested because people are allowed to make their own decisions. The question was not posed to four participants due to time constraints. Overall, the participants were interested in three questions: *Who* is taking action, *when* do they take action, and *why* do they take action (Table 8)?

Who is Taking Action? A few of the broadcasters were interested in who (demographics, personality characteristics) is taking action (shelter or no shelter, type of shelter) during severe weather. For example, a weekend meteorologist in a small market (I6) wanted to know the percentage of people who take shelter when their county is under a warning and the percent go outside to look for the tornado. Another broadcaster (I13) was interested in a person's actions during a severe thunderstorm event. They said, "When I say there's a severe thunderstorm warning headed for [a town] at 3:53, what does the average person [in that town] do? Do they actually go in the basement? Do they go outside and

Table 8: List of topics salient to broadcasters regarding how people make decisions and act during severe weather events.

Broadcasters' Questions Regarding Viewers' Action
What information do people need to take action?
***Who* is taking action:** Who (demographics, personality characteristics) is doing what action (taking shelter or not)? • If one's county is under a tornado warning, what percentage of people actually *go* to their basement or safe shelter vs. go outside to look for the tornado? • Why do people *not* take shelter?
***When* do they take action:** • At what point do people go inside or go to the basement? • "When I say there's a severe thunderstorm headed for [this town] at 3:53, what does the average person [in the town] do? Do they actually go in the basement? Do they go outside and look up at the sky?" • Do people react differently for a tornado warning vs. a severe thunderstorm warning? • "Do people really do anything different during a watch?" Have we desensitized people? Are watches more to alert the chasers now?
***Why* do they take action?** • What words trigger action (e.g., tornado, strong winds, friends and family…)? • Does the person actually seeing/experiencing the threat change their thinking and/or behavior? "A lot of times we say 'there's winds capable of up to 60 miles per hour.' If it's actually happening, I wonder if that changes their thinking." • How many people/who (personality characteristics) believe the myths (e.g., overpass myth)?

look up at the sky?" One chief (I9) described a tornadic event in the early 1990's where a man in a mobile home park refused to take shelter even after the police warned him that a large tornado was approaching. "The story goes, that guy refused to take shelter, and he was one of the fatalities." So the question remains, why did that man not take shelter even though a community shelter was available? What personality characteristics or experiences kept him from taking shelter?

When Do People Take Action? Some broadcasters were also interested in the *point* at which people take action. A large market meteorologist (I14) commented, ". . . at what point do they say, 'I'm gonna go inside' and 'I'm gonna get in my basement!' Or, are they more like, 'yeah whatever.'" In other words, are there meteorological triggers that cause people to take action? A couple broadcasters were also interested in whether people change their behavior during a severe weather watch, and whether the number of watches issued has desensitized them. Desensitization was an issue that surfaced in a few of the interviews without solicitation. One chief felt very strongly that the number of watches and warnings being issued nowadays is negatively affecting people. In fact, this individual brought up the topic several times during the interview even when it was not directly applicable to the subject at hand. He (I7) said:

> The biggest issue [is that] there are lots of warnings out . . . I think that the best thing a meteorologist can do. . . is to focus on where there really is severe weather. So if there's a tornado warning, we need to focus on the area of the storm that might produce a tornado. If there's a severe thunderstorm warning then we need to focus on where the strong winds are if there's a thunderstorm going to produce that. . . . these eight hour watches are directly opposite to that. . . . more specific information . . .would be helpful to viewers . . . we have to find a way for [The] SPC [Storm Prediction Center] and the National Weather Service to, understand that. . . . [A] 75% false alarm ratio on a tornado warning is . . . just unacceptable, it causes people not to pay attention.

Why Do People Take Action? Finally, broadcasters wanted to know *why* people take action and whether words such as *tornado*, *strong winds*, or *friends and family*, trigger action. One participant wondered whether a person's mindset or behavior changes when they actually see or experience the threat described by the meteorologist. "A lot of times we say, 'There's winds capable of up to 60 miles per hour.' If it's actually happening, I wonder if that changes their thinking," they (I14) asked? Another participant (I15) said that it is going to be important to determine the phrases that have an impact on people:

> Somebody's gonna have to find these key phrases that are out there, and just look at people, 'Does this cause you to take shelter? Does this cause you to be prepared?' . . . I think we definitely need to pick out our current

> phrases for warning people and test and make them see if it's making them do anything whatsoever.

