

**How Citizens Integrate Information without Ideological Cues:  
Local Weather and Americans' Beliefs about Global Warming**

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## **ABSTRACT**

Much of the recent research on mass public opinion has focused on identifying how messages with ideological cues affect individuals' attitudes regarding politics. But citizens also receive politically relevant information—including facts about the state of the world and their own personal experiences—that does not come with an ideological label attached. Who uses this information, and to what extent? It is difficult to explore these questions using observational data, because individuals may be exposed to such information in a selective fashion, and self-reports of exposure may not be reliable. In this study, we identify one piece of information that is devoid of ideological content and to which Americans are exposed at random—their local weather—and show that it leads a significant share of the public to reassess its beliefs about the evidence for global warming. This effect is much stronger for the less educated and those with weak partisan ties, and virtually non-existent for the most educated and most partisan citizens. Our results suggest that when politically relevant information is conveyed without ideological cues, political sophistication may prohibit the integration of this information into political beliefs regardless of the direction of one's predispositions.

In constructing their opinions about political issues, individuals wade through a sea of information that comes from sources including political elites, the media, issue experts, interpersonal relationships, and personal experience. Research on the effects of this information has focused recently on information delivered with ideological cues, or information that elites have made at least some effort to link to an ideological agenda. The prevailing theory about these messages is that (1) those who are interested in politics receive many more such messages than those who are not, and that (2) politically sophisticated individuals accept these messages in a selective fashion based upon whether the cues agree with their personal ideological predispositions, while the less informed are less consistent in what new information they accept (Zaller 1992).

Less explored is another kind of information that is politically relevant but devoid of ideological content. Events—such as terrorist attacks and natural disasters—fall into this category, as do statistics about the economy and crime. This class of information can also include personal experiences, such as a family’s changing economic circumstances or one’s interaction with a government agency. These are all facts that, in a vacuum, are politically relevant but are not accompanied by ideological cues. We know that this sort of information has tremendous implications for politics. Consistently bad economic data can sink a presidency. A natural disaster can earn a governor or mayor tremendous public sympathy. A negative experience with public schools can sway a voter’s choice in local government elections.

Just as is the case with ideological information, it is sensible for political scientists to be curious about how non-ideological information gets processed. Particularly, we might wonder if in the absence of ideological or partisan cues, political sophistication and personal predispositions play the same strong role. But two threats to inference typically make it difficult to assess how information conveyed without ideological cues is integrated into mass opinion about public affairs. First, events, statistics and personal experiences are often invoked by elites as evidence

for their arguments about public policy solutions, leading many individuals to view this information through an ideological lens. Second, individuals receive information in a non-random way. People who are well-informed about public affairs are more likely to be aware of distant events and abstract statistics than the less informed. And some individuals are more likely than others to have particular politically relevant personal experiences (for example losing a job, or enjoying an increase in their investment portfolio).

In this paper, we identify a source of non-ideological information that is subject to neither of these problems. The information source is fluctuation in local U.S. temperatures. The non-ideological message it potentially conveys is evidence for global warming. This source avoids the first threat to inference because the nation's liberal and conservative elites have largely avoided invoking short-term weather patterns to bolster their arguments about climate change. Moreover, predispositions toward incumbent political leaders are unlikely to influence citizens' perceptions of whether the temperature is hot or cold. It avoids the second threat because everyone, from the least- to the best-informed about politics, personally experiences the weather. Personal experience is augmented by weather reports that are so completely interspersed across all media as to be virtually inescapable. In essence, local changes in temperature randomly assign Americans to a range of positive and negative messages about the evidence for climate change.

The exogenous variation in local weather conditions allows us to assess how people receive new information and integrate that information into their beliefs and political preferences. By matching geocoded survey data to local weather records, we find a significant relationship between local weather and beliefs about global warming. For each three degrees that local temperature rises above normal, Americans become one percentage point more likely to agree that there is "solid evidence" that the earth is getting warmer. (The relationship holds for local temperatures that are below normal as well.) The size of this effect is substantial, larger for example than the effects associated with race, age, or education.

We show that the effect of temperature on beliefs is strikingly heterogeneous, varying by race, education and partisanship. Local weather affects those with the least education significantly but those with the most education not at all, and it affects those who “lean” Democratic or Republican much more than it affects “pure” Democrats, Republicans, or Independents.<sup>1</sup> Thus when survey respondents are asked about the existence of global warming and sample the information they have at hand, it is those with less political sophistication who are most likely to have weather-related considerations at the “top of the head.” These findings suggest that when politically relevant information is conveyed without ideological cues, political sophistication (measured here using the proxies of education and partisanship) may prohibit the integration of this information into political beliefs regardless of the direction of one’s predispositions. The role of sophistication here thus differs in an important way from the one it plays regarding information accompanied by ideological cues. There, it acts as a selective filter. Here, it acts as an overall block.

### **Making Sense of Global Warming**

***Beliefs about existence.*** Global warming is a case in which public understanding and concern about the issue lags behind opinions in the scientific community. Since 1990, the Intergovernmental Panel on Climate Change (IPCC) has been periodically evaluating the scientific basis of climate change risk. In its first report, the body found that global mean surface air temperature had increased 0.3-0.6°C (0.5-1.1°F) over the previous 100 years (Houghton, Jenkins, and Ephraim 1990); by 2007, its estimate of the 100-year global temperature increase had risen to 0.7°C, and it concluded that warming of the climate system is “unequivocal” (Trenberth et al. 2007). The IPCC cited evidence including rising air and ocean temperatures, widespread melting of ice and snow, and rising global sea levels. Yet a significant portion of the American public remains skeptical about the existence of global warming. In a March 2009 poll conducted by the Gallup Organization, only 53% of

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<sup>1</sup> As discussed later, we believe that the way party identification is measured in the survey data used in this paper leads us to believe that those identified as Independents are likely to be resistant to political information.

respondents agreed that the effects of global warming had already begun to happen; 16% predicted that global warming will never have any effects.<sup>2</sup>

In addition to lagging behind scientific consensus, Americans' beliefs about the existence of global warming are unstable. The belief level in 2009 represents an eight-point drop from a year earlier, when 61% of respondents surveyed by Gallup agreed that global warming effects had already begun.<sup>3</sup> This instability in opinion reflects the low public salience of the climate change issue and the sharp disagreement among policy elites about the problem and potential solutions. Within this political context of high contestation but low visibility, it is difficult for citizens to access factual information that will help them form stable opinions. Adherence to journalistic norms of balanced reporting for a long time led the U.S. media to understate the level of scientific consensus about the problem's existence (Boykoff & Boykoff 2004; Zehr 2000). Indeed, in a 2006 national survey, more Americans (45%) believed there was "a lot of disagreement" among scientists about global warming than believed that "most scientists agree with one another" (34%) (Curry, Ansolabehere & Herzog 2007). Regardless of the media's culpability, currently the media is not a trusted source for information about climate change. Just 29% of respondents to the March 2009 Gallup poll thought that news coverage about the seriousness of global warming is generally correct, and more people believe that the media exaggerates the problem (41%) than underestimates it (28%).

