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DIFFUSION OF NEW MEDIA AND RADAR TECHNOLOGY IN TV SEVERE WEATHER COVERAGE

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1. INTRODUCTION

Technology is constantly changing in American society and new forms of media are shaping the ways society operates. Accessing information via the Internet has become increasingly popular, 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 networking sites 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 news industry has been greatly impacted by the Internet, and 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-Olmsted & Ha 2003; Lin 2003).

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Technology also plays a large role in the weather broadcasting industry. Broadcast meteorologists use radar products and graphic displays to communicate weather messages to their audiences, and new tools and media are changing the ways they gather and disseminate information. In fact, broadcast meteorologists have been credited for saving lives during life-threatening weather events (e.g., Barnhardt 2003; Hoffman 2009) and people often turn to their TV for severe weather information (Hammer & Schmidlin 2002; Sherman-Morris 2009). However, there is limited research on the role of the broadcaster in the severe weather warning process and how new media and radar technology may be influencing the content and channels of the their messages. Thus, it is essential for the other partners in the severe weather warning process to understand how broadcasters are utilizing these tools.

This study begins with an overview of diffusion of innovation literature, followed by a description of the diffusion of new media and radar technology in the broadcast meteorology industry. Additionally, this paper describes the methodological choices used to develop the study and the results of the new forms of media and radar technology that are being utilized by some broadcasters. An analysis of the applicable diffusion attributes and the implications for future studies are provided at the end of the paper.

2. DIFFUSION OF INNOVATION

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. 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 fully accept the innovation in a shorter time-period than the early adopters (Ryan & Gross 1943).

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, vendor support, consultant support, and endurance were used to manage the changes.

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 (Rogers 2003). Yet, Rogers (2003) also says that most of the time innovation 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. The attributes are discussed below.

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). One example related to broadcast meteorology would be if a station implemented a new graphics system that updated much quicker than the previous system (e.g., a few seconds rather than a few minutes). If the benefits of the innovation 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). If the basis for understanding 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 notes that adoption will occur sooner if felt needs are met, which again hones in on 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) notes that the adoption of the personal computer exemplifies this attribute because 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. The ability to try out a product also dispels uncertainty and increases the likelihood of adoption. So, this attribute means that the likelihood that a new weather graphics system is purchased by a TV station should 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.

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 *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 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, researchers studied 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 1995). In essence, opinion leaders are individuals or organizations who have a strong affect on the rate of adoption. Prominent broadcast meteorologists, weather vendors, or the NWS could be possible opinion leaders for broadcasters.

2.3 *Diffusion Weaknesses*

While diffusion theory has been tested in many contexts, scholars agree that there are some weaknesses. Rogers (2003) notes that one weakness is that many diffusion studies are completed after an innovation has already been accepted (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 (e.g., conducting a study for a 10 year period), and they assume that innovation is always good. In other words, they forget to consider that the group, audience, or community may be better off *without* the technology. Also, while some studies have identified adoption barriers, which may slow down or stop the diffusion process (e.g., awareness, persuasion and influence (Veil 2010)), 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 have infiltrated into broadcast meteorology and radar technology continues to advance, diffusion theory may provide insight into the adoption of these tools in the industry. Additionally, since broadcasters have yet to commit to adoption of new media, this study adds to the short list of pre-adoption literature.

3. DIFFUSION IN TV SEVERE WEATHER COVERAGE

3.1 *New Media*

As the news industry changes, the ways broadcast meteorologists gather and disseminate weather information continue to change as well. Some evidence suggests that broadcast meteorologists are beginning to embrace new forms of media such as internet chat, 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 NWS Chat 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 a few years ago (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 for NWS forecasters, broadcast media, emergency managers, and first responders to communicate with one another 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. Are changes helpful or harmful? Broadcast meteorologists play an integral role in the severe weather warning partnership and the other partners must understand the role these new tools are playing in order to facilitate efficient and effective communication of severe weather messages. Thus, this study seeks to answer the question: How have new media such as internet and radio simulcasting, National Weather Service Chat, blogs, and social media influenced the ways broadcast meteorologists in the central United States gather and disseminate severe weather information?