Overall, the participants raised many questions to which they would like answered.

7.1.4 The Broadcaster's Role

Despite all of the questions broadcasters have about their viewers, one chief meteorologist (I3) said that it is "always up to the meteorologist for interpretation and explanation" of weather information and that broadcasters should know that their role is to convey weather information in a way that people understand. They illustrated the point by comparing the public taking on the role of a meteorologist to a meteorologist taking on the role of a surgeon:

> I don't expect [the public] to look at velocity data and understand it, generally. They know reds and greens are different wind directions. But it's our job to interpret it. So, I don't even want them probably going into that field. It'd be like, you know, you and I, stepping up, opening up a body and trying to operate You know, "I think this is the liver" [laughs] . . . doctors don't want us doing *those* types of things, and meteorologists don't want people, stepping into that arena.

A morning meteorologist also noted that meteorology is not the only field that has an understanding and interpretation issue by those outside of the field. They (I13) said that many fields use their own terminology and concepts that are difficult for most people to understand, and that it is the meteorologist's job to "boil down a very complicated science to things that people who don't have degrees . . . can understand."

Aside from an educational role, one chief in a medium market (I20) felt strongly that broadcast meteorologists need to assume an element of responsibility when deciding whether to interrupt programming. He noted:

> . . . hang on big shot meteorologists, hang on a second. I know you're excited about the tornadoes, and . . . you do a great job of getting the information out but there's a little bit of responsibility that comes with just going on the air and interrupting a show, and then having nothing ever happen from it.

The chief said broadcasters need to consider all the factors (e.g., storm location, time of day, whether there is ground truth, the TV program that is airing) when interrupting programming. "There's so many factors to consider before going on the air and how long you give an event. And it should *not* be determined by the general manager and it should not be determined by another TV station," he continued. The chief was also clear however, that it *is* important to get the information out to the public as soon as possible if warranted by the situation.

7.2 Discussion

7.2.1 Need for Research

While many of the broadcasters in this study said there is a significant need to research the public, one could argue that the research is unnecessary because TV stations hire consultants to conduct research on viewers. While this is true in some instances, most stations do not have consultants. In addition, the goal of the consultant hired by a TV station is to get the most viewers to tune-in and they are not necessarily concerned whether the viewer actually understands or interprets the information correctly (G. Eosco, personal communication, May 21, 2010). Traditional TV consultants are not fulfilling that research need. One chief in a large market (I9) also pointed out that the consultants do not have "scientific training in meteorology" so it can be difficult for them to fully understand the needs of the broadcaster. The participant said it would probably be more beneficial for the broadcaster to "take the lead" in the research because they understand *both* the communication and meteorological issues. The debate among broadcasters and station management about the content and type of severe weather messages may be resolved if the aforementioned issues are researched. Broadcasters were relying on academia to help address their questions.

7.2.2 Experiential Knowledge

The broadcasters agreed that several facets of severe weather are difficult to explain. The conditional nature of storms, probabilities, the meaning of a severe thunderstorm, and radar may be difficult for viewers to understand. The majority of broadcasters felt their tone of voice an important aspect of coverage that lets people know when they really need to take the situation seriously. Of course, in order for their messages to be effective broadcasters need to be careful in the way they treat each event. The participants consistently indicated that the *threat* and viewers' *safety* are the most important messages to focus on during a dangerous situation. A viewer's meteorological knowledge is probably dependent on many factors and varies from city to city. However, the many different questions raised by the broadcasters concerning the viewers' knowledge shows that there are many unanswered questions and researching these issues would probably benefit the broadcast community and society.

7.2.3 Salient Research Topics

The broadcasters in this study had many questions pertaining to the public's interpretation, preferences, and actions during severe weather. Aside from bringing in revenue for the TV station, the ultimate job of the broadcast meteorologist is to serve viewers, and if they can gain a better understanding of the wants and needs of their audience, they can tailor their coverage to suite those desires. Some broadcasters were interested in knowing whether people understand the conditional nature of severe weather and the general uncertainty surrounding weather. They would also like feedback on the information they provide during severe weather and/or weathercasts: What terms do people understand? What terms do they *not* understand? Which graphical products are confusing? Which graphical products enhance the public's understanding? Broadcasters also wante to know the *kind* of coverage people prefer, as well as who takes action, when do they take action, and why do they take action during an event.

