The topic of climate change has recently resurfaced on many news agendas, but increasingly, the scientific and political issues mix. Previous research has noted that even though the public relies primarily on television news as a source of climate change information, broadcasting has few environment and/or science reporters to cover the topic. This study considers another potential source—television weathercasters. This research measures weathercasters' acquired climate change knowledge against the scientific consensus and analyzes differences in their knowledge on the basis of several factors that may influence their climate change reporting. The results show that television weathercasters with the most accurate climate change knowledge scored highest in the affective domain—that is, the attitudes and values they hold about this scientific concept influenced their cognitive understanding of the topic more than any other independent variable. Put more simply—the "politics" of what some consider a controversial scientific topic had the greatest bearing on weathercasters' scientific knowledge.

Forecasting the Future

How Television Weathercasters' Attitudes and Beliefs about Climate Change Affect Their Cognitive Knowledge on the Science

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Creating Scientific Consensus

While media coverage of global warming did not really begin until 1988, research on the science of increased greenhouse gases in our atmosphere dates all the way back to the nineteenth century. As industrialization was sweeping across the Northern Hemisphere, a Nobel Prize–winning chemist from Sweden first hypothesized about the impacts of more carbon dioxide in the atmosphere (Arrhenius 1896). His research estimated that a global temperature increase of 4°C to 6°C would result from a doubling of industrial

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emissions. While the technological tools have become more sophisticated and the temperature estimate has been refined over the past one hundred plus years, the basic science has remained the same.

Climate modeling got an inadvertent boost in the 1950s Cold War era out of fears that the Soviet Union was modifying the global climate (Victor 1995). In 1965, the President's Science Advisory Committee published the first government report to recognize that climate change could be caused by human activities and that this would have important consequences for the world. Two years later, a numerical model of the atmosphere predicted that doubled carbon dioxide content in the atmosphere should raise the average surface temperature of the Earth 1.5°C to 3°C (Manabe and Weatherald 1967). More than one hundred independent estimates of average surface temperature were made between the mid-1960s and the mid-1980s, and all predicted temperature increases within the range of 1.5°C to 4.5°C with a doubling of greenhouse gases (Schlesinger and Mitchell 1985). Since then, multiple model enhancements and three international panels comprising thousands of leading scientists have concluded much the same. The third report of the Intergovernmental Panel on Climate Change (IPCC) (2001) projected that globally averaged surface temperatures will rise 1.4°C to 5.8°C this century. While the low end of the predicted temperature increase has remained largely the same throughout the advances and changes in modeling, the high end has gone through several modifications, with this new estimate of 5.8°C being higher than in the two previous IPCC reports.

The climate of the Earth has always fluctuated, so the task of separating the "signal" of anthropogenic warming amid the "noise" of the natural variability is extremely complex. Scientists around the globe are using large computers and esoteric programming to try to model both the current and predicted climate of the future. These general circulation models (GCMs) are three-dimensional representations of the atmosphere that involve hundreds of thousands of separate equations (MacDonald 1989). Although the models do show consistency with respect to increasing global temperatures, cloud cover, and precipitation, regional predictions remain problematic because of the large grid size used in the GCMs.

The IPCC was formed by the United Nations to synthesize scientific consensus. The principal finding in its first report was that a "discernable global warming has occurred and it may be due to anthropogenic causes" (Intergovernmental Panel on Climate Change 1995:22). The second report considered regional analyses of climate trends, future climate scenarios, and the impact for human and natural systems and comprised more biologists and geologists (Intergovernmental Panel on Climate Change 1998).

The third assessment included more than twelve hundred multinational scientists from twenty-three scientific disciplines who produced three separate working group documents, each more than one thousand pages. In addition the consideration of "improved analysis of data sets and comparisons among data from different sources that have led to a greater understanding of climate change" (Intergovernmental Panel on Climate Change 2001:2), more emphasis was also placed on the social aspects of potential climate change. Scientists were told to be "policy-relevant not policy-prescriptive" in their report. In other words, they were encouraged not to tell policymakers what to do about potential climate change but rather to provide "likely" scenarios in lay language that policymakers could understand and assimilate. While the ersatz separation of the science from the politics sounds like good practice, research, including the results of this study, suggests that this is difficult to do with this highly charged topic. And some scientists charge the IPCC itself with being "too political" (Lindzen 2001).

The IPCC reports represent scientific consensus, a term that creates confusion among scientists themselves, let alone journalists covering them. Scientists often accuse journalists of making science more certain than it is by eliminating important caveats, but the limited research to date suggests that journalists often also make science seem far less certain, many times out of ignorance (Stocking 1999). Some aspects of climate change science are considered certainties: the theory of the greenhouse effect itself is the most well-established certainty in all of atmospheric science (Kellogg 1991) and is not debated, although the large majority of weathercasters in the study discussed in this article believed that it still is. Dramatic increases in greenhouse gas concentrations, including a 31 percent increase in carbon dioxide since 1750 (Intergovernmental Panel on Climate Change 2001), are also considered certain science.

The next level of agreement is consensus, meaning that there is large agreement among scientists about the findings but still some unknowns. Consider this statement of attribution in the 2001 IPCC report:

> In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming in the last 50 years is *likely* [italics added] to have been due to the increase in greenhouse gas concentrations . . . and the balance of evidence suggests a discernable human influence. (P. 10)

Scientific consensus also occurs with regard to the measured 0.6°C increase in global surface temperature since 1861, when instrumentation began. Certainty is limited because of changes in measuring techniques, the expansion of urban heat islands, and vast areas of ocean without complete data, yet this panel of expert scientists considered the temperature increase real. Nine of the ten warmest years in recorded history have occurred since 1988, and 2001 was the planet's second hottest on record (National Climatic Data Center 2002).