Most individual-level research about climate change opinion has focused on risk perceptions (Krosnick et al. 2006; Leiserowitz 06; Brody et al. 2007; Kellstedt, Zahran & Vedlitz 2008) or support for government policies and voluntary action to mitigate the problem (O'Connor, Bord & Fisher 1999; O'Connor et al. 2002; Curry, Ansolabehere & Herzog 2007; Lubell, Zahran & Vedlitz 2007). In the few studies that have examined opinion about whether global warming exists, evidence suggests

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<sup>2</sup> Gallup Organization, Gallup Poll (March 5-8, 2009).

<sup>3</sup> Gallup Organization, Gallup Poll (March 6-9, 2008).

that people's values and political predispositions have a bigger impact than factual information on judgments about the nature and extent of the problem. Age, liberal ideology, general pro-environment attitudes, and being nonreligious contribute to existence beliefs, while the effect of scientific knowledge about the causes and consequences of climate change is weak and inconsistent (Bord, O'Connor & Fisher 2000; Kellstedt, Zahran & Vedlitz 2008; but see Curry, Ansolabehere & Herzog 2007). To a large extent, people's perceptions are likely to be guided by the polarized discourse of elites, with the consequence that more partisan and politically sophisticated citizens will express more consistent beliefs.

We propose an additional piece of factual information that should affect beliefs about whether the earth is getting warmer: people's personal experience with their local weather. Short-term temperature patterns are a credible but low-quality piece of information for forming a belief about the existence of global warming. Climate change increases the probability of milder winters and more frequent, intense, and long-lasting heat waves. Some of these changes already are underway: global surface air temperatures over the last fifty years have risen almost a quarter-degree Fahrenheit per decade, and the ten warmest years on record all occurred within the 12-year period between 1997 and 2008 (Trenberth et al. 2007; NASA 2009). Most of the United States has experienced warming over the last century, and urban heat island effects amplify the warming in densely populated areas. Without a doubt, local weather provides little information about broad climatic trends. Scientists have reached their judgments about global warming's existence based on evidence accumulated from many sources and over long periods of time. Given the natural variability that characterizes normal weather, it is impossible to attribute any specific weather event to human-caused climate change. Because climate change affects the probability that certain weather events will occur, however, it would be rational for an individual who had access to no other factual knowledge to use local weather to form a judgment about whether the earth is getting warmer.

Local temperature variation provides far less information about global warming than, say, the unemployment rate provides about the state of the economy. Nonetheless, it offers some advantages over other forms of factual information for measuring the effects of information on opinion formation. First, political elites and the media rarely invoke short-term weather trends in making their arguments about global warming. As a result, people experience the weather directly or hear about it on the news without an ideological frame that taps existing political beliefs. Conover, Feldman, and Knight (1986, 1987) have shown that partisan political evaluations influence both retrospective evaluations of the economy and economic forecasts; a similar relationship holds at the aggregate level, where economic news and policy have been found to affect public perceptions of the economy (De Boef & Kellstedt 2004). Political predispositions similarly affect people's perceptions of their own financial status. When ideological factors influence beliefs about factual information, it is difficult to measure the effect of information on beliefs. The second advantage is that exposure to weather is more constant across individuals than exposure to other types of information. People with higher levels of political sophistication learn more about the state of the economy. In contrast, everyone who goes outside experiences the weather, and news coverage of weather events is less stratified by media outlet than coverage of just about any other type of factual information.

The problems of ideological frames and selective information exposure may explain the inconsistent results in previous work that has examined information effects on beliefs and attitudes about global warming. Curry, Ansolabehere and Herzog (2007) found that factual knowledge about climate change (measured as familiarity with mitigation technologies and correct identification of sources and sinks for carbon dioxide) is positively associated with belief that scientists agree with one another about global warming. Yet it is likely that the preexisting interest and values that would motivate individuals to obtain information of this type also would expose them to information about scientific consensus on the issue. Kellstedt, Zahran and Vedlitz (2008) produced the somewhat contradictory finding that more informed

respondents show less concern for global warming and feel less personally responsible. They rely on respondents' self-reports about their level of information, however, which may be related to preexisting perceptions of the problem.

In their research on global warming agenda-setting, Krosnick et al. (2006) attempt to capture the effect of factual information gained from personal experience on beliefs about the existence of global warming. Using evidence from a national phone survey, they show that respondents who perceived an increase in local temperature in recent years were more likely to believe that global warming would occur in the future if nothing is done to stop it. Data from a survey of Ohio residents showed that this relationship was particularly strong among respondents with low levels of education and high trust in scientists. But without an objective measure of temperature conditions, the authors could not rule out the possibility that their results were attributable to projection, and that people who already believe that a global warming threat exists may perceive associated changes in weather.

The present study uses actual short-term local weather conditions to assess how changes in local temperature influence reported opinion about the existence of climate change. We believe that for many people, perceptions about the existence of this complex problem are shaped by political predispositions, attitudes about environmental protection, and factual information about scientific opinion. For some subset of respondents, however, we expect that beliefs about global warming remain unformed, and recent weather becomes a salient consideration when these people are asked to report their beliefs. If the temperature recently has been warmer than usual, respondents with unformed beliefs will be more likely to express a judgment that the earth is getting warmer. Because individuals with higher levels of political sophistication are more likely to hold stable opinions about issues, we predict that the relationship between temperature and beliefs about climate change will be strongest among people with low education and weak partisan attachments.

***Beliefs about problem seriousness and policy solutions.*** The exogeneity of weather to other factors that shape public opinion offers the additional benefit of providing an instrument that then allows us to measure the impact of existence beliefs on perceptions of the seriousness of the global warming problem and attitudes about policy solutions. Although knowledge and concern about the problem have been rising over time, global warming remains a low-salience issue (Bord, Fisher & O'Connor 1998; Curry, Ansolabehere & Herzog 2007; Dunlap 1998; Reiner et al. 2006). Public support for increased government effort to solve the problem is limited, even compared to other environmental issues (Konisky, Milyo & Richardson 2008). Previous research has demonstrated that existence beliefs, risk perceptions, and policy attitudes are interconnected (Bord, O'Connor & Fisher 2000; Curry, Ansolabehere & Herzog 2007; Lubell, Zahran & Vedlitz 2007; O'Connor, Bord & Fisher 1999). Without a good instrument for measuring beliefs, however, it is difficult to determine whether the low level of seriousness that Americans attach to the climate change problem is a consequence of skepticism about whether the earth is warming.