3.2 *Small-Scale Wind Analysis Tool: 3DVAR*

Aside from new media, radar advancements may also play a role in the way broadcasters communicate with their audiences during severe weather. A small-scale wind analysis tool called 3DVAR (see Gao et al. 2009) is being developed by the Center for Collaborative Adaptive Sensing of the Atmosphere (CASA). CASA is a National Science Foundation Engineering Research Center that is developing weather radars that sense closer to the ground and have higher spatial and temporal resolution than the WSR-88D (Weather Surveillance Radar – 1988 Doppler). CASA has a dense network of four (soon to be six) radars in southwestern Oklahoma (see McLaughlin et al. 2009). The dense network has allowed for the development of a small-scale wind analysis tool called 3DVAR (Figure 1). 3DVAR is unique because it shows low-level, mesoscale, Doppler-derived velocities and allows meteorologists to see thunderstorm and tornadic winds at a much smaller scale than currently possible in operation (Hu et al. 2009). Broadcast meteorologists are a potential user of this product, but it is not known how and whether it will be beneficial to them. This study will also answer the question: How may the CASA 3DVAR wind analysis product be useful to broadcast meteorologists?

3.3 *Dual-Polarimetric Radar*

Another tool that broadcasters will have access to in the future is dual-polarimetric radar data. Many broadcast meteorologists use radar data from the NWS, which currently has 158 WSR-88D's scattered across the United States (Whiton et al. 1998). While these radars help meteorologists observe the atmosphere, various limitations are associated with them such as overestimation of rainfall and beam overshooting. However, some limitations will disappear when the radars are upgraded to have dual-polarimetric technology beginning in June 2010 (Magnus et al. 2009). Dual-polarimetric radar data will provide the meteorologist with more detailed information about what is falling from the sky (e.g. rain, sleet, snow, hail, etc…). Figure 2 shows that unlike conventional weather radars that emit electromagnetic waves in the horizontal plane, dual-polarimetric radars scan both horizontally and vertically (Straka et al. 2000). This technology should benefit to meteorologists in multiple ways (Ryzhkov et al. 2005; Zrnic & Ryzhkov 1999) but it is not known if and how the broadcast community will embrace this technology, whether for analysis purposes behind the scenes, on-air, or both. The final question addressed in this study is: How will the National Weather Service dual-polarimetric radar upgrade be utilized by the broadcast meteorology community?

4. METHODOLOGY

Broadcast meteorologists in the central United States participated in semi-structured interviews regarding their use of new media and radar technology when communicating severe weather information on television. 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 et al. 1990). Thus, while the researcher leads the interview in a particular direction, the participant also has the opportunity to verbalize messages that are most salient to them.

4.1 *Protocol*

The interview protocol was based on insight provided by Seidman (1998) and Kvale and Brinkmann (2009). A limited number of studies have interviewed broadcast meteorologists about severe weather coverage, so a macro approach seemed appropriate. The protocol was comprised of demographic questions, questions about the use of new media, 3DVAR and dual-polarimetric radar. It should also be noted that the questions pertaining to 3DVAR were included in the study after several interviews had taken place. While some broadcasters were asked about the tool during the interview, some responses were solicited via email. Not all broadcasters responded to the email despite several attempts. In general, the researcher asked the broadcasters about the tools they used and the positive and negatives of each tool. The protocol also included questions pertaining to public understanding topics that are salient to broadcasters and how broadcasters use their prior experience to cover severe weather events, but it is beyond the scope of this report.

4.2 *Participants*

Twenty broadcast meteorologists in the central U.S., a prominent severe weather region, participated in the study (Figure 3). Personal network sampling was employed to recruit about half of the participants. "Sampling logic" (Maxwell 2005, p. 71) and feasibility were also taken into account to include broadcasters from a variety of demographics including market size, station position, age, gender, and experience, to obtain diverse responses.

Because there are no official definitions of a small, medium, or large market, size categories were based on Nielson (2009) rankings, participant insight, and designated market area (DMA) population. In this study, markets with a population greater than one million (DMA #1-30) were considered large, between 250,000 and one million (#31-115) were medium, and less than 250,000 (#116-210) were small. The broadcasters were equally representative of the various weathercaster positions at TV stations (morning/noon, evening/Chief, and weekend in most cases). Four female and sixteen male broadcasters participated. Twelve held meteorology or atmospheric science degrees and four held a broadcast meteorology certificate. Their experience as a broadcast meteorologist ranged from 1 to 37 years (*M* = 14.5 years). A demographic summary is provided in Table 1. Specific demographic associations cannot be provided due to confidentiality issues.