Uncertainties are greatest in the realm of future predicted effects. The models lack the precision and specificity to accurately foresee all of the future, especially regionally, and that is where much of the media attention, scientific debate, and political squabbling are focused. As mentioned above, all the models agree on global increases in temperature, cloud cover, and precipitation, but where these will occur and what the impacts of these changes will be are not possible to discern with certainty using current models. The IPCC (2001:2) acknowledges "improved methods of processing data," and some scientists are optimistic that that kind of sophistication is only a few years away. Although predicted future effects are problematic, that does not mean that the entire science of climate change is clouded with uncertainty.

Science is not a popularity contest, and many important minority views have later been proved correct (Ellsaesser 1991), but quality media reporting on climate change needs to accurately portray both the scientific consensus and dissent.

Climate Change and the Media

While no scholarly research currently exists on television weathercasters and climate change, research about media coverage in general does provide some context for why this study was conducted and how it adds to the literature.

Initially, the press was not very interested in atmospheric research on a doubling of carbon dioxide (Kellogg 1988)—it took the serendipitous confluence of extreme weather events, combined with the release of new data, to take the theory of global warming from the laboratories and science journals and thrust it onto the media agenda. While many people credit the *New York Times* for publishing the first article on the "greenhouse effect" (in 1981), a recent historical book uncovered the topic of "global warming" being reported in the *Saturday Evening Post* as early as 1950 (Fleming 1998). However, most news operations did not broach the subject until the summer of 1988, when NASA scientist James Hansen testified before Congress about the increasing evidence of global warming. At the time, the United States was embroiled in an extended heat wave and drought that many scientists and journalists used as "hooks" for the story.

Hansen never said that increased greenhouse gases had caused the record warmth and drought of 1988, but according to some scientists, that inference was drawn and widely reported in the media (Schneider 1990). In the wake of such coverage, a greenhouse backlash was created. Scientists who believed that there was much uncertainty about the effects of greenhouse gas buildup increasingly came forward to express "some coolness concerning global warming" (Lindzen 1989). Other scientists suggested that the press had spent too much time focusing on statements by a handful of global warming skeptics (Lashoff 1990). One study found that this controversy among scientists received greater attention during the maintenance and downside of the attention cycle to global warming (McComas and Shanahan 1999), but the lingering effects of this "dueling-scientists" debate were easily discerned among a survey of reporters (Wilson 2000).

Journalists struggle with the terminology of the science of climate change. Science writers used the term *greenhouse effect* as a label, while nonscience writers preferred the term *global warming* (Wilkins 1993). Later research discovered that these kinds of differences in media portrayals were partially responsible for knowledge disparities noted among a population of college students (Wilson 1995).

U.S. news reporting on global climate change peaked in 1988 (Trumbo 1995), declined in the early 1990s, and then resurfaced on most news agendas in late 1997. Several possible explanations exist for this rise and fall in coverage. Ungar (1995) argued that global warming reporting declined because of the inability of the topic to sustain the status of a dramatic crisis. Other research posits that the dramatic narratives media constructed drove the change in reporting (McComas and Shanahan 1999). Mazur and Lee (1993), examining a different issue, ozone depletion, found that in most cases, drama rather than science had played a role in bringing the story to the media's attention. Events such as the Kyoto Climate Summit and El Niño's dramatic return and its resulting weather effects may also partially explain the reemergence of climate change reporting, as well as the ongoing reporting on the scientific debate, which enhances the drama of the story at the expense of the science.

Fluctuation in coverage could also result from what Downs (1972) first identified as the issue—the attention cycle of reporting of environmental issues. In his model, Downs identified five stages in the life of an environmental issue: preproblem, alarmed discovery and euphoric enthusiasm, realizing the cost, a gradual decline of interest, and postproblem. Trumbo (1996) expanded Downs's ideas and applied them to climate change reporting to identify the first three distinct phases in the media coverage. Scientists were the primary sources in the early stages of climate change reporting, when the framing of the story was defining the problems and diagnosing the causes. As politicians and interest groups were increasingly successful in making their claims, they changed the framing of the story toward making judgments and suggesting remedies (Trumbo 1996). The results of the study reported here indicate that the politicizing of climate change has had a dramatic, deleterious impact on the ability of some weathercasters to communicate accurately about the science.

Wilkins (1990) was one of the first to consider the mix of science and politics in climate change reporting. She found that good science writers covered the scientific aspects of the story well but missed the political nuances. Political reporting reflected the same problem: because the science was not covered well, the politics lost its edge. Ungar (1999) discovered that peaks in climate change reporting were not pegged to dramatic weather-related events but rather stories about the politics of the Bush administration, the Rio Earth Summit, and the Kyoto Protocol.

