

Weather or Not? Examining the Impact of Meteorological Conditions on Public Opinion regarding Global Warming

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(Manuscript received 11 June 2013, in final form 24 March 2014)

ABSTRACT

Public opinion surveys in the United States have shown a substantial shift in American public views on global warming between 2008 and 2012. During the period between 2008 and 2010, surveys tracked a significant decline in the number of Americans that believed there was evidence that global warming was occurring. Then, during 2011 and 2012, surveys began to show a rebound in belief among Americans that global warming was indeed happening. This study serves to further establish the significant role that weather played in the short-term fluctuations in public opinion regarding global warming that has been observed since 2008. First, the study shows that individuals regularly refer to weather-related factors when explaining how they arrived at their conclusion that the planet is either warming or not warming and that these explanations correspond with broad weather patterns observed over the 2008–12 time frame. The study also finds that actual weather conditions, and specifically seasonal snowfall, shape the process by which individuals arrive at their conclusions regarding the existence of global warming. In particular, snowfall levels during the winters between 2009 and 2012 appear related to an individual's beliefs regarding the existence of global warming, expanding upon previous studies that have shown a link between weather conditions at or near the time of an interview and respondent views regarding the existence of global warming. The study also finds evidence that the effect of weather on perceptions of global warming is modified by factors such as party affiliation and educational attainment.

1. Introduction

Weather shapes everything. From the physical environment of the planet to the actions and feelings of human beings, weather plays a central role in life on Earth. Scholars have long shown that weather can affect numerous aspects of the daily life of humans, including their productivity, behaviors, and mental state. The French essayist Marcel Proust (1998, p. 472) eloquently captures the central role of weather when he contends “a change in the weather is sufficient to recreate the world and ourselves.” Proust's statement suggests the broad impact of weather on the human condition, a relationship between the core interests of this paper. If

weather does indeed affect so much of our lives, what impact does it have upon human views about the origin of weather itself—the climate? In this study, we seek to join a growing body of literature that examines the role that the weather plays in shaping the views of Americans regarding global warming. In particular, we seek to understand the impact of meteorological factors on public opinion regarding the existence of global warming.

Between 2008 and 2012, there was notable volatility in the views of the American public regarding global warming. Beginning in 2008 and culminating in 2010, numerous public opinion polls tracked a moderate decline in belief that global warming was occurring (Pew Research Center 2009; Leiserowitz et al. 2013). Then, in 2011 and 2012, those same surveys indicated a modest rebound in belief levels (Pew Research Center 2011; Borick and Rabe 2012; Leiserowitz 2012). Researchers have attributed this volatility to a variety of factors, including economic conditions, increased political polarization, incidents

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involving climate scientists, and variation in local temperatures (McCright and Dunlap 2011). While previous studies have been able to link shifts in attitudes on global warming to the array of factors noted above, the explanations for the variations in opinion appear to not be fully developed. In this study, we build upon the current literature on public opinion regarding global warming by examining the effect of meteorological conditions and events on belief in the existence of global warming. Using data from the National Surveys on Energy and the Environment (NSEE) between 2008 and 2012, we analyze the relationship between factors such as drought, snowfall, and hurricanes with individual perceptions of global warming. We find that Americans regularly connect their perceptions of global warming to their experiences with weather and that shifts in seasonal weather conditions during the period between 2008 and 2012 correspond with the volatility in public beliefs regarding the existence of global warming.

2. The American public and global warming

Between the turn of the century and 2008 the American public increasingly expressed views that global warming was or would be occurring in their lifetime. Surveys by organizations such as Gallup (Saad 2009) and Pew (Pew Research Center 2009) indicated that the percentage of Americans who believed global warming was happening had risen from around 50% in 2000 to over 70% in 2008. This expansion in belief in the existence of global warming came to an end in 2009 when an array of national polls began to show that fewer Americans maintained the view that global warming was occurring (see Table 1). This decline in belief continued into 2010 when many polls reached their low point in the post-2008 period. The descent in public acceptance ended in 2011 with most polls indicating modest increases in the percentage of Americans who believed temperatures on the planet were rising. These increases continued through polling conducted during 2012 (see Table 1).

The NSEE offers a bit more detail regarding fluctuations in views about global warming over the past few years because it has been conducted in both fall and spring iterations since 2010. Between fall 2008 and

TABLE 1. The percentage of Americans who believe global warming is occurring. Note that the survey question wording may be found in [appendix A](#).

	2008	2009	2010	2011	2012
Pew	71%	57%	59%	63%	67%
Gallup	61%	53%	50%	49%	52%
Stanford/Washington Post/ABC	80%	75%	74%	83%	73%
Yale/George Mason	71%	N/A	61%	64%	66%
NSEE	72%	65%	58%	62%	68%

spring 2010, the survey found a 20% point drop in American belief that temperatures on Earth are getting warmer (see Table 2). Following this substantial erosion in the acceptance of global warming, however, there has been a moderate increase in belief from fall 2010 to spring 2012. The results in spring 2011 are an exception that we will discuss later in the paper.