4.3 *Data Collection*

Eighteen interviews were conducted from May to July of 2009 during the prime spring severe weather season in hopes that hazardous weather would be fresh on the mind of the meteorologist and therefore provoke thoughtful responses. The final two interviews were conducted in October 2009, which saturated the sample. All but one interview was conducted in person. Sixteen interviews occurred at the participant's TV station while the rest were in a public venue or the primary author's office. These environments provided a comfortable setting for the participants (Taylor & Bogdan 1998) 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 all 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. The recording time was marked on the transcript in two-minute intervals so that the researcher could efficiently check data later on in the research process. Transcripts were analyzed to determine major themes and perceptions of innovation attributes. The researcher listened to all quoted material on the original recordings to ensure accuracy. The most prominent themes and innovation attributes will be determined in the future.

5. Preliminary Diffusion Results

5.1 *Media Usage*

The Internet has changed the way broadcasters gather and present severe weather information. For example, many broadcasters commented about the fact that there is a lot more information available to them today than there was in the past. One morning meteorologist from a large market said,

> ...probably the first, two or three years [of my career] I rarely used internet and I['d] 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 even wait for the products that [our weather vendor] sends out. It's all on the Internet that I can find.

Some also said that their forecasts are much more accurate because of amount of information available to them. One Chief in a medium market said,

> …when I started here, if I got within one or two degrees every day I was thrilled. But now I'm like if I don't get within two degrees I'm upset. … Our average on most days you know, one or two degrees is as far off as we ever are. So accuracy has gotten better.

While the advent of the Internet has played a tremendous role in the availability of new forms of media, the main focus of this analysis is the impact of the changing forms of individual media on the weather broadcasting industry as a result of the Internet, rather than the Internet as a whole.

Figure 4 provides a summary of the new media being used by the participants during severe weather. The most common new tool was the NWS Chat (95%). Many broadcasters raved about the Chat. One Chief from a small market said, "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."

Internet and radio simulcasting were also fairly popular dissemination tools. Of the participants whose stations simulcast on the Internet (60%), all had only been doing so for a couple of years. Radio simulcasting is actually not a new tool (some had been radio simulcasting for over 10 years), but just over half of the participant's stations use the technology (55%). While the technology itself may not be very new, it was included in the study because not every station has the capability to simulcast on the radio. Whether a station simulcasts on the radio depends on whether they have a contract with a radio station, and sometimes a single TV station can 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 said that while their station does not simulcast on the radio, another station in town does.

About half (45%) of the broadcasters said their stations have designated storm spotters, some paid and some unpaid by the station. Again, although the idea of storm spotting it not necessarily new, the broadcasters were questioned about it because the way the spotters relay information to the broadcasters back in the studio (e.g. cell phone and web cams) was not possible in the past.

A question pertaining to the use of social networking sites was not on the original protocol, but 40% of the broadcasters mentioned using Twitter to disseminate severe weather information to viewers. One participant mentioned using Facebook. In all cases, they had only been using the technology 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.

5.2 *New Media Innovation Attributes*

Numerous examples of innovation attributes in new forms of media were apparent in the interviews. Examples of each attribute are provided below, with the exception of observability.

5.2.1 Relative Advantage. Examples of relative advantage were often seen in the participant's responses, such as the fact that the amount of information available has increased dramatically in the last decade. A Chief in a medium market summarized how the industry has changed since the adoption of the Internet and use of new tools. They 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." For the most part broadcasters see the speed at which information is available in a positive light. A morning meteorologist in a medium market said, "…when I started I mean we had computers in '99, but we still did like hand-grafted…now…we can pick different models and show [people] a different perspective…I mean there's just so many advantages [to having more information]." They also said their forecasts have improved which benefits themselves and the audience. "Yeah I think our forecasts are getting more and more accurate and more and more specific and I think that's what people want," the broadcaster commented. One morning meteorologist in a small market talked about the advantages of the NWS Chat. They noted that the NWS Chat is "invaluable, it's a great product" and that it is "almost like the invention of the telephone" in that it has revolutionized the way broadcasters communicate with everyone else involved in the warning decision process.