The mixing of climate change science and politics seems to have had a special impact on television weathercasters. As one example, the Clinton administration inadvertently exacerbated the perceived politicizing of the climate change issue among television weathercasters. One hundred of them received personal invitations from then Vice President Al Gore to attend a climate change summit at the White House in 1997. While many appreciated the invitation and the exposure, many others who attended were offended that a politician would dare attempt to educate them on such a topic. Others who were not invited considered this a professional snub. The net result is that many television weathercasters feel that Washington politicians are attempting to skew the scientific data on climate change for their own purposes. The mixing of politics and science also occurs with television management, and that can also affect weathercasters' ability to communicate climate change effectively. One television weathercaster, who spoke on the condition of anonymity, said that his television group owners forbid the use of the term *global warming* on any of their stations. The same kind of pressure exists at The Weather Channel. While meteorologists there concur with the consensus that the planet has grown warmer, they are also encouraged "not to talk about it (the causes or consequences) because then we're put in a very difficult political situation" (Seabrook 2000:53).

Finally, research also found that use of sources had a direct impact on reporters' knowledge about climate change (Wilson 2000). In that study, climate change knowledge was most accurate among the minority of reporters who primarily used scientists as sources instead of other media, as well as among those who worked on the science and/or environment beat full-time.

There are very few full-time science and/or environment specialists, especially in television, the medium with the greatest reach, and that was one impetus for this research—to consider other potential broadcast sources of information. Given the public's preference for television as a primary news source (Roper 1998), television weathercasters are an unstudied and perhaps important source of climate change information.

Research Goals

To build on the findings of previous research, the goals of this study were threefold:

1. to identify sources of weathercasters' climate change knowledge;
2. to measure this knowledge and identify conceptual gaps in knowledge; and
3. to analyze differences in this knowledge on the basis of a set of variables, including educational background, staff position, market size, the use of sources, the acquisition of meteorological "seals of approval," and attitudes and values about climate change.

Method

A four-page survey was mailed to 445 randomly selected local television weathercasters. The *Broadcasting and Cable Yearbook* was used to identify all network affiliates and independent stations in the United States with local newscasts. A rotating system of primetime or main anchor, morning or noon anchor, and weekend weather anchor was then used to identify one person at each station to receive the survey. Once the position was selected, a personal phone call was made to the station to get the correct name and spelling of the person currently in that position. Then, a survey specifically addressed to that person was mailed along with a cover letter identifying the investigator and the reasons for the inquiry.

A total of 217 television weathercasters responded to the survey, for a response rate of 48.8 percent. This is a very high response rate given that it was a one-time mailing, and no postcard reminders were mailed out. Survey research typically garners a response rate between 19 and 27 percent with no postcard follow-ups (Dillman 1978). No code numbers were used on the surveys to ensure confidentiality and anonymity, which contributed to the higher response rate. The goal of a probability sample is a systematic selection procedure to represent the universe with a minimum of sampling error. This is one of the largest such surveys of television weathercasters ever conducted, and it provides some valuable insight into this profession's ability to communicate about this important scientific topic.

The sample had an excellent distribution among key variables. Half of the respondents were primetime anchors or chief meteorologists, and the other half worked weekends and noon or mornings. Half (108) held the American Meteorological Society's (AMS) seal of approval, while a quarter of the sample had earned the National Weather Association's (NWA) seal of approval (9 percent held both seals), and the remainder had neither of the voluntary credentials that on-air weathercasters can earn. The sample also included a broad distribution among market sizes, with 22 percent from the top 25 markets, 16 percent in markets 26 to 50, 32 percent in markets 51 to 100 and another 30 percent in markets 101 and smaller. More than half of the respondents held degrees in meteorology or atmospheric science, while a quarter of the weathercasters' degrees were in journalism or communications. The remainder had a mix of training and education. All of these factors allowed for optimal statistical analyses between and among groups of independent variables.

Cognitive knowledge about climate change was measured using seventy-six multiple-choice questions. "I don't know" was included as an option to more directly measure weathercasters' ignorance about a topic. They were encouraged to use that option rather than randomly guessing to hide a lack of knowledge (Converse 1984). Ignorance, in the sense of absence of scientific knowledge, is another concept in need of scholars' attention (Stocking 1999), and this study analyzed accurate, incorrect, and "I don't know" (ignorance) responses as proposed by Smithson (1989). The questions were developed using the consensus report of the IPCC and tested for accuracy with a national panel of atmospheric scientists. Knowledge was measured in four content areas: (1) scientific context, (2) greenhouse gases, (3) sources of increased greenhouse gas emissions, and (4) the predicted effects of climate change. An overall total knowledge and ignorance score for the entire test was also calculated and reported in table form.

Because the political aspects of global climate change are so intricately woven with the science, a series of Likert-type scale questions ranging from "strongly agree" to "strongly disagree" were also used to query weathercasters' attitudes and values. The design and purpose of these questions enabled an analysis of what Bloom (1956) first identified as the affective domain of knowledge. This is especially pertinent to learning from television, for research indicates that television is most effective at transferring attitudes and beliefs (Philo 1990). Another study measured learning about environmental issues (before climate change was identified) and discovered that outcomes in the affective domain are less tangible and more difficult to interpret and assess but are an integral aspect of knowledge (Marsden 1976). Bloom's taxonomy ultimately argues that attitudes and values must also be considered as part of the learning process, so this survey of television weathercasters included a large section designed to explore these attitudes and values.

