TV Weathercasters and Climate Education: Expanding the Reach of Climate Matters

NSF Award # DRL-1422431

Principal Investigator: Edward Maibach, George Mason University

Summative Evaluation Report

Proposed Project Summary

Overview: Through this broad implementation AISL proposal, our partnership (two universities, three NGOs, and two government agencies) will scale-up a proven climate education method delivered by TV weathercasters. TV weathercasts have extraordinary potential as climate educators. Unlike climate scientists, weathercasters have unparalleled access to the public: well over 100 million Americans across demographic, economic, ideological, and educational lines routinely watch local TV weathercasts, and these numbers expand dramatically when extreme weather strikes. Moreover, surveys show that TV weathercasters are one of American's most trusted sources for climate change information. Because most weathercasters are deeply involved in community education through broadcast media (TV, radio, newspapers, station websites), social media (Facebook, Twitter, and personal blogs), and community presentations (e.g., at schools, science museums and community events), they are ideally positioned to educate members of their community about the connections between climate variability, climate change and the local weather on air and in a variety of other informal settings.

Over three years, this project will expand the number of weathercasters participating in Climate Matters by 200 – from about 100 to 300, nationwide. Developed with NSF funding, Climate Matters is a project that supports TV weathercasters with localized climate data, broadcast-ready graphics and messages, and training and professional development and helps them expand their professional role to become climate educators. A controlled impact evaluation of Climate Matters – conducted over one year with the WLTX weather team (Columbia, SC) – demonstrated that Climate Matters improved local TV viewers' understanding of climate change in a manner consistent with the program's educational objectives, thus proving that when TV weathercasters educate their viewers about climate change, viewers gain a more science-based understanding. In an ongoing statewide impact evaluation of Climate Matters in Virginia, 36% of all invited weathercasters are now participating in the program, which confirms survey findings that suggest many weathercasters are willing to serve as climate educators.

This project will include four inter-related, complementary activities: (1) recruiting 200 TV more weathercasters nationwide with the aim of achieving the broadest possible implementation of Climate Matters in the shortest possible time; (2) providing participating weathercasters with professional development activities and training on use of Climate Matters materials to help them become confident and competent climate educators; (3) developing and distributing to participating weathercasters timely, localized, broadcast-ready graphics and messages – when possible tied to local weather and climatic events – to make it easy for them to educate their viewers about the local implications of climate change; and (4) R&D activities to improve the

rate of use, and effectiveness, of Climate Matters materials over time. The impact of the project will be evaluated with nationally representative surveys of the public, conducted twice per year over the course of the project. Our hypothesis is that there will be a dose-response relationship between the extent of TV weathercaster use of Climate Matters materials in a community (i.e., a media market) and change over time in viewers' understanding of climate change.

Intellectual merit: The efficacy of Climate Matters – which was developed using theories of informal and experiential learning – has been proven. The current challenge is to demonstrate effectiveness at scale, nationwide. This involves scaling up the project – using methods derived from diffusion of innovation and social marketing theories -- and conducting a rigorous and innovative national impact evaluation.

Broader impacts: This project has unusually large potential for impact – by delivering the right information (information about the local relevance of climate change), through the right messengers (trusted local news/weather professionals), at the right time (coincident with the local climate impact occurring), repeatedly, to tens of millions of diverse Americans – which itself is an important innovation in advancing informal science learning.

The project proposal included a detailed Impact Evaluation Plan, which is presented in Appendix A of this document.

Summary of Project Outcomes

Impact on TV weathercasters: Climate Matters is a climate change reporting resources program developed to support localized climate reporting by TV weathercasters across the United States. The reporting resources were produced and distributed on an approximately weekly basis, in English and Spanish. At the beginning of the award period, Climate Matters was supporting 150 TV weathercasters. That number grew to 784 weathercasters by the end of the award period, 38 of whom broadcast in Spanish. Those weathercasters broadcast from 420 local TV stations, with at least one weathercaster broadcasting in 88% of US media markets. Through workshops and webinars, the project also provided numerous professional development opportunities to TV weathercasters who wanted to increase their competence and confidence in local climate reporting.

Regarding impact, we documented substantial increases in both the science-based views and climate reporting practices of TV weathercasters.