Chapter 8: Conclusions

This study looked at a variety of issues related to TV severe weather coverage. Experience covering the weather, diffusion of media and radar technology, and public perceptions are factors that play a role in how broadcasters cover severe weather. Conclusions surrounding each topic are discussed below.

8.1 The Role of Experience

Broadcasters gain several areas of expertise from being on-air that are difficult to teach in an academic setting. Differentiating between storm severities and evolution, knowing which messages to disseminate to viewers and which are not as important, remembering to show the big picture during an event rather than focusing on a single city, and recognizing the importance and role of being human in what can be frightening situations for the public are components that broadcasters have learned throughout the years working in television. Most of the participants have a protocol to follow during severe weather that is determined by station management, but it is usually loose. Many managers leave room for broadcaster discretion and the broadcasters recognize that each event is unique and should be treated as such. Aside from experience and pressure from management, there are several external social factors that broadcasters must take into consideration during severe weather. TV programming, population density, time of day, and storm verification play a role in the amount and type of coverage an event receives. When experience is insufficient to guide decision-making, broadcasters may use aspects of sensemaking to make sense of a situation and provide the most effective coverage.

8.2 Diffusion of Innovation

While broadcast meteorologists are trying to provide severe weather information to a broad audience in multiple ways, it appears that they are approaching the capacity of their workload. Relative advantage is of utmost importance for an innovation near adoption, and opinion leaders are very influential at the beginning of the diffusion process. Diffusion of innovation is very complex, and the diffusion of new media and radar technology in the broadcast industry is part of a double-diffusion process. Not only are broadcasters concerned that the innovations be useful to themselves, but they are also concerned they are useful to their viewers. Resource limitations and lack of awareness of the benefits of the innovations to the broadcasters and their viewers slow down the diffusion process. Unless the number of staff members increase (rather unlikely considering the current economic state of the television news industry), broadcasters will need to determine the most effective means of communication. Radar technology can be useful as long as it benefits both the broadcaster and the viewer. In addition, these findings illustrate the importance of each partner in the severe weather warning process to understand their role and communicate with one another. Understanding each other's needs will allow them to take advantage of the benefits of technology and serve the public while not getting overwhelmed with tasks and information.

8.2.1 New Media

Some forms of new media are being adopted and many factors are influencing the adoption. Relative advantage was the most important innovation attribute for new media while complexity and observability were the least important. This finding coincides with diffusion theory. That is, for an innovation(s) that has already been adopted or is near adoption, relative advantage is the most important characteristic. The overwhelming barrier to adopting new media was limited resources. Although the broadcasters said having more information available helps them make better decisions and were enthusiastic about the use of some of the new tools, managing the information is certainly a challenge. Furthermore, while barriers exist for both broadcasters *and* viewers, they are more significant for broadcasters. Their ability to juggle multiple things at once is being tested and they are reaching their workload capacity. One participant (I15) summed up their dilemma:

> Do we want to do one thing with just great excellence or do we just wanna service all of these things? You come to a point where you just kinda, you don't know which one, you know okay, well do we drop the MySpace page because Facebook is so popular?

Internet access and new media such as the NWS Chat, internet and radio simulcasting, social media, and other various forms, have dramatically changed the broadcast meteorology industry in the last 10 to 15 years. Information that would previously take hours or days to obtain is now available in an instant, and the greater amount of information has improved forecast accuracy. The new tools also allow broadcasters to disseminate potentially life-saving information in a very quick manner.

The NWS Chat has improved communication between broadcasters and the NWS during severe weather events and all but one of the participants were using the NWS Chat at the time of the interviews. While some participants also used internet and radio simulcasting, social media, and storm spotters to gather and disseminate information, only one had ever utilized a blog during severe weather. Media usage depended on the size of the weather department staff as well as financial resources.

8.2.2 Dual-Polarimetric Radar

While some new forms of media have already infiltrated the industry, there is potential for new radar technology to be adopted as well. Some broadcasters in this study were very enthusiastic and eager to use dual-pol radar, but they had a lot of uncertainty as to how it will be used behind the scenes and on-air.