If local weather conditions have a significant impact on people's beliefs about the existence of global warming, we can use the variation in weather conditions to estimate the causal effect of existence beliefs on issue attitudes. In doing so, we assume that local weather will not affect attitudes except through its influence on judgments about the existence of the problem. One previous study has examined the influence of objective local conditions on climate change attitudes. Brody et al. (2007) geocoded the location of respondents in a 2004 survey to measure the effect of actual climate change vulnerability on respondents' perceptions of risk. They found that vulnerability to floods, sea level rise, and other natural hazards had an effect on risk perceptions, but a measure of long-term rising temperature in the respondent's region did not. Our study focuses not on the relationship between actual and perceived risk, but rather on identifying how personal experience influences perceptions of a problem and opinions about the problem's seriousness and potential solutions.

## Data

**Opinion on climate change.** Americans' attitudes about climate change come from publicly available data collected in five national surveys sponsored by the Pew Research Center from June 2006 through April 2008.<sup>4</sup> The surveys were conducted by telephone with a representative national sample of American adults living in the contiguous 48 states. In each survey, respondents were asked the following question: "From what you've read and heard, is there solid evidence that the average temperature on earth has been getting warmer over the past few decades, or not?" Americans' responses to this question were largely in the affirmative: on average over the five surveys, 74% of respondents agreed that the earth is getting warmer. The share of Americans believing that global warming is real rose and then fell over the course of the five surveys, with a substantial spike occurring between June and July 2006 (see Figure 1). It seems likely that the publicity surrounding Al Gore's film *An Inconvenient Truth*, which stresses the dangers of global warming, had something to do with this increase: as shown in Figure 1, the sharp rise in Americans agreeing that there is evidence of global warming occurred just as the documentary's presence in American movie theaters reached its peak.

**Local weather data.** Our goal was to measure the short-term weather conditions that respondents might call to mind when asked whether evidence supports the existence of global warming. The variable we used to capture these conditions is the departure from normal daily local temperature, measured in degrees Fahrenheit, averaged over the week prior to the date on which the respondent was interviewed by Pew.<sup>5</sup> That is, we calculated

$$ddt\_week = \frac{1}{7} \sum_{i=1}^7 temp_i - normaltemp_i ,$$

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<sup>4</sup> Pew conducted the surveys in June, July and August 2006; January 2007, and April 2008.

<sup>5</sup> We ran the analyses here with alternate versions of this variable, including departures from normal local temperature on the day of interview, the day before the interview, and the two weeks and four weeks prior to interview. All produced similar, but weaker, results than the weekly measure used here.

where  $temp_i$  is the respondent's local temperature  $i$  days before his or her interview, and  $normaltemp_i$  is the normal temperature for that date.

Data on local weather conditions come from the National Climatic Data Center (NCDC), part of the National Oceanic and Atmospheric Administration in the U.S. Department of Commerce. The NCDC compiles meteorological data over time from weather stations worldwide in order to produce climatic profiles of locations or regions. Zip code information in the Pew dataset allowed us to attach weather data to individual respondents. Pew asked each respondent to supply his or her five-digit zip code, and almost all did so (97.5%). Of these, we were able to match nearly all (95.6%) to a Zip Code Tabulation Area (ZCTA), a geographic entity developed by the U.S. Census Bureau to provide a spatial representation of U.S. Postal Service zip codes.<sup>6</sup> By overlaying a map of 448 U.S. weather stations onto a map representing ZCTA boundaries, we identified the weather station closest to each respondent's zip code and used temperature data from that station. The mean distance from a ZCTA to its associated weather station is 0.43 degrees in latitude/longitude, or approximately 25-30 miles.<sup>7</sup>

The temperature departure measure captures variation in local weather conditions both cross-sectionally and over time. Figure 2 tracks the movement of a heat wave across the country during the interview period for the January 2007 Pew survey.

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<sup>6</sup> U.S. Postal Service zip codes are a way of classifying linear features such as street segments, address ranges, and delivery points to facilitate mail delivery. The Census Bureau created ZCTAs for the first time in the 2000 Census to provide an areal representation of zip codes and allow calculation of Census data at the zip code level. The distinct origins and data types of zip codes and ZCTAs result in some degree of spatial mismatch. As a robustness check for those respondents whose reported zip codes we were unable to match to the NCDC dataset, we also calculated the mean daily temperature readings for ZIP3 ZCTAs, a larger geographic unit that entirely incorporates all five-digit ZCTAs beginning with the three-digit prefix. Most of the respondents we could not match to a five-digit zip code (89.0%) successfully matched to a ZIP3 ZCTA based on the first three digits of the zip codes they supplied to Pew. We repeated the analyses reported here with a dataset that included these respondents. As expected, the results were substantively similar but not as strong due to the less precise nature of the additional weather data.

<sup>7</sup> For the April 2008 survey wave, data come from 416 weather stations, and the mean distance to the nearest weather station is a slightly larger 0.44 degrees.

(Temperature departures are shown for three-digit ZCTAs rather than zip codes to improve visual interpretation.) On the first day of interviewing, the heat wave was located over the middle and upper Midwest, while the southeastern region of the United States experienced weather colder than normal for that day of the year. Over the following days, the heat wave moved east, and states in the West and Midwest experienced a prolonged cold snap.

It is possible that respondents who live in the upper Midwest, where temperature variability is highest, would be less responsive to a given level of departure from normal temperature than respondents who live in climates with more predictable weather patterns. A five-degree departure from normal on a January day should be more noticeable in Arizona than in Minnesota. To account for potential differences in expectation about weather patterns, we also collected data on the standard deviation in average monthly temperature over the period 1971-2000.<sup>8</sup> Dividing the *ddt\_week* measure by the local standard deviation produced an indicator of temperature departure measured in standard deviations. All of the analyses reported below produce similar results measuring temperature either in raw degrees or in standard deviations.

Data for control variables come from the Pew surveys. In the analyses that follow, respondents who did not supply valid responses on all the relevant variables were dropped via listwise deletion in particular analyses. See Table A1 in the Appendix for more details.

## **Results**

***Local weather's effect on beliefs that Earth is getting warmer.*** Figure 3 displays the simple bivariate relationship between temperature and beliefs about the

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<sup>8</sup> Data on standard deviation in temperature are not available from weather stations. Instead, we used data from 344 climate divisions, geographic entities developed by the NCDC that represent areas with fairly uniform climate conditions. We assigned each ZCTA to the climate division in which a majority of its land area lay.

evidence for global warming. Because the dependent variable is dichotomous, a typical scatterplot is inappropriate to display the relationship. To construct the figure, we divided the cases in our dataset into 100 percentiles on the basis of the *ddt\_week* variable and calculated the percentage of respondents in each percentile who agreed that there is solid evidence for global warming. In the figure, the weather percentiles are plotted on the x-axis and opinion on global warming is plotted on the y-axis. To summarize the relationship, the figure displays the best linear fit for the data along with a nonparametric smoother drawn with the lowess technique (Cleveland 1993).<sup>9</sup> The figure shows a clear and substantial relationship between the two variables: as local temperatures rise above normal, so does the percentage of Americans believing that global warming is a reality. The smoother consistently traces the regression line, indicating that the relationship between the two variables is close to linear.