They continued, "pity the meteorologists who aren't using it…" Participants also liked the NWS Chat because it sometimes allows them to get advanced warning notification from the NWS; something previously impossible. A Chief in a medium market also spoke highly of receiving information in advance from the NWS regarding the timing of storm development. They said it "…helps us a whole lot. Ten years ago that would've never happened." In addition to NWS Chat, internet simulcasting was also seen as a beneficial tool in that people can access it at work, where most of them do not have TV access. A Chief in a medium market said, "Particularly when people are at work, they really love [the internet simulcasting], because hardly anyone has a television at work but everyone has a computer."

5.2.2 Compatibility. Elements of compatibility were also apparent in the participant's responses. It appears that 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 said their station streams "when it's a wall-to-wall type thing and there's several tornadoes… Somebody up there [in the control room] flips the switch and we're on the web." Another participant said that their web team is accustomed to streaming news stories, so streaming severe weather coverage is not much change. They said, "our web team…is really adept to getting it live. They do a lot of live streaming anyway so, it's not a arduous task for them so it's pretty…standard if we go wall-to-wall it will be, on the website." Radar images and graphics are already on a computer and are easily converted to streaming content. If the 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. "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,'" a Chief in a medium market said. Another Chief 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."

5.2.3 Complexity. There was not very much discussion about new forms of media being difficult to use, so that could imply that they are not very complex. Aside from a few broadcasters being slightly irritated about having to change their NWS Chat passwords every 60 days, participants did not have any complaints about their ability to understand and use the NWS Chat. "I think Chat has simplified [all of the information]," one Chief from a small market said.

5.2.4 Trialability. Trialability was apparent in some responses pertaining to internet simulcasting. 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 said. In addition, while no official guidelines have been set as to how the broadcast community should utilize social media such as Twitter, the broadcasters interviewed in this study seemed to be adhering to a trial and error basis to account for rapid technological changes. However, because the use of Twitter was so new at the time of the interviews and some had not experienced a major severe weather event yet that season, participants were unable to provide many concrete examples to support trialability.

5.3 *New Media Barriers*

Although new media is being infiltrated in the broadcast industry, there are some barriers to adopting the technology. The biggest barrier to adoption seemed to be limited resources. The broadcaster's time and station's money are being stretched thin in order to cover all the media. Another adoption barrier was information overload. Because broadcasters have access to so much information, it can be difficult to know where to focus.

5.3.1 Limited Resources. While some broadcasters expressed the benefits of having so much information available, many discussed the difficulty of managing the data without the proper workforce. This limitation was especially apparent in the 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 commented on this issue.

> …in severe weather like, we're now expected to update the crawls [e.g. warnings scrolling across the TV screen], update Twitter, update our website, go on to TV, call radio stations in 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. The broadcaster 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." It appears that keeping up with technological changes takes time away from what broadcasters were originally hired to do: forecast.

Out 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 have blogs, they do not update them during severe weather because they do not have time. One Chief from a medium market 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 said, "I guess I'll say I'm not a fan of [a blog] because … I mean, people want that when there's weather happening. And unfortunately when there's weather happening, I'm busy doing, television."

While many broadcasters expressed interest in internet streaming, most do not do it very often. One reason is that not every weather situation warrants streaming, but staffing is another reason. A Chief in a medium market said, "we're not to the point where we have enough people or bodies to cover, streaming for everything." Sometimes a person is available to flip the switch so that the coverage goes on the Web, but that is not always the case.

5.3.2 Information Overload. In addition to limited resources, the amount of information can also be difficult for the broadcaster to sort through and process. While new media has the potential to increase efficiency, the amount of information available to a broadcaster can also be overwhelming. A morning meteorologist in a large market 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 made a similar remark and 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 and that they would prefer the current situation to that of the past, because technology has improved forecast accuracy and made severe weather coverage easier.

5.4 *3DVAR Innovation Attributes*

There was a general consensus among the broadcasters that 3DVAR could 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. Two innovation attributes, relative advantage and complexity, were apparent in the broadcaster's responses.

Some broadcasters said the 3DVAR product could be advantageous in identifying mesoscale boundaries (assuming the dense radar network, of course) compared to the current NEXRAD infrastructure. One Chief in a medium market 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, 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 red/green storm relative velocity products because small-scale circulations are more easily identifiable. One morning meteorologist in a small market noted, "It could easily replace SRV. In a case where we have a good couplet to show on-air the met[eorologist] must take time explaining what a couplet is. [3DVAR] more or less shows graphically with the wind vectors what a couplet cannot, circulation." In addition to relative advantage, product complexity was something that the broadcasters also honed in on.