Restricted monetary funds will probably limit TV stations from purchasing their own dual-pol radars, so broadcasters may be more reliant on NWS and weather vendor products than they have in the past. These opinion leaders will have a strong influence on the diffusion process and can help break down the awareness barrier. The broadcasters had relatively limited knowledge on the subject, so educational materials should be provided to them in the near future. In fact, most of the participants are relying on the NWS and weather vendors to supply them with training and information to serve their audiences most effectively. Some broadcasters said they understood that the diffusion of dual-pol radar into the industry may take some time, just as it did with the original WSR-88Ds. Implementing dual-pol products into their weathercasts and severe weather coverage is not going to be an instant change and will require multiple training sessions: when the technology is introduced as well as a few years down the road. One broadcaster (I9) noted, "We're gonna get trained at the beginning. What I think's gonna be important is to go back three years later."

There was also a general consensus among the participants that although they may find certain information useful to themselves, the information also has to be valuable to the viewer if it is to be shown on television. The radar products must be made suitable for TV, meaning they have to be relatively intuitive. Before broadcasters can show the new information on television however, they have to be able to understand the information themselves.

8.2.3 3DVar

Just like dual-pol, a product like CASA's 3DVar may have the potential to benefit the broadcast industry if made suitable for TV. Relative advantage was the most prominent attribute for the broadcaster, and complexity was the most prominent attribute for the broadcaster's perspective of the viewer. However, complexity was also the biggest barrier for the viewer. Thus, the broadcasters had different opinions as to whether the product would be simple enough or too complex to be shown on-air. A couple of broadcasters felt the product would confuse viewers, while others thought viewers would understand the product. The participants generally felt the product would be helpful to them as a diagnostic tool, however. A product like 3DVar would need to be incorporated into existing computer graphics and radar systems due to resource limitations. As with dual-pol, broadcasters would probably rely on the NWS, and/or weather vendors to supply them with the high resolution information.

8.3 Broadcasters' Perceptions & Questions of the Public

Broadcasters appear to develop perceptions of the public based on their experience. They know that some concepts are difficult to explain such as severe weather potential, probabilities, and that severe winds can cause as much damage as tornadoes. Some broadcasters also believed that people have trouble interpreting radar velocity data and 3D radar images. Some also said that using a serious tone of voice and simple phrases to explain the threat will get people to take appropriate action during a dangerous event. They also said that the most important message to portray during severe weather coverage is the threat at hand and what people should do to stay safe. Despite this experiential knowledge of their viewers, almost all of the participants said there is a need to study how people understand, interpret and act when severe weather information is communicated to them.

Many of the broadcasters in this study said that social science research is critical for them to provide the most effective coverage to their viewers. Broadcasters rarely receive feedback from viewers and the feedback they do receive is usually negative. Ideally, they would like research pertaining to their particular DMA audience and specific feedback on the content of their weathercasts and severe weather coverage. Broadcasters also wanted to know the phrases and graphics that people do and do not understand. In addition, the participants wanted to know the *type* of coverage their viewers prefer. They would also like answers to three overarching questions pertaining to viewer decision-making: *Who* is taking action, *when* do they take action, and *why* do they take action? The participants were interested in many different subtopics and have diverse needs, yet the aforementioned questions can provide a foundational understanding on which to build.

One challenge broadcasters face when deciding how to tailor their messages during severe weather is the conflict of interest between serving the viewers and serving the TV station. (Of course, the definition of "serving the viewers" might differ depending on the event; it could mean that the broadcaster is on TV for more *or* less time than they are allotted by management). The station management has a strong influence on the type and amount of coverage a broadcaster provides, especially for less dangerous events (e.g., 65mph winds in open countryside). On the other hand, some of the broadcasters' comments leads one to believe that if the event is extremely threatening (e.g., large EF-4 or EF-5 tornado on the ground, no matter the location), they will do all that is in their power to save lives and property and the station-viewer conflict becomes a non-issue.

This study shows that broadcast meteorologists face many challenges during severe weather. They must deal with financial and time constraints as well as pressure from management and viewers. However, when a dangerous situation presents itself they are committed to protecting life and property. Yet, they need research that declares the most effective way(s) to do so.