Results and Discussion

Sources of Weathercaster Knowledge about Climate Change

Only 7 percent of these weathercasters said that their stations had environment and/or science reporters, and 40 percent of them said that they had already reported on the broad topic of global warming. Unlike reporters in a previous survey who said that they relied on other mediated sources (primarily newspapers) for their climate change knowledge (Wilson 2000), these weathercasters said that they primarily used scientific journals (29 percent) and scientists (26 percent) as sources. College coursework also played an important role for some television weathercasters (17 percent), while only 8 percent said that they used any form of media (print, television, radio, or the Internet) as primary climate change sources. This is a striking shift in the use of sources. Perhaps one reason this occurs is that on-air meteorologists working in a science discipline feel more comfortable using scientific sources. Reporters often cite the difficulty in approaching scientists as a constraint to their reporting (Dunwoody 1986), but clearly, many television weathercasters do not share this apprehension.

Weathercasters' Knowledge about Climate Change

All 217 weathercasters (100 percent) were familiar with the term *global warming*, but follow-up questions uncovered large variability in the accuracy of their acquired knowledge. To examine the relationship between the individual predictors and weathercasters' knowledge, ten summary scores were created (Table 1).

Four summary scores represented weathercasters' accurate responses to the survey questions in each of the four content areas. An additional four summary scores were created to represent weathercasters' lack of knowledge or their ignorance ("I don't know" responses). There were five dimensions to each aspect of knowledge, as denoted by the content areas: scientific context, knowledge of greenhouse gases, knowledge of increased greenhouse gas emissions, knowledge of predicted effects, and total knowledge index. The total knowledge index represented the sum of the four other dimensions. Table 1 shows the means, standard deviations, and coefficient alphas for each

TABLE 1
Accuracy and Ignorance Index for the Five Content Areas

Outcome	M	SD	α
Accuracy of scientific context	2.69	1.05	.22
Ignorance of scientific context	0.97	1.02	.40
Accuracy of knowledge of greenhouse gases	4.00	2.04	.67
Ignorance of greenhouse gases	2.84	2.41	.80
Accuracy of knowledge of increase in greenhouse emissions	5.59	2.43	.68
Ignorance of increase in greenhouse emissions	4.04	3.07	.83
Knowledge of predicted effects	2.05	1.88	.78
Ignorance of predicted effects	4.08	2.44	.86
Total knowledge index	14.33	5.53	.80
Total ignorance index	11.94	7.03	.87

NOTE: To examine the relationships between the individual predictors and weathercasters' knowledge, ten summary scores were created. Five summary scores represent weathercasters' accuracy in responding to questions represented by a correct answer. An additional five summary scores were created to represent weathercasters' lack of knowledge. There were five dimensions to each aspect of knowledge: scientific context, knowledge of greenhouse gases, knowledge of increase in greenhouse emissions, knowledge of predicted effects, and total knowledge index. The total knowledge index represents the sum of the four other dimensions. The table shows the means, standard deviations, and coefficient alphas for each score. Overall, most reliabilities appear adequate, except for scientific context.

score. Overall, reliabilities were good except for scientific context, which will be elaborated on later, indicating a consistency of responses within the domains. More variation occurred in the ignorance index, implying that despite the "I don't know" option, some weathercasters were more willing to admit their ignorance than others.

Table 2 shows the interconnections between the dependent variables, demonstrating consistent relationships between knowledge and ignorance—as accuracy increases, ignorance is reduced. All correlations were statistically significant at $p < .01$. Weathercasters' responses were consistent within and across knowledge domains. Those with higher accuracy in the area of scientific context, for instance, also showed higher knowledge in other content areas.

To highlight some findings within the content areas: carbon dioxide was correctly identified as a greenhouse gas by 80 percent of the weathercasters and methane by 63 percent. Weathercasters did not perform as well in recognizing other important greenhouse gases such as chlorofluorocarbons (CFCs) (56 percent) and nitrous oxide (22 percent). Most weathercasters were knowledgeable about sources of increased greenhouse emissions related to carbon dioxide, including auto emissions (87 percent) and

TABLE 2

Correlations among Independent Variables

Correlation	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. Accuracy of scientific context	1.00									
2. Ignorance of scientific context	–0.63	1.00								
3. Accuracy of knowledge of greenhouse gases	0.41	–0.36	1.00							
4. Ignorance of greenhouse gases	–0.39	0.34	–0.85	1.00						
5. Accuracy of knowledge of increase in greenhouse emissions	0.34	–0.28	0.60	–0.58	1.00					
6. Ignorance of increase in greenhouse emissions	–0.41	0.37	–0.62	0.71	–0.83	1.00				
7. Knowledge of predicted effects	0.41	–0.39	0.30	–0.34	0.29	–0.41	1.00			
8. Ignorance of predicted effects	–0.39	0.38	–0.33	0.39	–0.31	0.42	–0.87	1.00		
9. Total knowledge index	0.63	–0.51	0.81	–0.75	0.82	–0.81	0.66	–0.63	1.00	
10. Total ignorance index	–0.54	0.56	–0.73	0.84	–0.71	0.88	–0.65	0.72	–0.91	1.00

NOTE: The table shows the intercorrelations between the ten scores. All correlations were statistically significant at $p < .01$.

deforestation (65 percent) but were substantially less aware of sources related to other greenhouse gases—such as landfills (25 percent) and rice agriculture (13 percent) associated with methane and air conditioning leaks (47 percent) related to the release of CFCs. Surprisingly, all of these numbers were lower than reporters' responses to the same questions a few years earlier (Wilson 2000).