We have strong evidence—both empirical and anecdotal—that our project is having a positive impact on the broadcast meteorology community. Our weathercaster survey data enabled us to publish an article in the *Bulletin of the American Meteorological Society* which concluded—based on a review of all available surveys of American broadcast meteorologists conducted over the past 15 years or so—that since the start of the Climate Matters project in 2010, weathercasters' views about climate change have evolved rapidly, in ways consist with climate science. Our first NSF-funded survey of weathercasters in 2010 found that members of the American broadcast meteorology community were largely divided on the reality of human-caused climate change—in fact, they were less convinced about human-caused climate change (on average) than members of the American public (on average). By 2017, when we conducted our most recent survey of weathercasters, their views had changed dramatically—nearly all were

convinced of the reality of human-caused climate change. (Citation: Maibach, E., Mazzone, R., Myers, T., Seitter, K., Hayhoe, K., Ryan, B., Witte, J., Gardiner, N., Hassol, S., Lazo, J., Placky, B., Sublette, S. & Cullen, H. (2017) TV weathercasters' views of climate change appear to be rapidly evolving. *Bulletin of the American Meteorological Society,* doi: 10.1175/BAMS-D-15-00206.1)

Although we can't claim credit for these rapidly evolving views of broadcast meteorologists—because we haven't attempted to evaluate the impact of our efforts on their views—we do have peer-reviewed evidence that Climate Matters is having a beneficial impact on the climate reporting practices of broadcast meteorologists. In a paper published in *Weather, Climate & Society,* we demonstrated that participation in Climate Matters was the strongest predictor of which weathercasters had reported on climate change on-air in the prior 12 month period. This evidence strongly suggests that the large increase in on-air reporting by weathercasters between 2012 and 2018—an approximately 3,200% increase—occurred in large part because of the resources provided by the Climate Matters program. (Citations: Perkins, D. Myers, T., Francis, Z., Mazzone, R. & Maibach, E. (2018) Attributes of weathercasters who engage in climate change education outreach. *Weather, Climate & Society*. doi.org/10.1175/WCAS-D-17-0025.1.)

During the project period, on-air climate change reporting by TV weathercasters increased 2,566%. Specifically, the use rates of Climate Matters materials on TV, and all electronic uses (TV, online and social media, but excluding presentations at community events), were as follows:

	Climate Matters Use Rates					
	2014	2015	2016	2017	2018	% Increase ('14 –'18/)
TV Uses: Full year	69	492	460	879	1,771	2,566%
Total Uses: Full year	625	1,357	2,113	4,217	9,026	1,444%

(Related citation: Timm, K., Perkins, D., Myers, T., Placky, B. & Maibach, E. (2019) Reporting on climate change by broadcast meteorologists: A national assessment. *Bulletin of the American Meteorological Society. doi.org/10.1175/BAMS-D-18-0225.1)*

Furthermore, anecdotal evidence from various sources, including and especially a 90-minute plenary session at the 2018 American Meteorological Society Annual Meeting also suggests that the community of broadcast meteorologists in America has changed profoundly since 2010, and that Climate Matters has played a role supporting this evolution. At the conclusion of prepared talks by Bernadette Placky, Ed Maibach, John Morales (who is an active user of Climate Matters materials, and who translates all Climate Matters materials into Spanish), and Elisa Raffa (a young broadcast meteorologist from Springfield, MO, who has been creative in her on-air use of Climate Matters materials), several dozen audience members—broadcast meteorologists and students studying to become broadcast meteorologists—gave spontaneous testimonials about the importance of educating one's viewers about the relevance of climate change to their community. Many of these speakers specifically credited the Climate Matters program for making such reporting feasible. An audiotape of this session can be heard on the AMS conference website: https://ams.confex.com/ams/98Annual/webprogram/Paper334904.html (Citation: Placky, B., Maibach, E., Morales, J., Raffa, E. (2018) Broadcast Meteorologists

Leading as Climate Change Communicators. American Meteorological Society Broadcast Annual Meeting, Austin, TX.).

These forms of evidence give us a growing sense of confidence that the Climate Matters program is having a profound positive impact on the primary discipline that we set out to help, the community of American broadcast meteorologists. Moreover, Climate Matters achieved the major goal of the project, growing reach and engagement with weathercasters substantially during the project period.