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Appendix A: Implications for Academic & Industry Partners

The results of this study raise important issues for academic and industry partners. Implications for academia, the Center for Collaborative Adaptive Sensing of the Atmosphere (CASA) & private weather vendors, the National Weather Service (NWS), and broadcasters are discussed below.

Academia

- Many broadcasters want and need research on the public to be able to deliver effective messages. They have many questions (see Tables 6 and 7), many of which have yet to be addressed by the academic community.
- Ideally, research on the public should be tailored to specific designated market areas (DMA) or a small group of DMA's due to the unique geographical and sociological challenges associated with each DMA.
- Some of the salient research questions that broadcasters are interested in have already been answered by the academic community but most broadcasters appear to be unaware of them. Thus, researchers should publish relevant material in places where broadcasters will see the information (e.g., *Bulletin of the American Meteorological Society*, National Weather Association[4] newsletters, COMET[5], EarthGauge[6], etc...) to bridge the gap between research and practice.

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[4] http://www.nwas.org/

[5] http://www.comet.ucar.edu/aboutus.htm

CASA & Private Weather Vendors

- Time and resource limitations mean that new technology has to be sufficiently better and advantageous over what is currently available for it to be useful to broadcasters.
- A product like 3DVar would probably be helpful to broadcasters, especially behind the scenes, but the resolution must be compatible with TV. Ideally it should also be embedded in the station's weather graphics system for ease of use. Automated tornado detection or wind speed algorithms would also be useful and appreciated.
- Shrinking budgets in the broadcast industry may mean that new technology will need to be cheaper than what TV stations are currently paying to use their weather vendor's graphics system. Thus, cost should certainly be considered when develop products that are geared towards the broadcast industry.

NWS

- The majority of broadcasters are thrilled to be able to use the NWSChat and believe it has greatly improved communication between them the NWS during severe weather.
- Most broadcasters have a very good relationship with the forecasters at their local NWS weather forecast office (WFO).
- Broadcasters are limited in the amount of time they have to analyze mesoscale data since they have to focus on an entire DMA. Thus,

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[6] http://www.earthgauge.net/

broadcasters rely on the NWS to perform detailed analysis, especially during intense events in which multiple storms exist.

- Some broadcasters would like watches and warnings to be tailored to more specific geographical locations.
- Hands-on training with dual-polarimetric radar data will be essential for broadcasters to learn how to utilize it most effectively. It would be best if individual WFO's visited TV stations, once when the technology is implemented and also a few years later.

Broadcasters

- Broadcasters should seek out information about dual-polarimetric radar from their local WFO.
- Broadcasters could contact their local WFO or university (if applicable) to see whether they're aware of studies addressing public understanding, interpretation and action during severe weather.
- Broadcasters could seek out societal impacts research results in the *Bulletin of the American Meteorological Society* and *Weather Climate and Society* journals, and from COMET, EarthGauge, and the National Weather Association.

Appendix B: Evaluation & Reflection of Interdisciplinary Approach

This work is the result of an opportunity to pursue an interdisciplinary degree through the Special Master's Program at the University of Oklahoma (OU). The OU interdisciplinary degree program is designed to allow students to pursue an area of study that does not fit within traditional university degree requirements. The program of study consisted of communication, meteorology, and journalism and mass communication courses and approved by The Graduate College at OU. Pursuing this type of degree proved to be a very unique experience and lead to many challenges and opportunities.

Challenges

Understanding a New Paradigm. My first communication class was an introductory graduate level course. I had no idea what to expect when I entered the room but after five minutes of the class, I was completely confused. I had no idea what my professor was talking about. He kept referring to all these *theories*. "What do you mean by theories," I thought? I was used to *Einstein's theory of relativity*, not something like *social responsibility theory*. I was completely lost. Even worse, the majority of the students in the class were Ph. D students. Not only was I immersed in a completely new discipline, I was also surrounded by people who were already very knowledgeable about the subject.

The introductory course enlightened me and I began to understand the meaning of "social science." I thought I had some understanding of what it meant to be a social scientist prior to the class, but I quickly realized my assumptions were incorrect. Taking the class made me realize the depth in which I had gotten into meteorology and the physical sciences, and how my understanding of the world was so fundamentally different from many of my colleagues around me. I learned a lot by learning a little that semester, and I learned that I really did not know anything about social science.