Some broadcasters said they would show the product on-air because it is a fairly simple graphic and something that viewers could probably understand. One Chief in a medium market commented, "I think we could show it on the air...it's pretty normal looking reflectivity with wind vectors, you should be able to explain that to average folks..." Another Chief agreed, "I think the public could understand it. However, I would only use it when it was appropriate as in strong wind event or meso development."

5.5 3DVAR Barriers

While complexity (lack thereof) of 3DVAR was seen as an attribute by some broadcasters, others felt the product was too complex and would be a barrier to adoption. One weekend meteorologist in a small market said that 3DVAR would be too difficult for viewers to understand. The broadcaster said, "I would definitely NOT use such a product on air, there is too much going on, it would most likely confuse viewers as they would not understand what they are looking at…" Another barrier to adoption could be that the resolution is not appropriate for TV. A few broadcasters mentioned that the product would have to be altered a bit to be made suitable for TV, especially since computer screens have a higher resolution than TV screen. One weekend meteorologist in a medium market commented, "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."

5.6 Dual-Polarimetric Radar Innovation Attributes

In addition to 3DVAR, the broadcasters were also asked about their knowledge of dual-polarimetric radar and whether they will use the information behind the scenes or on-air. Their knowledge ranged from not having heard of it to having fairly extensive knowledge on the topic. Only a couple broadcasters seemed very comfortable with the subject. Sixteen out of 20 broadcasters (80%) were aware of the NWS upgrade.

Relative advantage seemed to be an important attribute in adopting dual-polarimetric radar. Although the broadcasters did not have a complete understanding of dual-polarimetric technology, they seemed to understand there would be some benefits over the current, single polarization, and that might motivate them to use the technology. One Chief commented, "TV stations are in the business of…trying to…um have the latest technology and then have viewers care about seeing that technology." Another innovation attribute that surfaced was complexity. Similar to 3DVAR, complexity was seen as an attribute or a barrier, depending on the nature of the product(s). Because the broadcasters were uncertain about how the dual-polarimetric information will 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 noted, "I think yeah [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 a, an issue because the velocity, it's going to and from the radar. There [are] some complications there…" While some innovation attributes were present in their responses, many of the broadcaster's remarks focused on barriers to adoption.

5.7 *Dual-Polarimetric Radar Barriers*

Some broadcasters were very excited about the potential on-air and behind the scenes analysis benefits, 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 to themselves and the viewers seemed to be the biggest barrier to adoption. Some broadcasters also discussed the importance of learning to analyze and interpret the data accurately themselves, prior to using it on-air. A weekend meteorologist in a small market 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...

Another barrier to adoption could be financial, because as one broadcaster noted, most TV stations do not have the ability to purchase their own dual-polarimetric radars now. The broadcaster said, "…a lot of stations that perhaps are thinking about upgrading their equipment or going to dual-pol or whatever…I don't see it happening right now." Overall, the biggest theme for their use of the dual-polarimetric data was that it will have to be in a format that is simple and valuable to the viewer.

5.8 *Opinion Leaders*

While this study was not 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 into the broadcast industry. For example, the NWS Chat was developed by a group of individuals (the leader was not associated with the government agency) prior to it being managed by the government. The researcher's experiential knowledge also suggests that individual broadcasters may influence one another's adoption patterns because the 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.

At the organizational level, the NWS may also influence change because it is an important component of the severe weather warning process. In addition, the NWS is playing a major role in the implementation of the dual-polarimetric radars, and without that network most broadcasters would be unable to access that type of data. Private industry organizations such as weather vendors could also be classified as an opinion leader because the broadcasters use their graphics and data during severe weather.

6. CONCLUSION

The analysis of diffusion of innovation in the broadcast industry shows that new forms of media are being adopted and many factors are influencing the adoption. Internet access and new media such as the NWS Chat, internet and radio simulcasting, social networking sites, 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 were also using internet and radio simulcasting, social networking sites 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 staffs as well as financial resources.

Coinciding with diffusion theory, relative advantage was the most common innovation attribute. Complexity was the least common, but this finding may be a result of the broadcasters rarely discussing the technical aspects of the media. Aside from the attributes, there were also some barriers to adoption. The main barrier was limited resources (time and money). Although many broadcasters said the greater amount of information helps them make better decisions and were quite enthusiastic about the use of some of the new tools, managing the information is certainly a challenge.