Americans' political views do, of course, vary by region (e.g. Gelman et al. 2008). To rule out a spurious relationship between local weather and opinion on climate change, it is necessary to control for variables that are correlated with both geography and opinion using multivariate analyses. We do this with a series of ordered probit regressions in which respondents' assessments of the evidence for global warming are the dependent variable. We first model the simple bivariate relationship, then add fixed effects for wave of survey and state of residence, and then include standard demographic, political and other controls (for details, see Appendix Table A2). The relevant findings from these analyses are summarized in predictions displayed in Table 1, which shows that under all three specifications, the estimated effect of weather on beliefs about climate change is significant and consistent: a shift in local temperature from the 5<sup>th</sup> to 95<sup>th</sup> percentile (that is, from 4.3°F below normal to 14.7°F above normal) increases the probability that

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<sup>9</sup> Excluded from the display are three percentiles that—due to the lumpiness of the weather data—included very few cases and thus yielded means of those agreeing there is evidence for global warming of zero and 100 percent. These observations were included in calculations of the linear fit and lowess smoother.

Americans believe there is solid evidence for global warming by about six percentage points.

Figure 4 provides a sense of the relative size of the effects of local temperature compared to other variables associated with opinion on climate change. It is a graph in which the “first difference” associated with individual demographic, political and other variables—that is, the *ceteris paribus* change in probability of believing in global warming accompanying a shift from the minimum to maximum value of that variable—is represented by a horizontal bar. (The predictions are generated from Model III in Table A2.) The figure shows that the effect of temperature is substantial compared to other variables typically considered important in shaping Americans’ attitudes on the environment. A shift in local temperature from the 5<sup>th</sup> to 95<sup>th</sup> percentile results in opinion change that is larger than the *ceteris paribus* differences between whites and either blacks or Hispanics, between those belonging to the youngest and oldest age groups, and between the least and most educated. The effect of local weather on beliefs regarding global warming is about a quarter of the size of that of the two variables that play the largest roles in shaping attitudes on the environment: party identification and ideology.

As an identification check, we estimated the association between local weather patterns and responses to two survey questions where we have no theoretical reason to expect a relationship: respondents’ assessments of the decision to invade Iraq and their approval of Bush’s job as president. Table 2 displays the results of these placebo tests, which confirm that the relationship is not statistically significantly different from zero after controlling for fixed effects. It is particularly reassuring to see that to the extent that there is any relationship between local weather and these variables, it is not in an ideologically consistent direction: warmer weather is (insignificantly) associated with negative attitudes regarding the Iraq War but with positive attitudes about President Bush’s performance.

**Interaction effects.** Given that the strength of the public’s opinions on climate change—and the depth of their understanding of the issue—can vary substantially, it is possible that the effect of local weather may be smaller or larger for different groups of Americans. We assess this with another series of models in which control variables are interacted with local temperature on a variable-by-variable basis (see Appendix Table A3).<sup>10</sup> The signs and calculated statistical significance on coefficients associated with interaction terms in nonlinear models such as those estimated here can mislead about the true sign and magnitude of interaction effects (Ai & Norton 2003). We therefore calculate the change in probability of each subgroup’s agreeing there is evidence for global warming associated with a 5<sup>th</sup>-to-95<sup>th</sup> percentile shift in local temperature. These changes are displayed in Figure 5. The top panel of Figure 5 displays those groups for whom the effect of weather is greater than the estimated average treatment effect of 5.9 percentage points. The lower panel displays the groups for whom the effect is less than or equal to average.

The figures show that the effect of local weather on assessments of the evidence for climate change varies dramatically by subgroup. Blacks, those with a high school education or less, and those identifying as leaning Republican or leaning Democrat are all at least ten percentage points more likely to agree that there is solid evidence for global warming after a spell of particularly hot weather than after one of particularly cold weather. Those whose opinions on global warming are estimated to be unmoved by local weather patterns (estimated effect is  $\leq .02$ ) include those with a post-graduate education, Independents and Republicans, and those aged 25 to 34.<sup>11</sup>

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<sup>10</sup> We estimated a full model which included all variables and their interactions with temperature and found largely similar results to those shown in Table A3 (not shown). The high degree of multicollinearity in this model caused substantial loss of precision in its estimates, and so our discussion is based on the on the variable-by-variable models.

<sup>11</sup> A future version of this paper will include calculations of confidence intervals around these predicted probabilities and the extent to which they are significantly different from the average effect.

Prevailing theory about the formation of public opinion leads us to be particularly interested in the varying effects of local weather on the attitudes of those with different party identifications and education levels. To illustrate these differences, Figure 6 plots the share of Americans predicted to agree there is evidence for global warming at different local temperature levels according to their values on these two variables. The top panel of Figure 6 shows that changes in local weather do little to shift the opinions of Democrats, Republicans or Independents on global warming, while those who “lean” Democratic or Republican are estimated to shift their opinions by more than ten percentage points, holding all other factors constant. Given that Independents are considered most likely to accept new information about politics (e.g. Zaller 1992), it is surprising that they are found here to be the least likely to shift their position on global warming in response to the stimulus of local weather. But it is worth noting that in the Pew surveys, respondents are first asked “In politics today, do you consider yourself a Republican, Democrat, or Independent?” Those who respond “Independent” or volunteer that they have no preference, prefer another party, or don’t know are then asked, “As of today, do you lean more to the Republican Party or more to the Democratic Party?” It is only those who reach this question and then insist (without explicitly being given the option to do so) that they lean toward neither party (about 12% of Americans) who are considered “Independents” according to this classification.<sup>12</sup> We surmise that the resistance to accept a party label may therefore be associated with a particularly non-partisan, but somewhat sophisticated, orientation toward politics and public affairs.

The lower panel of Figure 6 shows that variation in local temperature completely shifts the direction of the relationship between education levels and beliefs about global warming. When temperatures are cooler than normal, those with a high school education or less are the least likely of any education group to agree there is evidence for climate change. But when temperatures are hotter than usual, the least

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<sup>12</sup> More details about question wording and response sets may be found in the Appendix.

educated become those most likely to agree that there is evidence for climate change.

## **Conclusion**

This paper presents results that are both of topical relevance and of theoretical interest. Global climate change has been called one of the most important public policy challenges of our time and one of the greatest threats to life on Earth as we know it. But it is a complex issue of low salience about which Americans have little direct experience in their day-to-day lives. As they try to make sense of this difficult issue, the public uses fluctuations in local temperature to reassess their beliefs about the existence of global warming. Across a variety of estimation strategies and model specifications, the effect of weather on beliefs is significant and substantively large.