3. Weather shifts 2008–12

As previously noted, American public opinion regarding global warming demonstrated substantial volatility during the period between 2008 and 2012. While opinion regarding global warming was turbulent during that period, weather in the United States was also considerably volatile. Over those 5 years there were winters with record snowfall followed by years with little to no frozen precipitation in the United States, summers with historic droughts in one region and record rainfall in another, a unique and devastating hurricane hitting the east coast and some of the hottest periods on record in American history. A brief overview of weather conditions in this period demonstrates the volatility experienced between 2008 and 2012.

Winter weather was particularly volatile during the 2009 to 2012 period, with record snowfalls in some years and record warmth and dryness in others. The winters of 2009/10 and 2011/12 were marked by blizzards on the East Coast that were referenced in the media as “Snowmageddon” and the “Snowpocalypse,” and on 12 February 2010, 49 of the 50 states had measurable snow on the ground (NOAA 2010). Conversely, the winter of 2011/12 was notable for its unusual warmth and lack of snow. During that season many of the same states that experienced the record cold and snowy winters between

TABLE 2. Answers to the NSEE survey 2008–12 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 four decades?” Note that the NSEE methodology may be found in [appendix B](#).

	Fall 2008 (<i>n</i> = 603)	Fall 2009 (<i>n</i> = 988)	Spring 2010 (<i>n</i> = 730)	Fall 2010 (<i>n</i> = 933)	Spring 2011 (<i>n</i> = 725)	Fall 2011 (<i>n</i> = 887)	Spring 2012 (<i>n</i> = 726)	Fall 2012 (<i>n</i> = 917)
Yes	72%	65%	52%	58%	55%	62%	65%	68%
No	17%	20%	36%	26%	32%	26%	24%	21%
Not Sure	11%	15%	13%	16%	12%	12%	11%	11%

2009 and 2011 saw record levels of warmth and snowfall deficits (Lindsey 2012). In the densely populated cities of the northeastern United States, this variation was particularly notable. For example, in the winter of 2010/11, New York City had its second snowiest winter (62 in.) since records began in 1869, only to be followed by the sixth least snowy year (7 in.) during the 2011/12 season.

In addition to the exceptional variation in snowfall over the winter seasons between 2010 and 2012, there have been other extreme weather occurrences, with 2011 and 2012 particularly notable for historic weather events. The National Oceanic and Atmospheric Administration (NOAA) described 2011 as a record-breaking year for climate extremes with regard to heat, precipitation, flooding, and severe weather. In particular, the Southern Plains experienced record droughts, while the Northeast witnessed its wettest year on record (National Climatic Data Center 2012a). The National Weather Service (NWS) declared that Texas had its driest year on record in 2011, with the state receiving about 14 in. of rain compared to the 35 in. it receives on average. Meanwhile, dozens of cities in the Northeast experienced their wettest year in recorded history, with Philadelphia's 62 in. of rain, the most the city has received since record keeping began in 1820.

The high volatility in precipitation in those years was accompanied by extreme temperatures throughout the nation. The warmest 12-month period for the contiguous United States during the period from 1895 to 2012 occurred between July 2011 and June 2012, with temperatures 3.23° above the twentieth-century average (National Climatic Data Center 2012b). During the winter seasons between 2009 and 2012, there was tremendous variation in temperatures, with the winter of 2011/12 ranking 4 of 117 in terms of warmest winter seasons (Table 3). Comparatively, the winter of 2010/11 ranked 80 of 117 in warmest winter seasons, while the 2009/10 season ranked only 102 out of the 117 warmest winters (NESDIS 2012).

4. The literature on individual views regarding global warming

A substantial body of literature has emerged in the past decade that attempts to explain why people differ on the issue of whether or not global warming is occurring. The confluence of a period of dramatically fluctuating weather conditions with volatile public opinion has led numerous analysts to contend that weather may be a contributing factor to the short-term fluctuation of views on global warming observed among the American public. However, many earlier studies have emphasized political and demographic factors as more significant determinants of public views on global warming.

TABLE 3. Rankings of U.S. winter season temperatures in terms of overall temperatures in the 48 contiguous States. Note that the winter seasons run from 1 December to 31 March.

	2009/10	2010/11	2011/12
Ranking	102 out of 117	80 out of 117	4 out of 117

Perhaps the most prominent predictors of an individual's views about global warming are their partisan affiliation and ideological leanings. Numerous studies (Egan and Mullin 2012; Lachapelle et al. 2012; McCright and Dunlap 2011; Zia and Todd 2010; Borick and Rabe 2010; Dunlap and McCright 2008) have shown that individuals who describe themselves as Republican or conservative are significantly less likely than those who call themselves Democrat or liberal to believe that global warming is occurring.

Demographic factors such as educational attainment, age, and gender have had mixed results in terms of their ability to predict individual views on global warming. In a number of studies (Hamilton 2011; McCright and Dunlap 2011; Borick and Rabe 2010), greater educational attainment has been shown to increase the likelihood that an individual believes global warming is occurring. However, concerns regarding the effects of global warming have also been shown to decrease with higher levels of education (Wood and Vedlitz 2007; Malka et al. 2009). McCright (2010) and Hamilton and Stampone (2013), among others, have found a gender effect in global warming acceptance, with women slightly more likely than men to indicate that they believe that it has already begun.