While new forms of media have already infiltrated the industry, there is potential for new radar products to be adopted as well. A product like CASA's 3DVAR may have the potential to benefit the broadcast industry if made suitable for TV. The broadcasters generally felt the product would be helpful to them as a diagnostic tool, but some were unsure of its applicability on the air. Although a couple broadcasters felt the product would confuse viewers, others thought it was simple and could be shown on TV.

Dual-polarimetric radar is another form of technology that will soon be introduced in the broadcast industry. Dual-polarimetric radar data should have some applicability in the broadcast industry, but the broadcasters do not yet know how they will utilize the data. Some broadcasters seemed very enthusiastic and eager to use the technology, but there is a lot of uncertainty as to how it will be used behind the scenes and on-air. In addition, it appears that substantial training will be necessary for broadcasters to be able to understand and use the data effectively on-air. As with 3DVAR, dual-polarimetric products must also be suitable for television. While elements of diffusion theory were apparent in some of the broadcaster's responses, they mainly focused on barriers to adoption. This may have been due to their lack of knowledge and uncertainty about the technology.

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. 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. 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. This will allow them to take advantage of the benefits of technology and serve the public while not getting overwhelmed with tasks and information.

7. ACKNOWLEDGMENTS

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9. TABLES AND FIGURES

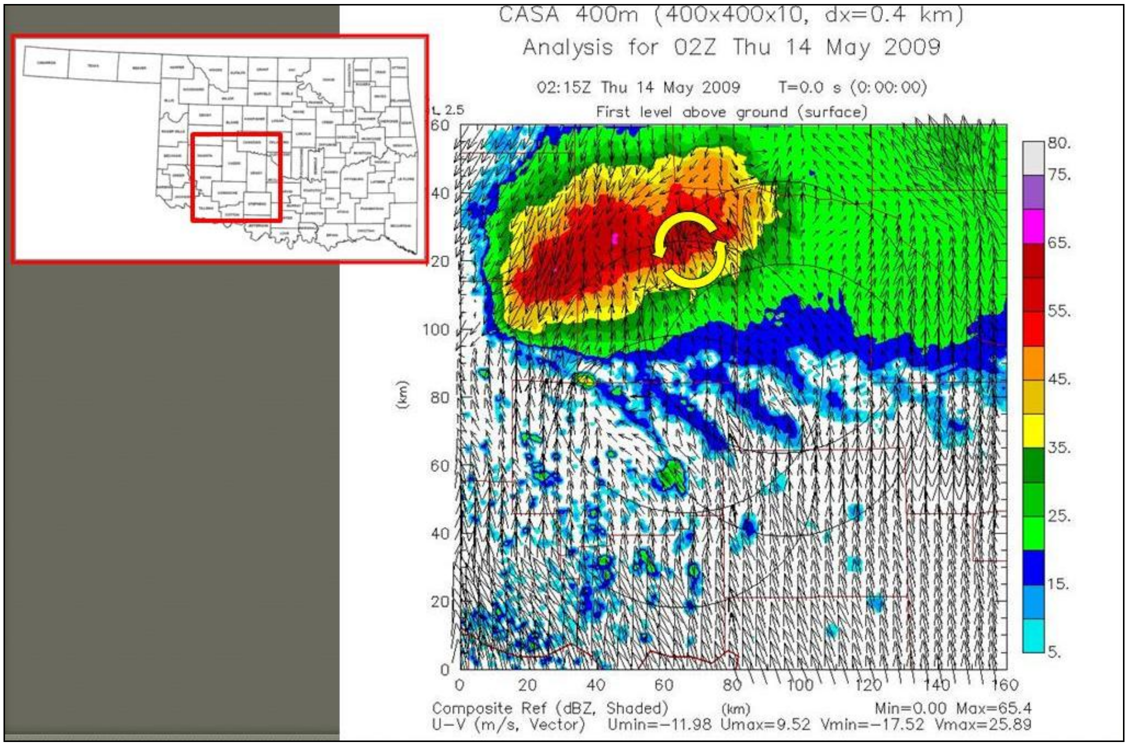

Figure 1: Image of CASA 3DVAR composite reflectivity overlaid with Doppler-derived wind vectors from 14 May 2009 at 0200 UTC where an EF-2 struck Anadarko, Oklahoma. The yellow arrows denote the tornadic circulation that can be identified by the wind vectors. The small red box in the state of Oklahoma is the domain. The product updates every 5 minutes and has a 10 minute delay in real-time, but that delay should improve as computing speeds increase. It has a 400m resolution, and this sample image shows data 200m AGL, but any height can be shown. Broadcasters were shown this image and asked if would be helpful to them, either behind-the-scenes or on-air.