We think this is an interesting and important finding in itself. But we seize upon it to explore a more general theoretical question about how attitudes regarding public affairs are affected by information that is politically relevant but non-ideological. The effects of this kind of information are difficult to measure in an observational setting, because Americans are selectively exposed to such information and they are often supplied with ideological cues regarding the information by elites. We claim that short-term variation in local temperatures provides Americans with a legitimate (if low-quality) non-ideological message about the evidence for climate change. In this respect, local weather serves as a rare example of politically relevant information that is neither subject to selective reception nor invoked by elites to further their ideological agendas.

We find that the way the public integrates this non-ideological information into beliefs differs substantially from how it processes information accompanied by explicit ideological cues. It appears that those who are sophisticated about politics (here identified as those who are more educated or more attached to the specific

partisan labels of Democrat, Independent, or Republican) reject this information across-the-board. Those who are less politically sophisticated (here identified as those who are less educated, or “lean” Democratic and Republican) accept this information regardless of where they stand on the ideological spectrum. Note how this differs from the framework developed by John Zaller that reliably explains how the public processes ideological information: there, individual predispositions and sophistication interact to accept ideologically faithful information and reject the rest; here, acceptance of ideology-free information decreases in a simple monotonic fashion as sophistication increases.

Of course, one example does not a theory make. Our claim about how the public processes non-ideological political information can be tested in other policy domains with better measures of political sophistication. But we believe that local weather and attitudes about global warming provide a rare and valuable instance in which we can explore how this kind of information is processed in a quasi-experimental setting.

**Table 1. Local Weather's Effect on Americans' Beliefs  
about the Evidence for Global Warming**

*source: predictions generated by ordered probit regressions, Table A2 (Models I, II, and III)*

<b>Model</b>	<b>Estimated effect of shift in local temperature from 5<sup>th</sup> to 95<sup>th</sup> percentile on probability of believing there is evidence for global warming</b>
Bivariate	.059***
Fixed effects for state of residence and survey wave	.062**
Fixed effects and controls for sex, race, age, education, party identification, ideology and frequency of attendance of religious services	.059**

Estimated quantities statistically significantly different from zero at \* $p < .10$ ; \*\* $p < .05$ ; \*\*\* $p < .01$ .  
Predictions and calculations of statistical significance throughout this paper were generated with SPost  
software (Long & Freese, 2005) in Stata 10.

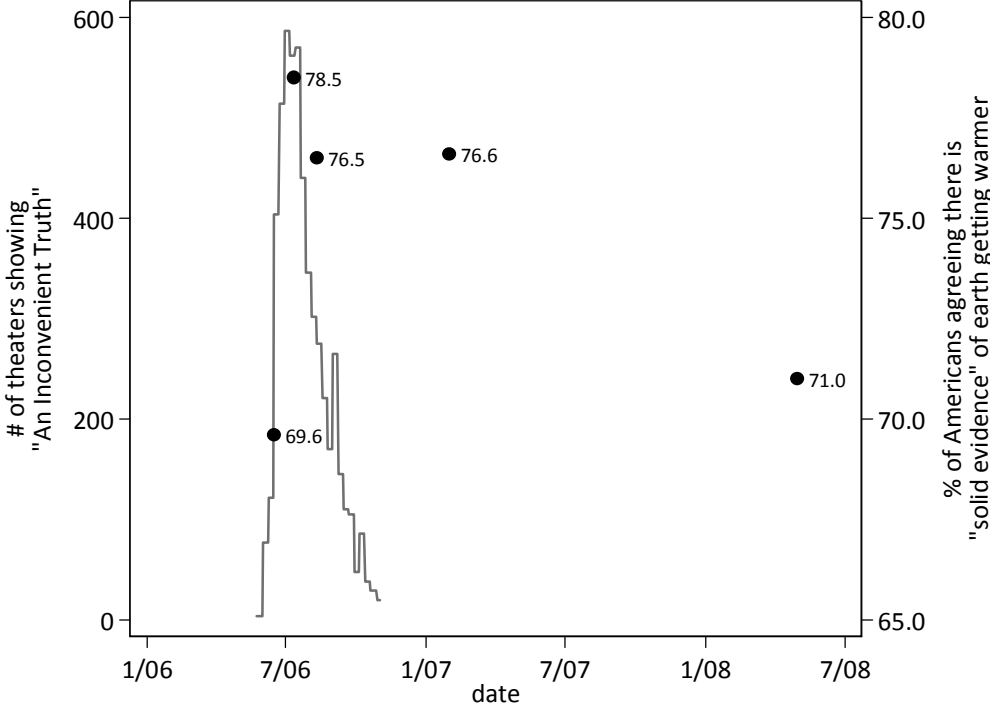
**Table 2. Placebo Test: The Association of Local Weather with Americans' Attitudes on the Iraq War and Approval of Bush as President**  
*source: predictions generated by ordered probit with specifications same as in Table A2 (Models I, II, and III), but with dependent variable Iraq War attitudes and Bush approval*

Model	Change associated with shift in local temperature from 5 <sup>th</sup> to 95 <sup>th</sup> percentile [95% CI]	
	Iraq War (wrong decision)	Bush as president (approve)
Bivariate	.059 <sup>***</sup> [.021, .096]	-.029 [-.063, .006]
Fixed effects for state of residence and survey wave	.028 [-.022, .079]	.011 [-.031, .052]
Fixed effects and controls for sex, race, age, education, party identification, ideology and frequency of attendance of religious services	.023 [-.034, .080]	.037 [-.006, .079]