This sample of weathercasters also demonstrated serious misconceptions about the scientific consensus regarding predictions of climate modeling. Most weathercasters were aware of the scientific consensus of a global temperature increase (73 percent), although nearly a quarter answered, "I don't know." Only a third accurately identified the models' agreement on an increase in global cloud cover (35 percent) and a global precipitation increase (34 percent) with a doubling of greenhouse gases. These statistics are startling, given that all atmospheric models agree on these predictions, and they represent basic atmospheric science with which weathercasters work daily. In a warmer world, more evaporation will occur, which will increase cloud cover, which will lead to more global precipitation. This is basic meteorology yet apparently misunderstood by two thirds of these television weathercasters. It was expected that television weathercasters, who use many similar models in their forecasting activities, would understand climate models better than reporters or the public, but the results of this survey did not support such a hypothesis.

Like the reporters before them, many weathercasters also tended to ascribe scientific agreement where it does not exist by overestimating the scientific consensus about increased drought and hotter summers in the United States. While such speculation might seem intuitive with the theory of global warming, current climate modeling does not yet provide such specificity for regional predictions. Kempton (1997) found that these misconceptions were shared in a sample of voters as well and may have resulted from media coverage, although this was not tested in his research. Many people are unable to distinguish between the concepts of climate, which refers to long-term, stable patterns, and weather, which is short-term and highly variable. But the fact that weathercasters, whose daily lives revolve around such nuances, are unable to do so is a bit surprising. Ninety-three percent of the weathercasters disagreed with a later statement in the survey that "weather and climate are the same thing," but many of them were confused about these concepts when applied to the predicted effects of increased greenhouse gases. Clearly, something is contaminating their understanding of the science of their discipline.

Some preliminary clues to this influence can be found in the first knowledge area. The coefficient alpha was lowest in the area of scientific context (Table 1), suggesting some problems with survey questions in this portion of the instrument or perhaps with weathercasters' understanding of the concepts associated with the science of climate change. Only 22 percent of weathercasters correctly acknowledged that the theory of global warming is accepted by most atmospheric scientists. Most weathercasters (58 percent) thought that the topic was still strongly debated among these specialists. Although the greenhouse effect is a scientific "certainty" and the most well-established theory in atmospheric science (Kellogg 1991), as noted earlier, fewer than half (44 percent) of all television weathercasters knew this.

Weathercasters also scored poorly in three of the four other contextual measures in the survey related to the Earth's current temperature, as well as the scientific agreement on predicted global temperature increase. Seventy percent of weathercasters accurately identified the scientific consensus that the Earth's surface temperature has indeed increased in the last one hundred years. But only 13 percent were able to identify the range of predicted temperature increase. The largest percentage (35 percent) thought that there was no scientific consensus on a global temperature increase.

As these numbers indicate, significant numbers of weathercasters were ignorant or misinformed about these contextual measures that assist in making connections to ongoing climate change research. Even though a majority of these weathercasters said that they primarily used scientists and science journals to inform them about this topic, which was previously demonstrated to positively increase knowledge about climate change, something plainly is negating this practice. Discovering why this is occurring is one of the goals of the next section.

Factors Affecting Weathercasters' Knowledge about Climate Change

The same four content knowledge areas were used for this analysis, as well as the total knowledge index. To test which weathercaster characteristics would best predict knowledge outcomes, a set of hierarchical multiple linear regressions was conducted (Table 3). The following predictors were included in step 1: staff position (primary anchor or other), educational background, and market size. It was expected that those weathercasters who had risen in their careers to larger markets and/or primary anchors and who had science degrees would possess better knowledge than other weathercasters.

In step 2, predictors were entered representing whether weathercasters had earned seals of approval from the AMS and/or the NWA. Again, the expectation was that those who had passed meteorological exams and obtained the certification required to earn these seals would have more accurate climate change knowledge than those who had not earned these

TABLE 3

Hierarchical Multiple Regression Using Accuracy Indexes as Dependent Variables

Equation	*Accuracy of Scientific Context*		*Accuracy of Knowledge of Greenhouse Gases*		*Accuracy of Knowledge of Increase in Greenhouse Emissions*		*Knowledge of Predicted Effects*		*Total Knowledge Index*	
	Standardized β Coefficient	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2
Step 1		.086*		.05		.03		.09*		.08*
Primary anchor	.00		.09		–.08		.02		.01	
Other anchor	.05		.03		–.04		.00		.00	
Meteorology degree	.02		.17		.17		.08		.17	
Journalism degree	–.17		.03		.09		–.07		–.01	
Other science degree	.03		.14		.08		–.07		.06	
Journalism and science degree	–.03		.03		.07		–.06		.01	
Market size	–.02		.06		.09		–.02		.05	
Step 2				.01		.00		.03		.01
AMS seal	.16		.01		.06		.18*		.13	
NWA seal	–.06		.11		–.01		.07		.05	
Step 3		.07*		.07*		.12***		.10**		.14***
Climate change is a serious issue	.08		.10		.11		–.02		.10	
Weathercast is the proper place to educate	–.03		.09		.09		–.01		.06	
Variations becoming increasingly common	.15		.11		.24*		.23*		.26**	

TABLE 3 (continued)

Equation	Accuracy of Scientific Context		Accuracy of Knowledge of Greenhouse Gases		Accuracy of Knowledge of Increase in Greenhouse Emissions		Knowledge of Predicted Effects		Total Knowledge Index	
	Standardized β Coefficient	Change in R^2	Standardized β Coefficient	Change in R^2	Standardized β Coefficient	Change in R^2	Standardized β Coefficient	Change in R^2	Standardized β Coefficient	Change in R^2
Variations symptomatic of climate change	.01		–.29**		–.26*		–.13		–.27**	
Weather and climate are the same thing	–.05		.00		–.10		–.12		–.10	
I understand the science of climate change	.19*		.12		.18*		.24*		.25**	
Total R^2		0.17**		0.13		.15*		.22***		.23***

NOTE: AMS = American Meteorological Society; NWA = National Weather Association.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

credentials. By entering the seal characteristics in step 2, the regression model tested variation in their knowledge after controlling for position, education, and market size characteristics in step 1.