Impact on news viewers: We also found that viewers appreciated climate reporting by local TV weathercasters, feeling that it provided them with a helpful local perspective on a global problem. (Citation: Engblom, A., Timm, K., Mazzone, R., Perkins, D., Myers, T., Maibach, E. (2019). Local TV news viewer reactions to weathercasters reporting the local impacts of climate change. *Weather, Climate & Society*. 11: 321-335. doi.org/10.1175/WCAS-D-18-0066.1)

During the project period, public understanding of climate change has also increased dramatically. For example, these increases are seen clearly in our *Climate Change in the American Mind* survey results, including an 11 point increase in acceptance of global warming, a 15 point increase in acceptance of human-caused global warming, and a 15 point increase in understanding that most scientists are convinced that human-caused global warming is happening: https://climatecommunication.yale.edu/publications/a-growing-majority-of-americans-think-global-warming-is-happening-and-are-worried/.

In two not-yet-published evaluation studies, we found evidence that viewers who are exposed to climate reporting by TV weathercasters develop more science-based views of climate change:

Paper #1 is under a "Revise and Resubmit" at the *Bulletin of the American Meteorological Society*. Its abstract states: A rapidly growing number of TV weathercasters are reporting on the local implications of climate change, although little is known about the effectiveness of such communication. To test the impact of localized climate reporting, we conducted an internet-based randomized controlled experiment in which local TV news viewers (n=1,200) from two American cities (Chicago and Miami) watched either three localized climate reports or three standard weather reports featuring a prominent TV weathercaster from their city; each of the videos was between 1 and 2 minutes in duration. To assess participants' understanding of climate change as real, human-caused, and locally relevant, they were asked a battery of questions after watching the set of three videos. Compared to participants who watched weather reports, participants who watched climate reports became significantly more likely to: (1) Understand that climate change is happening, is human-caused, and is causing harm in their community; (2) Feel that climate change is personally relevant and express greater concern about it; and (3) Feel that they understand how climate change works and express greater interest in learning more about it. In short, our findings demonstrate that watching even a brief amount of localized climate reporting (less than 6 minutes) delivered by TV weathercasters helps viewers develop a more accurate understanding of global climate change as a locally and personally relevant problem, and offer strong support for this promising approach to promoting enhanced public understanding of climate change through public media.

Paper #2 has been invited for submission to *Weather, Climate and Society*. Its abstract currently states: Climate Matters is a localized climate change reporting resources program developed to support TV weathercasters across the United States. Developed as a pilot test in one media market in 2010, it launched nationwide in 2013; currently more than 780 weathercasters participate in the program. In this paper we present evidence of the impact of the Climate Matters program on American's science-based understanding of climate change. We analyzed three sets of data in a multi-level model: 18 nationally-representative surveys of American adults conducted bi-annually since 2010 (n=21,038); data on when and how frequently Climate Matters stories were aired in each US media market; and data describing the demographic, economic and climatic conditions in each media market. We hypothesized that: (1) Reporting about climate change by TV weathercasters will increase science-based public understanding of climate change; and (2) this effect will be stronger for people who pay more attention to local weather forecasts. Our results partially support the first hypothesis: controlling for market-level factors (population size, temperature, political ideology, and economic prosperity) and individual-level factors (age, education, gender, and political ideology), there is a significant positive association between the amount of Climate Matters reporting and some key indicators of science-based understanding. These key indicators include certainty that climate change is occurring, understanding that climate change is primarily human caused, and understanding that climate change causes harm. There was only limited evidence for the second hypothesis, however. These findings suggest that climate reporting by TV weathers, as enabled by the Climate Matters program, is increasing the climate literacy the American people. Given the potential importance of these findings, further impact evaluation research is warranted.

Thus, in addition to substantially expanding the amount of local climate reporting on air by TV weathercasters, there is evidence to suggest that this increase in reporting is helping Americans to better understand the personal relevance of climate change.

Additional Publications

Bloodhart, B., Maibach, E., Myers, T. & Zhao, X. (2015). Local climate experts: The influence of local TV weathercaster information on climate change perceptions. *PLoS ONE*. DOI: 10.1371/journal.pone.0141526

Maibach, E. (2018) Using the art and science of communication to address real-world problems. Spectra, National Communication Association.

Maibach, E. (2017) Climate Matters: A novel approach to educating Americans about humanity's greatest challenge. Scientia, 116: 38-42.