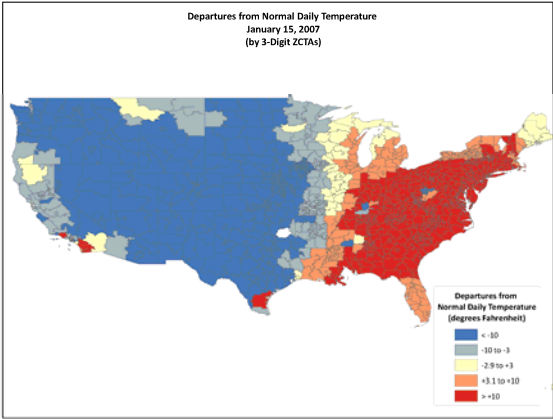
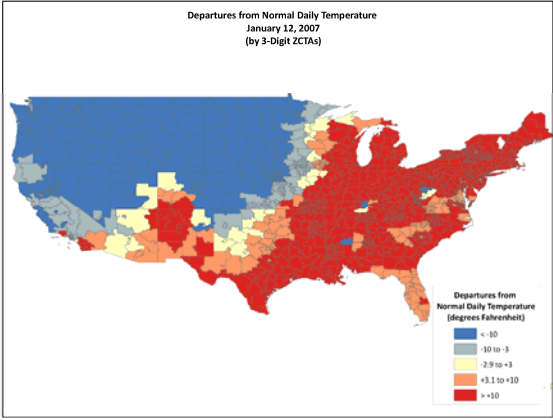
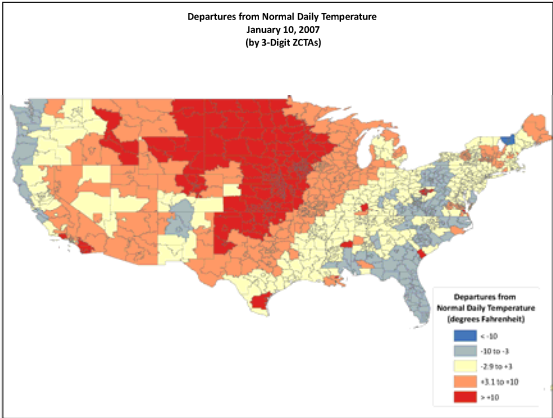
Estimated quantities statistically significantly different from zero at \* $p < .10$ ; \*\* $p < .05$ ; \*\*\* $p < .01$ .

**Figure 1. Americans' Beliefs about the Evidence for Global Warming and Theaters Showing *An Inconvenient Truth*, 2006-2008**

*sources: survey data: Pew Research Center; theaters: boxofficemojo.com*

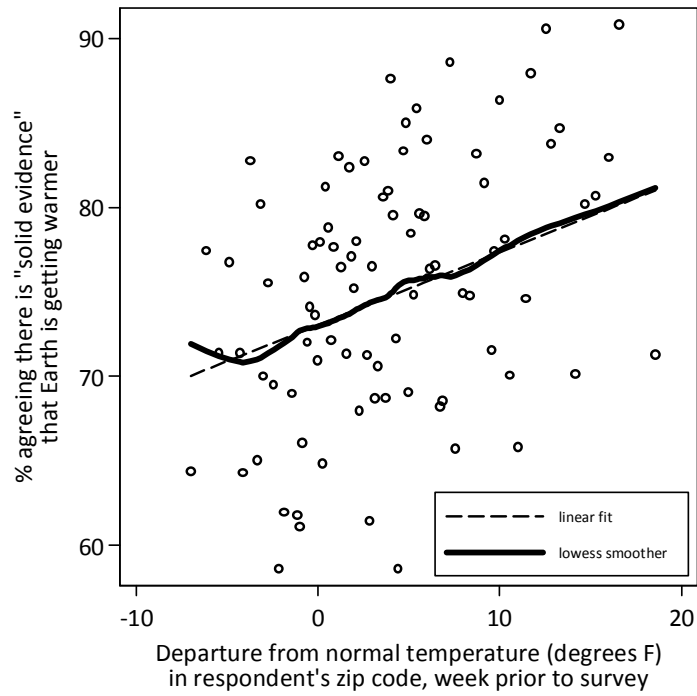


**Figure 2. Departures from Normal Daily Temperature (by ZCTA),  
January 10, 12, and 15, 2007**  
*source for data: National Climate Data Center*



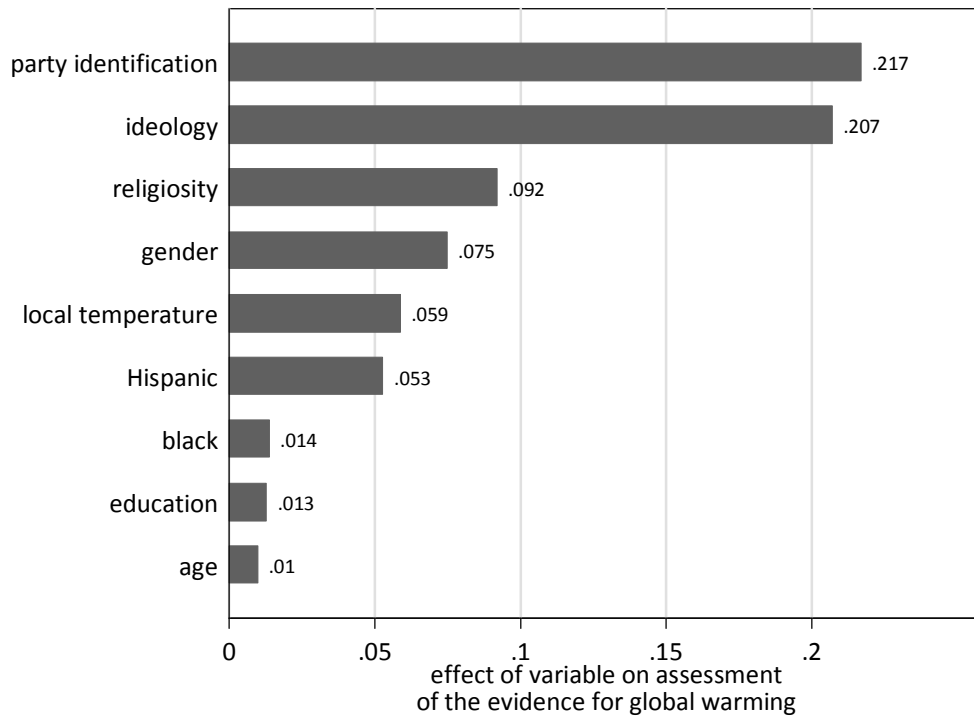
**Figure 3. Americans' Beliefs about the Evidence for Global Warming,  
by Departure of Local Weather from Normal Temperature  
in Week Prior to Survey**

*source for weather data: National Climate Data Center  
source for survey data: Pew Research Center*