Step 3 included six variables representing television weathercasters' attitudes and beliefs about climate change as measured with Likert-type scale questions in the survey. The questions asked weathercasters to choose among a five-point scale ranging from "strongly agree" to "strongly disagree" with the statements. Negative numbers in the table represent disagreement with the statements.

Table 3 shows the individual standardized regression coefficients (β values) for the predictors and the incremental R^2 values for the three blocks of variables along with the overall R^2 values for the entire model using the five knowledge accuracy scores as dependent variables. Overall, very few of the variables in step 1 and step 2 had the expected impact on television weathercasters' knowledge (Table 3). For example, the seven predictors in step 1 explained about 9 percent of the variation in weathercasters' accuracy in the domain of scientific context and 8 percent of the variation in total knowledge, but none of the individual predictors exhibited statistical significance. Having a meteorology degree was the most consistent predictor of accurate climate change knowledge in step 1, but again, it was not statistically significant by itself. Surprisingly, market size and seniority in the business and on the weather staff had no statistical effect on climate change knowledge, which challenges one of the basic tenets of television that the best in the business rise to senior positions in larger markets.

Step 2 characteristics explain none of the variation in weathercaster knowledge. Only in the area of predicted effects did having a seal (from the AMS) positively predict an increase in accurate knowledge, but overall, neither seal had any statistical significance on climate knowledge. This finding may be especially distressing to those organizations that administer these seal programs and require extensive testing and certification to earn the distinction of a seal of approval. Although the seals do not directly test for climatological knowledge, they do require meteorological training that covers many of the same issues presented earlier.

While expected stronger findings in the first two steps were not found, the strongest predictors explaining variation in television weathercasters' knowledge were consistently found in their attitudes and values about the topic of climate change, even after controlling for those factors in the previous analyses. These six questions tested knowledge in the affective domain, and the results indicate that they had the largest bearing on these weathercasters' cognitive knowledge. Before analyzing the multiple regression results, responses to each of the questions are first discussed to provide some context for the analysis.

Three quarters of the weathercasters agreed that "climate change is a serious environmental issue." Fewer than 5 percent disagreed with the statement. More than 93 percent of them accurately acknowledged that climate and weather are distinct concepts, while 3 percent thought that the terms were the same. More than half of the respondents (57 percent) believed that "I understand the science of climate change," while only 12 percent thought that they did not. The accuracy of their responses in this survey, however, contradicts this belief, because many weathercasters actually had distorted understandings of the science. A third of the sample felt neutral in responding to this question, perhaps indicating that many weathercasters believed that they understood some aspects of the science while being ignorant of others. These Likert-type questions were asked at the end of the survey, after weathercasters had answered the cognitive knowledge questions, perhaps also giving some of them an insight into the breadth and depth of climate change concepts they may not have considered before.

These television weathercasters were evenly split about whether their broadcasts were "the proper place to educate about environmental issues such as climate change." More than 40 percent agreed with the statement, 30 percent disagreed, and 28 percent felt neutral about using their weather broadcasts to educate about climate change. In follow-up interviews, many television weathercasters bristled at the word *educate*, which many did not feel was their job or purview, which may have unintentionally complicated the results to this question.

Finally, the two remaining questions asked respondents to comment on changes in local weather, their area of expertise. Weathercasters were evenly divided in their responses to "variations in weather are becoming increasingly common." More than a third agreed with the statement, which is supported by IPCC findings. Almost the same number disagreed with the statement. What these questions cannot discriminate is whether these responses are linked to variations in weather in specific locales based on the personal experiences of the individual weathercasters or on climate change research. A follow-up question got to the debate over these increasing changes in weather, asking respondents if these "local variations are symptomatic of global climate change." A majority (53 percent) accurately disagreed with the statement, and only 9 percent mistakenly took the research beyond its current capabilities to ascribe local, regional effects not yet linked to climate change. The single largest group of respondents (38 percent) did not know.

Each of these questions was used in a hierarchical multiple regression model to measure their potential impact on weathercasters' accuracy and ignorance of climate change knowledge. The significance was greatest in the accurate knowledge of greenhouse gases and total knowledge ($p < .001$) but occurred in all five content areas (Table 3). An inverse relationship (negative number) found in four of the content areas with the statement about variations in local weather indicates that television weathercasters accurately disagreed with the statement. No credible scientist claims the ability to ascribe a particular weather event to global climate change, and those weathercasters who knew that had more accurate climate change knowledge.

The same kind of statistical significance occurred with those weathercasters who agreed that "variations in local weather are becoming increasingly common" in the content areas of knowledge of greenhouse gases and total knowledge. Most weathercasters acknowledged that their own local weather had become more variable, but by carefully not describing those local changes as symptomatic of global climatic change, they elevated their knowledge scores. Finally, those weathercasters who possessed the attitude that "I understand the science of climate change" actually did better in four of the content areas, with statistical significance of $p < .01$ in total knowledge.