Maibach, E. (2019) Increasing public awareness and facilitating behavior change: Two guiding heuristics. In L. Hannah and T. Lovejoy (eds.) *Climate Change and Biodiversity*, 2nd edition. Yale University Press.

Maibach, E., Cullen, H., Placky, B., Witte, J., Seitter, K., Gardiner, N., Myers, T. & Sublette, S. (2016) TV meteorologists as local climate educators. *Oxford Research Encyclopedia of Climate Science*. DOI: 10.1093/acrefore/9780190228620.013.505

Perkins, D., Maibach, E., Gardiner, N., Witte, J., Ward, B., Placky, B., Seitter, K. & Cullen, H. (2017) Most Americans want to learn more about climate change. *Bulletin of the American Meteorological Society,* doi: 10.1175/BAMS-D-16-0097.1

Placky, B., Maibach**,** E., Witte, J., Ward, B., Seitter, K. et al. (2015) Climate Matters: A comprehensive educational resource for broadcast meteorologists. *Bulletin of the American Meteorological Society*, doi.org/10.1175/BAMS-D-14-00235.1

Roser-Renouf, C. & Maibach, E. (2018) Strategic communication research to illuminate and promote public engagement with climate change. In D. Hope & R. Bevins (eds.) *Change and Maintaining Change*: *Nebraska Symposium on Motivation 65*. Basil, Switzerland: Springer Nature. https://doi.org/10.1007/978-3-319-96920-6_6.

Rowan, K., Kotcher, J., Walsh-Thomas, J., Baldwin, P., Trowbridge, J., Thaker, J., Witte, J., Klinger, B., Cohen, L., Tresch, C. & Maibach, E. (2018) Best practices of "innovator" TV meteorologists who act as climate change educators. In D. O'Hair (ed.) *Risk and Health Communication in an Evolving Media Environment*. London: Routledge.

Stenhouse, N., A. Harper, X. Cai, S. Cobb, A. Nicotera, and E. Maibach (2016) Conflict about climate change at the American Meteorological Society: Meteorologists' views on a scientific and organizational controversy. *Bulletin of the American Meteorological Society*. doi:10.1175/BAMS-D-15-00265.1.

Timm, K., Maibach, E., Boykoff, M., Broeckelman-Post, M. & Myers, T. (2019) The prevalence and rationale for presenting an opposing viewpoint in climate change reporting: Findings from a national survey of TV weathercasters. *Weather, Climate and Society.* doi.org/10.1175/WCAS-D-19-0063.1

Selected Recent News Stories about the Climate Matters Program

https://www.theguardian.com/environment/2019/sep/18/tv-weathercasters-shift-public-opinion-climate-crisis

https://www.cjr.org/special_report/eric-sorensen-meteorologist-iowa-climate-change.php

https://www.cityweekly.net/utah/cloudy-with-a-chance-of-melting-ice-caps/Content?oid=14405830

https://www.thenation.com/article/weather-climate-meteorologist/

https://www.cnn.com/2019/03/08/us/climate-change-tv-weathercaster/index.html

https://mashable.com/article/weather-forecasters-tv-climate-change/

https://www.latimes.com/environment/story/2019-07-23/nsf-climate-central-gop-politicians

https://www.nbcnews.com/news/us-news/global-warming-now-brought-you-your-local-tv-weathercaster-n884831

https://www.washingtonpost.com/weather/2019/01/22/tv-meteorologists-are-uniquely-positioned-lead-climate-change-conversation-lets-get-it/

https://www.forbes.com/sites/marshallshepherd/2019/06/19/why-tv-meteorologists-will-show-their-stripes-for-climate-on-june-21st/#28aa6e184532

https://weather.com/news/climate/news/2019-06-21-warming-stripes-meteorologists-global-warming-climate-change

https://www.dw.com/en/weather-forecasters-put-climate-change-on-their-maps/a-48110257

https://www.nytimes.com/2019/05/12/climate/climate-solutions-polar-bears.html?login=email&auth=login-email

Appendix A: Detailed Information about the Impact Evaluation

Hypotheses

We will evaluate the effectiveness of the program by measuring a "campaign" dose-response relationship between use of Climate Matters materials by TV weathercasters and participant exposure to the materials on science-based attitudes and knowledge about climate change. Specifically, we hypothesize that the more TV weathercasters utilize *Climate Matters* materials on-air and through social media, the more participants will demonstrate positive learning outcomes about climate change.