**Figure 4. Effects of Variables on Americans' Beliefs about the Evidence for Global Warming**

*source: predictions generated by Model III, Table A2*

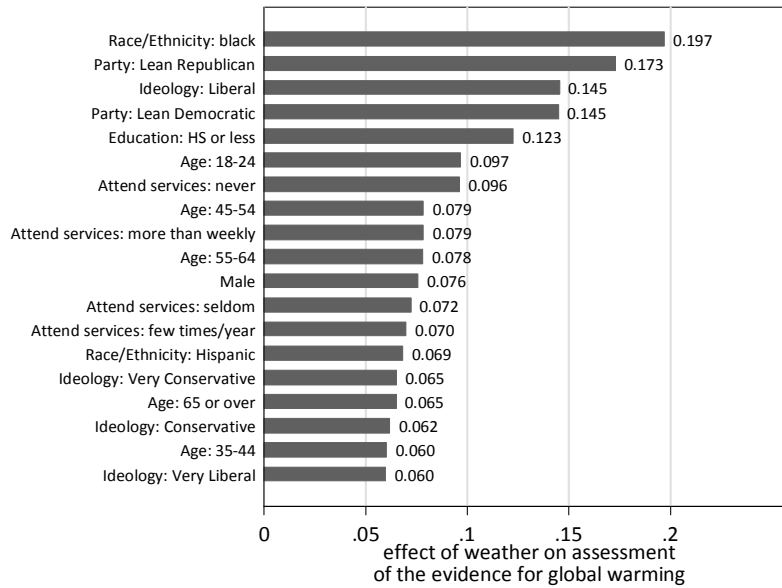


Effects are the differences in predicted probabilities of agreeing there is evidence for global warming accompanying shifts in variables as follows: party identification: Republican to Democrat; ideology: very conservative to very liberal; religiosity: attend services more than weekly to never attend services; gender: male to female; Hispanic: compared to white, not Hispanic; black: compared to white, not Hispanic; education: HS or less to post-graduate; age: 18-24 to 65 or over. In calculating effects, values of all other variables were held at their modes (female, white) or medians (Independent, moderate, some college, attend services a few times per month, local temperature 2.9°F above normal, between 45-55 years old). For additional details, see Table A2.

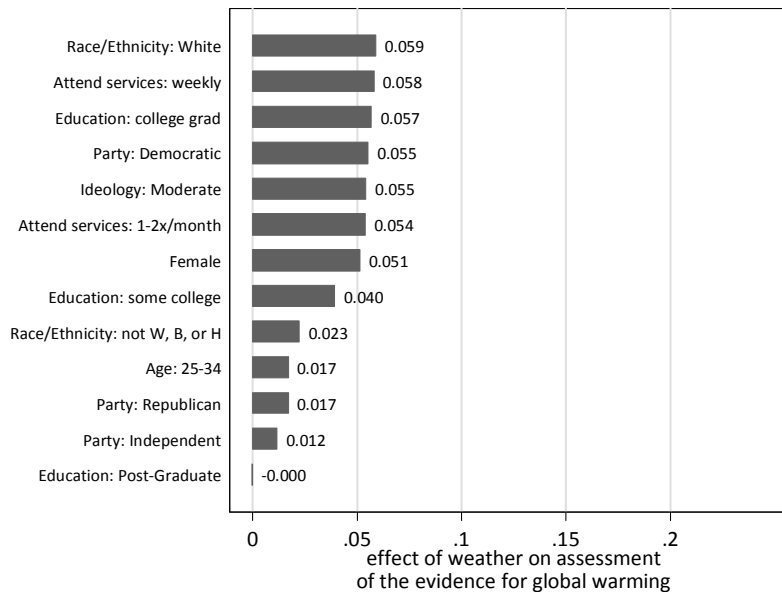
**Figure 5. Weather’s Effect on Beliefs about the Evidence for Global Warming, by Subgroup**

source: predictions generated by models in Table A3

*a. Groups for whom weather’s effect is greater than average*



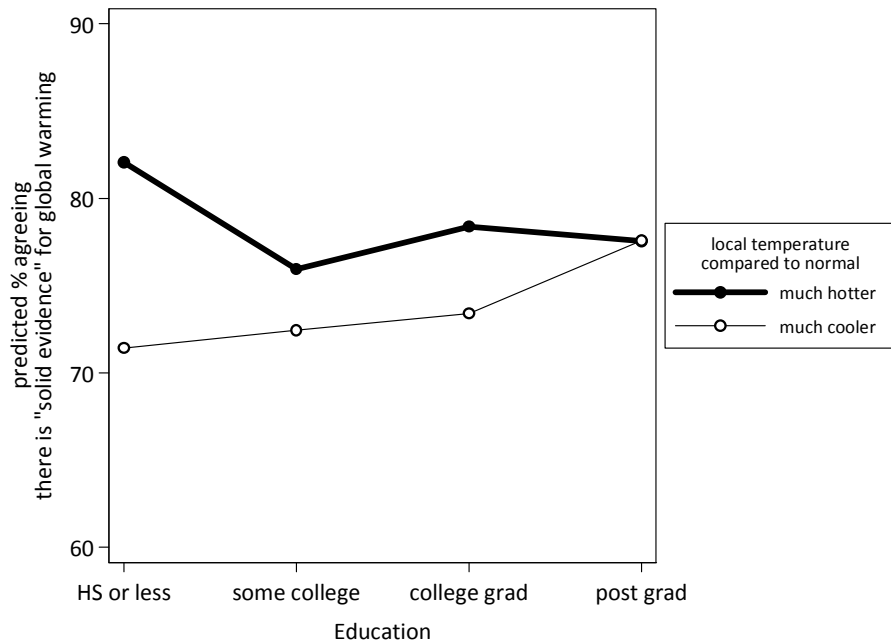
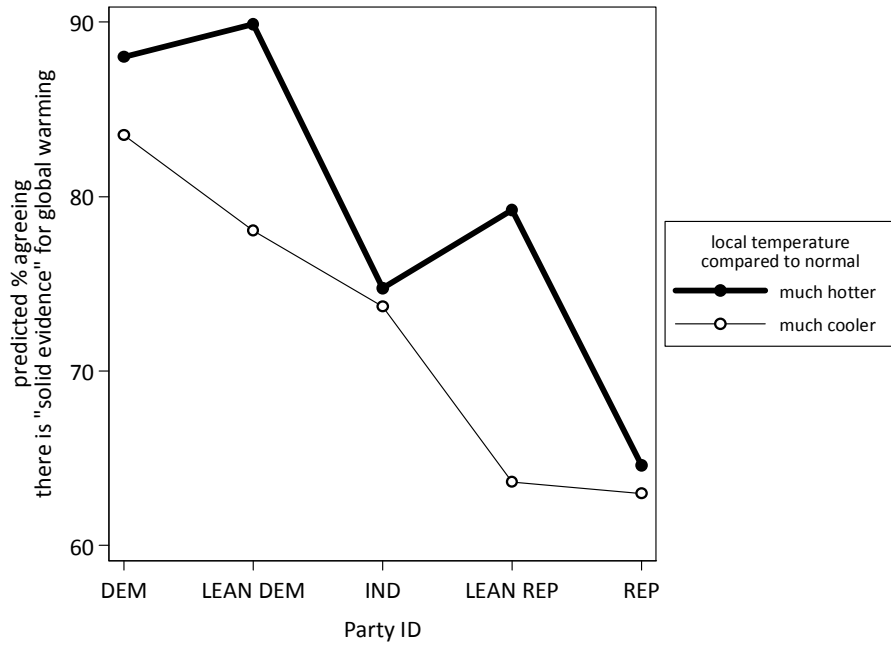
*b. Groups for whom weather’s effect is less than or equal to average*



Effects are the differences in predicted probabilities of agreeing there is evidence for global warming accompanying a shift in local temperature from the 5<sup>th</sup> percentile (4.3°F below normal) to the 95<sup>th</sup> percentile (14.7°F above normal). In calculating effects, values of all other variables were held at their modes (female, white) or medians (Independent, moderate, some college, attend services a few times per month, between 45-55 years old). For additional details, see Table A3.