Overall, the predictors explained 23 percent of the variation in accurate weathercaster knowledge, which is statistically significant ($p < .001$).

Because this study was based on previous research that encouraged the measurement of ignorance as well as knowledge, a similar set of hierarchical multiple regressions was performed using the five ignorance scores as dependent variables. Table 4 shows the individual standardized regression coefficients (β values) for the predictors and the incremental R^2 values for the three blocks of variables along with the overall R^2 values for the entire model. Overall, the same predictors of accuracy were also the most consistent statistically significant predictors of ignorance.

Conclusions

Public understanding of science is critical in a society increasingly affected by its impacts and its related policy implications (Nelkin 1987). The world's leading scientists acknowledge the vital role of a well-informed public to set appropriate climate change policy (Intergovernmental Panel on Climate Change 1995). Today, the media are the most common source of such

TABLE 4

Hierarchical Multiple Regression Using Ignorance Indexes as Dependent Variables

Equation	*Ignorance of Scientific Context*		*Ignorance of Greenhouse Gases*		*Ignorance of Increase in Greenhouse Emissions*		*Ignorance of Predicted Effects*		*Total Ignorance Index*	
	Standardized β Coefficient	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2	*Standardized β Coefficient*	*Change in* R^2
Step 1		.11**		.06		.06		.06		.08*
Primary anchor	–.12		–.06		.01		.04		–.02	
Other anchor	–.20*		–.07		–.06		.06		–.06	
Meteorology degree	–.16		–.19		–.22		–.09		–.22	
Journalism degree	.03		–.12		–.17		.05		–.09	
Other science degree	–.13		–.16		–.10		.07		–.09	
Journalism and science degree	–.01		.00		–.07		.08		.00	
Market size	.07		–.06		–.09		.03		–.04	
Step 2		.00		.00		.01		.03		.01
AMS seal	–.05		–.07		–.09		–.16		–.13	
NWA seal	.01		–.03		.02		–.10		–.04	
Step 3		.08*		.07*		.12***		.12***		.14***
Climate change is a serious issue	–.04		–.06		–.14		–.07		–.11	
Weathercast is the proper place to educate	–.10		–.06		–.02		.05		–.02	
Variations becoming increasingly common	–.07		–.09		–.23*		–.27**		–.24*	

Variations symptomatic of climate change	.03		.25*		.30**		.17		.28*	
Weather and climate are the same thing	.12		–.02		.11		.05		.08	
I understand the science of climate change	–.22**		–.18*		–.17*		–.26**		–.26*	
Total R^2		.20***		.13		.19**		.21***		.24***

NOTE: AMS = American Meteorological Society; NWA = National Weather Association.
$*p < .05$. $**p < .01$. $***p < .001$.

scientific information. The media were the sole source of information on climate change for most New Zealanders (Bell 1994), and in the United States, the media, especially television, were also identified as the primary source of climate change knowledge (Wilson 1995). This research has addressed another area of mediated climate change information that had yet to be considered—the role of television weathercasters. Previous content analyses helped understand how media covered climate change, while this study adds to the literature on why this reporting is occurring. No content analyses of weathercasts have yet been conducted to compare the use of climate change language, visuals, and connotations with the findings of other media coverage, and that is an area ripe for future study.

The results of this research suggest that the political aspects of climate change are not easily separated from the science. Even among this group of specialists in atmospheric science, widespread ignorance of and misinformation about basic climate change science is evident, and as the data describe, much of that can be connected to the values and beliefs that weathercasters hold about the topic. These results substantiate other recent findings about the power of people's "feelings" (affective domain) over knowledge in public support for biotechnology (Priest 2001).

Solutions to this dilemma are not easily rendered. Recommending that reporters go to scientists and science journals instead of other media as the primary sources of knowledge, as suggested in previous research, does not apply here. These weathercasters say that they are already using those preferred sources, and yet the distortion of their scientific knowledge persists. Previous research also found that full-time science and/or environment reporters had more accurate climate change knowledge than other reporters, and it was recommended that increasing their number and status might also improve reporting. However, the television weathercasters in this survey are already full-time, and the data show that being the primary anchor in the largest market or the weekend anchor in the smallest market had no statistical impact on their climate change knowledge. Neither did possessing either of the two coveted seals of approval, suggesting that more training and education alone also may not address the disparity in accurate knowledge.

The results of this survey indicate that many television weathercasters have created dissent in areas in which scientific consensus exists. Their misunderstandings of the basic principles of meteorology, which also apply to climate change, are baffling and ultimately can be explained in this sample by their own politicizing of the science.

New strategies that address both science and policy will be required to overcome these obstacles in addition to the remedies previously recommended for other journalists.

References

Arrhenius, S. 1896. On the influence of carbonic acid in the air upon the temperature of the ground. *Philosophical Magazine* 41:237-71.

Bell, A. 1994. Media (mis)communication on the science of climate change. *Public Understanding of Science* 3 (4): 259-75.

Bloom, B. 1956. *Taxonomy of educational objectives, handbook I.* New York: McGraw-Hill.

Converse, J. M. 1984. Strong arguments and weak evidence: The open/closed controversy. *Public Opinion Quarterly* 48:267-82.

Dillman, D. 1978. *Mail and telephone surveys: The total design method.* New York: John Wiley.