Experimental Design

The program evaluation will follow a quasi-experimental "dose-response" multiple time-series, nonequivalent groups design. Treatment markets (those in which one or more TV weathercasters adopt and use the *Climate Matters* materials) will receive varying "doses" of Climate Matters materials based on the level of adoption by weathercasters in their market and will be compared to control markets in which there are no adopters. We will assess the relationship between the strength of the "dose" of Climate Matters ("0" for control markets) and public learning outcomes.

We will utilize the ongoing *Climate Change in the American Mind* (CCAM) survey data to create multiple baselines for each of the tested treatment and control markets, thereby controlling for differences between markets in existing climate change knowledge and attitudes prior to the implementation of the program. Participant data from both treatment and control markets will be collected every six months in order to observe growth of the treatment effect within markets. This will also allow us to examine changes in markets as TV weathercasters come into the program, which helps to rule out possible threats to internal validity. Although we will not randomly assign "start dates" for the meteorologists or markets, adoption is likely to occur intermittently throughout the program (i.e., not all at once), and some markets are likely to have a much higher rate of adoption over time than other markets. Comparing markets with similar characteristics, such as geography, education, political ideology, and demographics based on

changes from multiple baselines with quasi-random introduction of the treatment will help to rule out other explanations for changes in the data over time.

Independent Variables

Because we plan to utilize multi-level modeling, the independent variable (IV), is two-fold. On a market level, the IV will be the campaign strength (the "dose"). This will be calculated by adding the number of stories and strength of information TV weathercasters present on-air and through social media within a market, adjusted by the weathercaster's station's market share. IV data will be ascertained by independently monitoring weathercaster use of *Climate Matters* material via direct observation and via NOAA's newly developed Media Watch system that can automatically track key terms in social media. Media Watch can gather data on social media and blog sites regarding content about climate change reported by various sources (TV weathercasters and/or stations), over a six-month or longer period. Once content is collected, it will be coded for quality and tone of content, length, and strength of content. This observed data will be supplemented by weathercasters' self-reported use data (as ascertain in our annual census survey of weathercasters).

On an individual level, data will be collected during the CCAM survey to ascertain how closely participants pay attention to local weather news. The item asks: "How closely do you follow news about the local weather forecast?" Responses range from "1" (not at all) to "4" (very closely). This will be tested as a moderator of the level of campaign strength, expecting that those who more closely attend to the local weather forecast will shower more campaign effects than those who less closely attend.

Dependent Variable Data Source

Data for this evaluation will be drawn from the ongoing Yale/George Mason *Climate Change in the American Mind* [CCAM] project; a bi-annual survey of American's opinion about global warming that has been conducted first in Fall of 2008, next in January of 2010, and then approximately every six months after. Participants for CCAM are drawn from a nationally representative online panel maintained by Knowledge Networks. Knowledge Networks recruits their panel using random digit dialing and provides small incentives as well as a free netbook and Internet service to those segments of the population without computers to ensure their representation in the panel. The surveys reported here measured respondents' climate change beliefs, risk perceptions, policy preferences, and related behaviors.

At present there are eight waves of cross-sectional data, from 2008 to 2013, that will be included as baseline data in the evaluation model. The first wave of data was collected in the fall of 2008 (N_{T1} = 2497, completion rate = 63%); the second in January of 2010 (N_{T2} = 1001, completion rate = 52%); third in June of 2010 (N_{T3} = 1024, completion rate = 55%); fourth in May of 2011 (N_{T4} = 1010, completion rate = 66%); fifth in November of 2011 (N_{T5} = 1000, completion rate = 65%); sixth in March of 2012 (N_{T6} = 1008, completion rate = 59%); seventh in September of 2012 (N_{T7} = 1061, completion rate = 54%); and eighth in April of 2013 (N_{T8} = 1045, completion rate = 47%). In order to gain sufficient power for analyses (see discussion in the "power" section below) waves will be collapsed within year, resulting in 2,497 participants in 2008; 2,025 participants in 2010; 2,010 participants in 2011; 2069 participants in 2012; and 1,045

participants in 2013. For the next six waves of CCAM data collection, we will increase the sample size by 25% per wave (n=1,250) to increase the sensitivity of our design.