**Figure 6. Predicted Probabilities of Agreeing there is “Solid Evidence” for Global Warming, by Education, Party ID and Local Weather**

*source: predictions generated by models in Table A3*



Figures show predicted probabilities of agreeing there is evidence for global warming when local temperature is much hotter than normal (at the 95<sup>th</sup> percentile, or 14.7°F above normal) and much cooler than normal (at the 5<sup>th</sup> percentile, 4.3°F below normal). In calculating probabilities, values of all other variables were held constant as described in Figure 5.

## APPENDIX

### Wording of Survey Questions

#### *Questions about party identification*

##### ASK ALL:

PARTY In politics TODAY, do you consider yourself a Republican, Democrat, or Independent?

- 1 Republican
- 2 Democrat
- 3 Independent
- 4 No preference **(VOL.)**
- 5 Other party **(VOL.)**
- 9 Don't know/Refused **(VOL.)**

##### IF ANSWERED 3, 4, 5 OR 9 IN PARTY, ASK:

PARTYLN As of today do you lean more to the Republican Party or more to the Democratic Party?

- 1 Republican
- 2 Democrat
- 9 Other/Don't know/Refused **(VOL.)**

#### *Question about global warming*

- From what you've read and heard, is there solid evidence that the average temperature on earth has been getting warmer over the past few decades, or not?

- 1 Yes
- 2 No
- 3 Mixed/some evidence **(VOL.)**
- 9 Don't know/Refused **(VOL.)**

**Table A1.**  
**Respondents in Analyses as Percent of All Respondents in Original Pew Dataset**

	<i>N</i>	Percent of cases in original dataset
Respondents in original dataset	8,220	100.0
Respondents who supplied five-digit zip code	8,010	97.5
Respondents for whose zip codes NCDC database had valid weather data	7,656	93.1
<b>Respondents successfully matched to NCDC database with valid responses on all variables in analysis</b>	<b>6,726</b>	<b>81.8</b>

**Table A2. Local Weather's Effect on Beliefs about Global Warming**

*Ordered probit. DV: Opinion on whether there is "solid evidence" for global warming (scored "no" = 1; "mixed"/"some"/DK/ref = 2; "yes" = 3)*

Variable	I	II	III
Departure from normal local temperature (°F), week prior to survey	.010*** (.003)	.010** (.004)	.010** (.004)
Sex: Female			.218*** (.035)
Race/Ethnicity: Black			.044 (.068)
Race/Ethnicity: Hispanic			.174** (.079)
Race/Ethnicity: Not White, Black or Hispanic			.111 (.083)
Age: 18-24			-.030 (.073)
Age: 25-34			-.047 (.063)
Age: 35-44			-.057 (.054)
Age: 45-55			.021 (.051)
Age: 55-64			.049 (.052)
Education: high school diploma or less			.071* (.043)
Education: college grad			.051 (.048)
Education: post grad			.114** (.056)
Party ID: Republican			-.290*** (.060)
Party ID: lean Republican			-.098 (.069)
Party ID: lean Democrat			.334*** (.070)
Party ID: Democrat			.417*** (.061)
Ideology: very conservative			-.422*** (.067)
Ideology: conservative			-.198*** (.041)
Ideology: liberal			.222*** (.061)
Ideology: very liberal			.181* (.098)
Attend services: never			.116 (.071)
Attend services: seldom			-.103 (.064)
Attend services: few times per year			-.042 (.060)
Attend services: weekly			-.066 (.054)
Attend services: more than weekly			-.166*** (.063)
State and survey wave fixed effects	No	Yes	Yes
Pseudo-R <sup>2</sup>	.001	.013	.086
Estimated effect of 5 <sup>th</sup> -to-95 <sup>th</sup> percentile shift in temperature on probability of agreeing there is evidence for global warming, holding all other variables constant at their medians	.059***	.062**	.059**

*N* = 6,726. All analyses include estimates of cutpoints (not shown). Estimated quantities significantly different from zero at \**p* < .10; \*\**p* < .05; \*\*\**p* < .01. Medians of variables are: female, between 45-55 years old, some college, Independent, moderate, attends services a few times per month. Changes in probabilities calculated for respondent surveyed in wave 5 (April 2008) and living in the state with median level of opinion on climate change (Michigan).

**Table A3. Local Weather's Effect on Beliefs about Global Warming, by Subgroup**

*Ordered probit. DV: Opinion on whether there is "solid evidence" for global warming*

*(scored "no" = 1; "mixed"/"some"/DK/ref = 2; "yes" = 3)*

Variable	gender	race/ ethnicity	age	education	party identification	ideology	attendance of religious svcs
Departure from normal local temperature (°F), week prior to survey	.011** (.005)	.009** (.004)	.009 (.006)	.006 (.006)	.002 (.009)	.008 (.005)	.008 (.008)
Temperature x Female	-.003 (.006)						
Temperature x Race/Ethnicity: Black		.021* (.012)					
Temperature x Race/Ethnicity: Hispanic		.002 (.016)					
Temperature x Race/Ethnicity: Not White, Black or Hispanic		-.005 (.015)					
Temperature x Age: 18-24			.005 (.013)				
Temperature x Age: 25-34			-.007 (.011)				
Temperature x Age: 35-44			-.001 (.009)				
Temperature x Age: 45-55			.002 (.009)				
Temperature x Age: 55-64			.002 (.009)				
Temperature x Education: high school diploma or less				.013* (.007)			
Temperature x Education: college grad				.003 (.008)			
Temperature x Education: post grad				-.006 (.009)			
Temperature x Party ID: Republican					.001 (.009)		
Temperature x Party ID: lean Republican					.023* (.012)		
Temperature x Party ID: lean Democrat					.025** (.012)		
Temperature x Party ID: Democrat					.009 (.010)		
Temperature x Ideology: very conservative						.001 (.011)	
Temperature x Ideology: conservative						.001 (.007)	
Temperature x Ideology: liberal						.017 (.011)	
Temperature x Ideology: very liberal						.002 (.018)	
Temperature x Attend services: never							.007 (.012)
Temperature x Attend services: seldom							.002 (.011)
Temperature x Attend services: few times per year							.002 (.010)
Temperature x Attend services: weekly							.000 (.009)
Temperature x Attend services: more than weekly							.003 (.011)
Pseudo-R <sup>2</sup>	.086	.086	.086	.086	.087	.086	.086

*N* = 6,726. Analyses include constitutive terms for all control variables, state and survey wave fixed effects, and estimates of cutpoints (not shown). Coefficients significantly different from zero at \**p*<.10; \*\**p*<.05; \*\*\**p*<.01.

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