Downs, A. 1972. Up and down with ecology—the issue-attention cycle. *The Public Interest* 28:38-50.

Dunwoody, S. 1986. The scientist as source. In *Scientists and journalists: Reporting science as news*, edited by S. M. Friedman, S. Dunwoody, and C. L. Rogers, 3-16. New York: Free Press.

Ellsaesser, H. 1991. Comment on the global warming debate heats up: An analysis and perspective. *Bulletin of the American Meteorological Society* 72 (7):1009-10.

Fleming, J. R. 1998. *Historical perspectives on climate change.* Oxford: Oxford University Press.

Intergovernmental Panel on Climate Change. 1995. *Climate change 1995: The science of climate change.* Contribution of working group I to the second assessment of the IPCC. New York: Cambridge University Press.

———. 1998. *Climate change: Policymakers summary of the scientific assessment of climate change.* New York: Cambridge University Press.

———. 2001. *Summary for policymakers: A report of working group I.* New York: Cambridge University Press.

Kellogg, W. W. 1988. Human impact on climate: The evolution of an awareness. In *Societal response to regional climate change: Forecasting by analogy*, edited by M. Glantz, 9-39. Boulder, CO: Westview.

———. 1991. Response to skeptics of global warming. *Bulletin of the American Meteorological Society* 74 (4): 499-511.

Kempton, W. 1997. How the public views climate change. *Environment* 39:1-12.

Lashoff, D. A. 1990. *Concern about global warming: Panic or prudence?* Washington, DC: Natural Resources Defense Council.

Lindzen, R. 1989. Some coolness concerning global warming. *Bulletin of the American Meteorological Society* 71:288-99.

———. 2001. *Weaknesses in the alarmist case.* Global climate change presentation to the Knight Science Journalism Fellowships at MIT. 26 April.

MacDonald, G. 1989. Scientific basis for the greenhouse effect. In *The challenge of global warming*, edited by D. E. Abrahamson, 123-45. Washington, DC: Island.

Manabe, S., and R. Weatherald. 1967. Thermal equilibrium of the atmosphere with a given distribution of relative humidity. *Journal of Atmospheric Science* 24:241-59.

Marsden, W. E. 1976. *Evaluating the geography curriculum.* Edinburgh, UK: Oliver and Boyd.

Mazur, A., and J. Lee. 1993. Sounding the global alarm: Environmental issues in the U.S. national news. *Social Studies of Science* 23:681-720.

McComas, K., and J. Shanahan. 1999. Telling stories about global climate change: Measuring the impact of narratives on issue cycles. *Communication Research* 26 (1): 30-57.

National Climatic Data Center. 2002. Home page. Retrieved 18 January from http://lwf.ncdc.noaa.gov/oa/ncdc.html

Nelkin, D. 1987. *Selling science: How the press covers science and technology.* New York: W. H. Freeman.

Philo, G. 1990. *Seeing and believing: The influence of television.* London: Routledge.

Priest, S. H. 2001. Misplaced faith: Communication variables as predictors of encouragement for biotechnology development. *Science Communication* 23:97-110.

President's Science Advisory Committee. 1965. Restoring the quality of our environment. Report of the Environmental Pollution Panel. Washington, DC: President's Science Advisory Committee.

Roper, B. W. 1998. Public attitudes toward television and other mass media. A report by the Roper Organization, Inc. New York: Television Information Office.

Schlesinger, M., and J.F.B. Mitchell. 1985. Climate model simulations of the equilibrium climatic response to increased CO_2. *Review of Geophysics* 25:760-98.

Schneider, S. 1990. The global warming debate heats up: An analysis and perspective. *Bulletin of the American Meteorological Society* 71 (9): 1292-1304.

Seabrook, J. 2000. Selling the weather. *The New Yorker,* 3 April, pp. 44-53.

Smithson, M. 1989. *Ignorance and uncertainty: Emerging paradigms.* New York: Springer-Verlag.

Stocking, S. H. 1999. How journalists deal with scientific uncertainty. In *Communicating uncertainty: Media coverage of new and controversial science,* edited by S. M. Friedman, S. Dunwoody, and C. L. Rogers, 23-41. Mahwah, NJ: Lawrence Erlbaum.

Trumbo, C. 1995. Longitudinal modeling of public issues: An application of the agenda-setting process to the issue of global warming. *Journalism and Mass Communication Monographs* 152, August.

———. 1996. Constructing climate change: Claims and frames in U.S. news coverage of an environmental issue. *Public Understanding of Science* 5 (3): 1-15.

Ungar, S. 1995. Social scares and global warming: Beyond the Rio convention. *Society and Natural Resources* 8: 443-56.

———. 1999. Is strange weather in the air? A study of U.S. national network news coverage of extreme weather events. *Climatic Change* 41:133-50.

Victor, D. 1995. On writing good histories of climate change and testing social science theories. *Climatic Change* 29:363-69.

Wilkins, L. 1993. Between facts and values: Print media coverage of the greenhouse effect, 1987-1990. *Public Understanding of Science* 2 (2): 71-84.

———. 1990. Taking the future seriously. *Journal of Mass Media Ethics* 5:88-101.

Wilson, K. M. 1995. Mass media as sources of global warming knowledge. *Mass Communications Review* 22 (1): 75-89.

———. 2000. Drought, debate, and uncertainty: Measuring reporters' knowledge and ignorance about climate change. *Public Understanding of Science* 9 (1): 1-13.

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