Pleasing Multiple Parties. Another challenge in pursuing an interdisciplinary degree was pleasing multiple parties. I had to convince meteorologists that communication and people were worth studying. I also had to convince the communication scholars that theory was not the only important part of research and that the practical implications of the research were very important as well. Thankfully, it was fairly easy to convince people of the practical implications of weather hazards. Yet, it was a challenge to switch my mindset between theory and practice as I conversed with colleagues in multiple disciplines.

Opportunities

Bridging a Gap. I had the opportunity to be in constant conversation with people in both disciplines since I took both communication and meteorology courses and had several opportunities to clear up misconceptions among both of the disciplines. I also had the opportunity to try to understand the way both of the disciplines think. This has helped me learn to communicate more effectively. I strongly believe that I would not have had the same experience had I only pursued a communication degree. While I took more communication classes than I did meteorology, my office was in a building that houses the meteorology faculty and students. While I spent more class time with my communication colleagues, I also spent much of my time with meteorology colleagues. It is very easy to start thinking and acting like the people with which you most frequently interact, and limiting my interaction with meteorologists would have been detrimental. It also would not have been as convenient to attend seminars and stay up-to-date on meteorological research had I been housed in the communication building. I would not have had the opportunity to discuss the importance of social science in weather and climate with my meteorology colleagues as often as I did.

Pursuing a Passion. I was very fortunate to be in the situation that I was. Designing a program of study and researching of a topic that was and is of great importance to me was a luxury that not all graduate students have. I met many amazing people throughout my graduate career and feel very lucky to have had this opportunity. My interdisciplinary degree has probably closed some career doors, but it has also opened others. I believe it has also left me with a very specialized skill set such as communicating across boundaries and respecting different problem-solving viewpoints. It was a wonderful experience overall and I am blessed to have been given the opportunity.

Appendix C: List of codes for portion of interviews pertaining to diffusion of innovation.

Innovation Attributes		Adoption Barriers	
Code	Description	Code	Description
[Attribute][Medium]		Barrier[Barrier][Medium]	
INTERNET SIMULCASTING		INTERNET SIMULCASTING	
RAI	Relative Advantage Internet Simulcasting	BLRI	Limited Resources Internet Simulcasting
CBI	Compatibility Internet Simulcasting	BIOI	Information Overload Internet Simulcasting
CXI	Complexity Internet Simulcasting	BXI	Uncategorized Barrier Internet Simulcasting
OI	Observability Internet Simulcasting	ABLRI	Audience Barrier Limited Resources Internet Simulcasting
TI	Trialability Internet Simulcasting	ABXI	Audience Uncategorized Barrier Internet Simulcasting
OLI	Opinion Leader Internet Simulcasting		
CPI	Competition Internet Simulcasting		
ARAI	Audience Relative Advantage Internet Simulcasting		
AOI	Audience Observability Internet Simulcasting		
RADIO SIMULCASTING		RADIO SIMULCASTING	
RAR	Relative Advantage Radio Simulcasting	BLRR	Limited Resources Radio Simulcasting
CBR	Compatibility Radio Simulcasting	BIOR	Information Overload Radio Simulcasting
CXR	Complexity Radio Simulcasting	BIR	Influence Radio Simulcasting
OR	Observability Radio Simulcasting	BXR	Uncategorized Barrier Radio Simulcasting
TR	Trialability Radio Simulcasting		
OLR	Opinion Leader Radio Simulcasting		
ARAR	Audience Relative Advantage Radio Simulcasting		
AOR	Audience Observability Radio Simulcasting		
NWSCHAT		NWSCHAT	
RAC	Relative Advantage NWSChat	BLRC	Limited Resources NWSChat
CBC	Compatibility NWSChat	BIOC	Information Overload NWSChat
CXC	Complexity NWSChat	BXC	Uncategorized Barrier NWSChat
OC	Observability NWSChat	BCC	Barrier Competition NWSChat
TC	Trialability NWSChat	BWFOC	Weather Forecast Office Discontinuity