We will be conducting multi-level modeling by nesting participants within media market [DMA] and within year (see "Model" section below for more detail); therefore, in order to gain sufficient power for analyses, we will restrict analyses to DMAs in which there are an average of 10 participants per year in all waves of the CCAM data collection (including our assumptions about the next six waves of data collection). We estimate this will yield 101 DMAs (49% of all DMAs) and 87% of all CCAM participants to date (n = 8,362). The largest three media markets included are New York, Los Angeles, and Philadelphia, and the smallest three included DMAs will be Bakersfield, CA; Sioux Falls/Mitchell, SD; and Johnstown/Altoona, PA (estimated). An inherent limitation of our design is that smaller DMAs, by their very nature, are less likely to be included in comparison to larger DMAs. However, given that the design allows for a relatively large range in population size of the included DMAs, we are confident that we can still control for the influence of population size on the effects of campaign strength.

Power

In order to estimate the power to detect effects of campaign strength on the outcomes of interest, we utilized the program Optimal Design (version 3.01), which was created to calculate power for multilevel models. Assuming 101 DMAs ("J" in multilevel modeling nomenclature), with 10 participants per DMA per year ("n"), with $\alpha = .50$, we plotted estimated power (1-β) as a function of effect size (δ) and effect size variability between DMAs (σ_δ^2). Results demonstrate with 101 DMAs the proposed multilevel analysis would have the power to detect small effect sizes ($\delta \gtrsim .19$, see Figure 1).

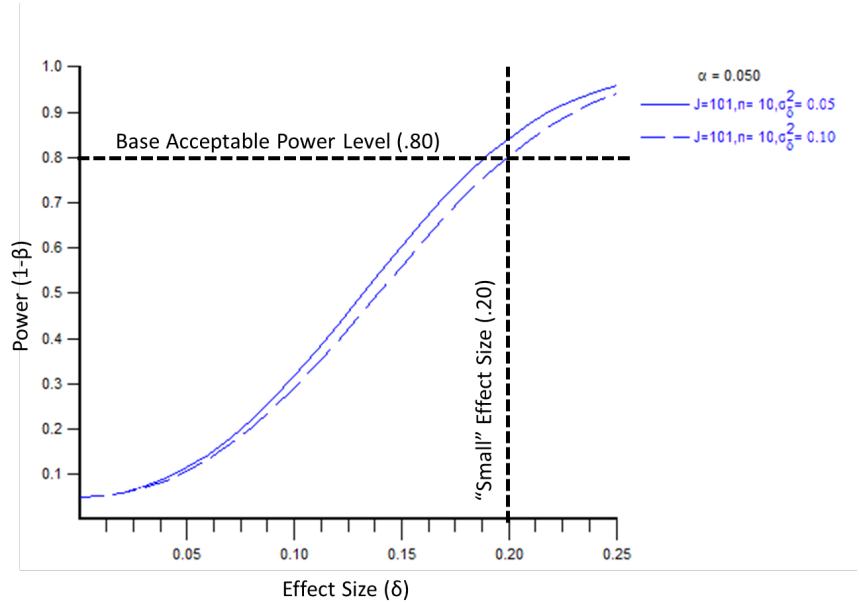

Figure 1. Plot of Estimated Power by Effect Size, Number of Included Groups, and Effect Size Variability

Dependent Variable Measures

Dependent variables will include multiple public learning outcomes. The learning outcomes are various science-based beliefs about climate change that will be measured in every survey, including that climate change is: (a) happening; (b) human-caused; (c) already causing a variety of local impacts (in my community), including changes in the weather; and (d) harmful.

Global warming belief certainty ("Is Happening"). CCAM respondents are first asked whether they think global warming is happening, with options being yes, no, or I don't know. Individuals who answer yes or no then respond to a follow up question asking how sure they were about their position (0= not at all sure, 3=extremely sure). Responses to these items are integrated to create a final belief certainty measure, ranging from those individuals who choose "no" to the first question and "extremely sure" to the second question as "1" (extremely sure global warming is not happening) to those who choose "yes" and "extremely sure" as "9" (extremely sure global warming is happening); those who respond "don't know" to the first question are coded as "5." Overall, the mean response to this question is 6.40, closest to "somewhat sure global warming is occurring, with a standard deviation of 2.25 (M_{2008} = 6.79, SD_{2008} = 2.19; M_{2010} = 6.02, SD_{2010} = 2.36; M_{2011} = 6.22, SD_{2011} = 2.27; M_{2012} = 6.45, SD_{2012} = 2.14; M_{2013} = 6.40, SD_{2013} = 2.26).