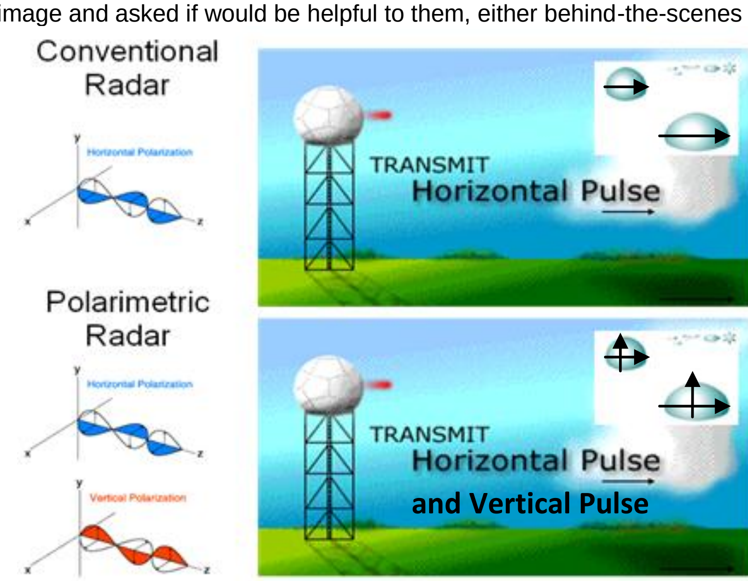

Figure 2: Conventional radar emits a single polarized electromagnetic wave in the horizontal plane, whereas polarimetric radar emits a dual-polarized electromagnetic wave in the horizontal *and* vertical plane. (Image credit: National Severe Storms Lab, http://www.nssl.noaa.gov/dualpol/)

Figure 3: Summary of the number of participants in each state. Broadcasters from twelve markets participated in the study.

Table 1: Summary of participant demographics. Due to protecting identities, limited information can be given. Market sizes were based on Nielson (2009) rankings, participant insight, and designated market area (DMA) population. In this study, markets with a population greater than 1 million (DMA #1-30) were considered large, between 250,000 and 1 million (#31-115) were medium, and less than 250,000 (#116-210) were small.

Participant Demographic Summary	
# of Interviews/ Market Size	3 Large, 12 Medium, 5 Small
Station Position:	7 Chiefs, 7 Morning, 6 Weekend
Gender:	16 Males, 4 Females
Experience:	1-37 Years, M = 14.5 yrs
Education:	12 Meteorology Degrees, 4 Meteorology Certificates

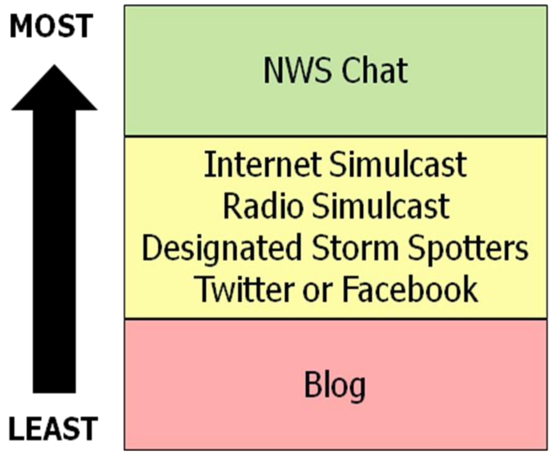

Figure 4: Summary of new media being used by participants. NWS Chat was being used by all but one broadcaster (95%). Internet simulcasting (60%), radio simulcasting (55%), gathering information from storm spotters in the field (45%), and social networking sites like Twitter and Facebook (40%) were used by about half of the participants. Blogs were not used during severe weather, except in one instance where a broadcaster said their station tried it once but resource limitations made it very difficult to keep it updated.