OLC	Opinion Leader NWSChat		
ARAC	Audience Relative Advantage NWSChat		
AOC	Audience Observability NWSChat		
SOCIAL NETWORK		SOCIAL NETWORK	
RAN	Relative Advantage Twitter or Facebook	BLRN	Limited Resources Twitter or Facebook
CBN	Compatibility Twitter or Facebook	BION	Information Overload Twitter or Facebook
CXN	Complexity Twitter or Facebook	BXN	Uncategorized Barrier Twitter or Facebook
ON	Observability Twitter or Facebook		
TN	Trialability Twitter or Facebook		
OLN	Opinion Leader Social Network		
ARAN	Audience Relative Advantage Twitter or Facebook		
AON	Audience Observability Twitter or Facebook		
STORM SPOTTERS		STORM SPOTTERS	
RASS	Relative Advantage Storm Spotters	BLRSS	Limited Resources Storm Spotters
CBSS	Compatibility Storm Spotters	BIOSS	Information Overload Storm Spotters
CXSS	Complexity Storm Spotters	BXSS	Uncategorized Barrier Storm Spotters
OSS	Observability Storm Spotters	BLSS	Liability Barrier Storm Spotters
TSS	Trialability Storm Spotters	BLoSS	Logistical Barrier Storm Spotters
OLSS	Opinion Leader Storm Spotters	ABXSS	Uncategorized Audience Barrier Storm Spotters
BLOG		BLOG	
RAB	Relative Advantage Blog	BLRB	Limited Resources Blog
CBB	Compatibility Blog	BIOB	Information Overload Blog
CXB	Complexity Blog	BXB	Uncategorized Barrier Blog
OB	Observability Blog		
TB	Trialability Blog		
OLB	Opinion Leader Blog		
AOB	Audience Observability Blog		

OTHER		OTHER	
RAO	Relative Advantage Other	BLRO	Limited Resources Other
CBO	Compatibility Other	BIOO	Information Overload Other
CXO	Complexity Other	BXO	Uncategorized Barrier Other
OO	Observability Other	BAWO	Awareness Barrier Other
TO	Trialability Other		
OLO	Opinion Leader Other		
ARAO	Audience Relative Advantage Other		
OVERALL (w/ Internet)		OVERALL (w/ Internet)	
RAInf	Relative Advantage Internet Info	BLRInf	Limited Resources Internet Info
CBInf	Compatibility Internet Info	BIOInf	Information Overload Internet Info
CXInf	Complexity Internet Info	BXInf	Uncategorized Barrier Internet Info
Oinf	Observability Internet Info	ABX	Uncategorized Audience Barrier Internet Info
TInf	Trialability Internet Info	ABIOInf	Audience Information Overload Internet Info
OLInf	Opinion Leaders Internet Info	ABCXInf	Audience Barrier Complexity Internet Info
CPInf	Competition Internet Info	ABAWInf	Audience Barrier Awareness Internet Info
ARAInf	Audience Relative Advantage Internet Info		
DUAL-POL		DUAL-POL	
RADP	Relative Advantage Dual-Pol	BLRDP	Limited Resources Dual-Pol
CBDP	Compatibility Dual-Pol	BIODP	Information Overload Dual-Pol
CXDP	Complexity Dual-Pol	BAWDP	Awareness Barrier Dual-Pol
ODP	Observability Dual-Pol	BCXDP	Complexity as Barrier Dual-Pol
TDP	Trialability Dual-Pol	BXDP	Uncategorized Barrier Dual-Pol
OLDP	Opinion Leader Dual-Pol	ABCXDP	Complexity as Audience Barrier Dual-Pol
CPDP	Competition Dual-Pol	ABIODP	Audience Barrier Information Overload
ARADP	Audience Relative Advantage Dual-Pol		
ACXDP	Audience Complexity Dual-Pol		

3DVAR			3DVAR	
RA3D	Relative Advantage 3DVar		BLR3D	Limited Resources 3DVar
CB3D	Compatibility 3DVar		BIO3D	Information Overload 3DVar
CX3D	Complexity 3DVar		BX3D	Uncategorized 3DVar
O3D	Observability 3DVar		BAW3D	Awareness 3DVar
T3D	Trialability 3DVar		BCX3D	Complexity Barrier 3DVar
OL3D	Opinion Leader 3DVar		ABCX3D	Audience Barrier Complexity 3DVar
ARA3D	Audience Relative Advantage 3DVar		ABIO3D	Audience Barrier Information Overload 3DVar
ACX3D	Audience Complexity 3DVar			