Global warming causation ("Is Human-Caused"). Respondents are then asked to respond to the prompt: "Assuming global warming is happening, do you think it is…" Response options are "0" (neither because global warming isn't happening), "1" (caused mostly by natural changes in the environment), "2" (caused by human activities and natural changes), and "3" (caused mostly by human activities). Some participants indicated they don't know (.7% of responses) or volunteered some other response (1.2% of responses), and are counted as missing for this dependent variable. Overall, the mean response is 2.03, closest to "caused by human activities and natural changes," with a standard deviation of 1.06 (M_{2008} = 2.15, SD_{2008} = 1.02; M_{2010} = 1.95, SD_{2010} = 1.09; M_{2011} = 1.98, SD_{2011} = 1.09; M_{2012} = 2.02, SD_{2012} = 1.06; M_{2013} = 2.00, SD_{2013} = 1.07).

Personal Experience with Global Warming ("Is Already Causing Local Impacts"). Respondents are asked to rate their level of agreement with the following statement: "I have personally experienced the effects of global warming." Responses range from "1" (strongly disagree) to "4" (strongly agree). Overall, the mean response is 2.07, closest to "somewhat disagree," with a standard deviation of .90 (M_{2008} = 2.12, SD_{2008} = .84; M_{2010} = 1.92, SD_{2010} = .88; M_{2011} = 2.12, SD_{2011} = .91; M_{2012} = 2.09, SD_{2012} = .92; M_{2013} = 2.06, SD_{2013} = .89).

Local Weather Changes ("Is Already Causing Local Impacts"). As a second measure of local impact, CCAM respondents in the last two waves have been asked: "In your opinion, over the past several years, has the weather in your local area been ..." Responses range from "1" (much worse) to "3" (the same) to "5" (much better). Overall, the mean response is 2.59, closest to "the same," with a standard deviation of .94 (M_{2012} = 2.61, SD_{2012} = .95; M_{2013} = 2.57, SD_{2013} = .93).

Extent of Harm ("Is Harmful"). Participants are asked to indicate how much they believe global warming will harm: (a) their family, (b) their community, (c) people in the United States, (d) people in other modern industrialized countries, (e) people in developing countries, (f) future generations of people, and (g) plant and animal species. Responses range from "1" (not at all) to "4" (a great deal) and are averaged across these potentially affected groups. Overall, the average response was 2.63, closest to "a moderate amount," with a standard deviation of .97 (M_{2008} = 2.73, SD_{2008} = .97; M_{2010} = 2.56, SD_{2010} = .99; M_{2011} = 2.53, SD_{2011} = .96; M_{2012} = 2.64, SD_{2012} = .96; M_{2013} = 2.69, SD_{2013} = .95).

Model

To assess the effects of campaign strength on public learning outcomes, analysis will be done using a cross-classified multilevel linear model. Individuals will be nested within both DMA and year. Figure 2 exemplifies this concept of cross-classification; as shown in the figure, each participant will be nested within both media market and year – and thus outcomes will be modeled as functions of (a) media market characteristics, (b) time-frame characteristics, and (c) individual characteristics.

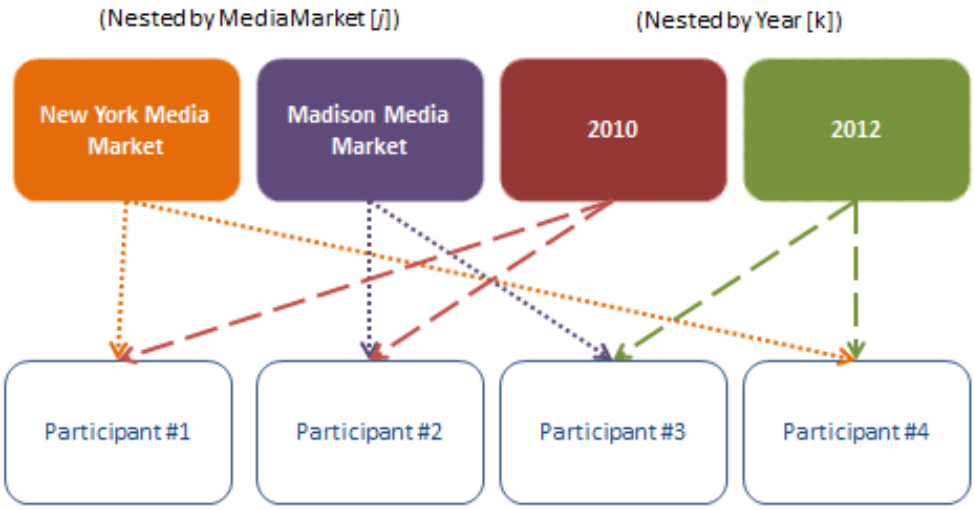

Figure 2. Example of Cross-Classification by Media Market and Year

At this time, our proposed model is below. We will estimate this model first at the end of grant year one, refine and rerun the model at the end of grant year 2, and then estimate the final model at the end of grant year 3.

At Level 1 (the individual level) we will model the IV of attention to the local weather forecast and the individual level controls of age, education, income, and political ideology. At Level 2 (the DMA and Year level) we will model the IV of campaign strength and the DMA controls of DMA population size, region of the country, average education level, and average political ideology as well as the Year level control of amount of national global warming coverage in the news.

Proposed General Level 1 Model:

$$\text{Outcome}_{ijk} = \pi_{0jk} + \pi_{1jk}(\text{LocalWeatherAttn}) + \pi_{2jk}(\text{Age}) + \pi_{3jk}(\text{Gender}) + \pi_{4jk}(\text{Education}) + \pi_{5jk}(\text{Income}) + \pi_{6jk}(\text{PoliticalIdeology}) + e_{ijk}$$

Proposed General Level 2 Model:

$$\pi_{0jk} = \theta_0 + \gamma_{01}(\text{CampaignStrength}) + \gamma_{02}(\text{DMAPopulationSize}) + \gamma_{03}(\text{DMARegion}) + \gamma_{04}(\text{DMA\_AverageEducationLevel}) + \gamma_{05}(\text{DMA\_AveragePoliticalIdeology}) + \beta_{01}(\text{AmountofNationalGWCoverage}) + b_{00j} + c_{00k}$$

$$\pi_{1jk} = \theta_1 + \gamma_{11}(\text{CampaignStrength})$$

Outcome = public learning dependent variables for individual, *i*; in DMA, *j*; at time, *k*

$\boldsymbol{\pi_{0jk}}$ = mean level of outcome for DMA, *j*; at time, *k*

$\boldsymbol{\pi_{(1\text{-}6)jk}}$ = individual-level coefficients of the effect of level 1 variables, including the primary independent variable: attention to local weather and the controls of age, gender, education, income, and political ideology

$\boldsymbol{\theta_0}$ = grand mean of outcome

$\boldsymbol{\gamma_{0(1\text{-}5)}}$ = DMA level 2 coefficients of the effect of DMA variables, including the primary independent variable: campaign strength and the controls of the population size, region, average education level, and average political ideology of the media market

$\boldsymbol{\beta_{01}}$ = Year level 2 coefficient of the effect of the control variable of the amount of national global warming coverage

$\mathbf{e_{ijk}}$ = individual level random effect (the deviation of any individual *ijk* from the mean of their DMA, *j*, at time, *k*, that they were surveyed. It is assumed that these deviations are normally distributed with a mean of zero and a within-group variance in the outcome of σ^2)

$\boldsymbol{b_{00j}}$ = the random main effect of the DMA (the contribution of DMA *j* across all time points; it is assumed to be normally distributed with a mean of zero and variance, τ_{b00j})

$\boldsymbol{c_{00k}}$ = the random main effect of the year (the contribution of time period *k* across all DMAs; it is assumed to be normally distributed with a mean of zero and variance, τ_{c00k})

Summary

The evaluation of this project implements an innovative design which allows us to capitalize on the synergy between two ongoing entities – *Climate Matters* programming and our CCAM project – to more thoroughly test the effects of nation-wide public education of climate change by weathercasters than has previously been possible. Because Mason already conducts nation-wide surveys with proven and reliable measures on public opinion and knowledge of climate change (which is funded by other sources) we have the unique capacity to model statistical effects on multiple levels with a large sample of the American public, from many different media markets. The proposed evaluation can successfully assess changes in public attitudes and knowledge about climate change.