In addition to demographic and political factors, there is some evidence that factors such as economic conditions, media framing, the "Climategate" incident, and related attacks on the credibility of climate scientists have affected American public opinion on global warming. Scruggs and Benegal (2012) for instance, found evidence that the economic decline during the Great Recession contributed to the decline in public acceptance of global warming between 2008 and 2010. Leiserowitz et al. (2013) also found that the 2009 e-mail hacking incident produced a modest decline in public belief that global warming is taking place. McCright and Dunlap (2011) have likewise found that increased efforts by interest groups to denounce climate science may have contributed to the decline in belief that global warming is occurring.

However, most recently, scholars have begun to link public acceptance of global warming with weather conditions experienced. Spence et al. (2011), for instance, found that residents of the United Kingdom who had been severely affected by flooding were more confident that global warming was occurring; further, they

demonstrated higher levels of concern about the impact of global warming. In another study, American farmers were shown to have memories of rainfall and temperatures that were consistent with their beliefs regarding global warming. In particular, farmers who believed their region was experiencing global warming remembered weather trends that conformed to those beliefs (Weber 2010). In an experimental design, Joireman et al. (2010) find that outdoor temperatures are correlated with individual perceptions regarding signs of global warming.

Further, Li et al. (2011) found that participants were more likely to believe that global warming was occurring when they perceived that temperatures in their area were hotter than normal at the time of their interview. Akerlof et al. (2012) find that perceptions of personal experience with global warming heighten an individual's perception of the risk posed by global warming. Likewise, Hamilton and Stampone (2013), Egan and Mullin (2012), and T. Deryugina (2012, unpublished manuscript; available online at <http://economics.mit.edu/files/5945>) have found that an individual's views on the existence of global warming are related to their experience with local temperature. Their studies provide evidence that outside temperatures in the period preceding an interview with a respondent are related to their responses regarding evidence of global warming. In particular, they find that warmer-than-average temperatures in the period before an interview increases the likelihood that a respondent will agree that there is evidence that the planet is warming, while cooler-than-average temperatures will have the inverse effect. Even activities that change perceptions of body temperature such as chewing various flavors of gum have been shown to moderately influence an individual's level of concern regarding global warming (Lewandowski et al. 2012).

Interaction effects among many of the previously noted determinants of individual views on the existence of global warming have also been demonstrated in a number of scholarly works. Studies by Hamilton (2011), McCright and Dunlap (2011), and McCright (2011) all provide evidence that the effects of education on one's views regarding global warming are significantly modified by their partisan affiliation and/or ideological leanings. Most recently, Hamilton and Stampone (2013) find that temperatures on the day of and day before an interview predict beliefs regarding anthropogenic climate change, but are concentrated primarily among individuals who are not affiliated with a political party.

This is where our research enters into the conversation. Surveys conducted by the NSEE have included a battery of questions that asks Americans to identify the factors that lead them to their conclusions regarding

the existence of global warming. The results help to further clarify the impact of weather on the recent shifts in public opinion regarding global warming discussed earlier in this paper (see Tables 1 and 2). In the remainder of this study, we describe what Americans have said regarding the effects of weather on their views about global warming as well as examine how actual weather conditions are related to what individuals have told us about their beliefs on this matter.

5. Evidence from the NSEE surveys

The NSEE regularly includes an open-ended question asking Americans to identify the primary factor that has led them to either believe or not believe that temperatures on Earth have risen over the past four decades. These open-ended comments are coded by two raters with a first iteration Cohen's kappa score of 0.86 calculated before the final reconciliation and merge process. Regarding those Americans who indicate that they believe global warming is occurring, a number of factors have been commonly identified as the primary reason for their beliefs. As can be seen in Table 4, respondents in this category most commonly cite declining polar ice and glaciers, observed temperature increases, and changing weather conditions as the factors most responsible for their conclusions.

Importantly, and consistent with prior research (Li et al. 2011; Egan and Mullin 2012; T. Deryugina 2012, unpublished manuscript; Hamilton and Stampone 2013), the number of Americans citing either observed warmer temperatures or changing weather conditions as the main reason for their belief in global warming reached its highest level during the relatively warm periods of late 2011 and early 2012 and reached its lowest levels following the cold and snowy winters of 2010 and 2011. This suggests that weather may be employed selectively in coming to terms with the existence of global warming, perhaps in a conditional rather than constant manner across groups and susceptible to shifts as weather patterns emerge.

In the spring 2012 NSEE, for example, a middle-aged man from Connecticut stated that the fact that "there was no winter this year" was the major reason for his belief that the planet was warming, while a senior citizen in Minnesota indicated that the primary factor behind his position on global warming is that there "was no snow in his area" during the last winter.

For those Americans who do not believe there is evidence that the planet is warming, observations of temperature and weather conditions have also been a key determinant of their position on this matter. After the relatively cold and snowy winters of 2009/10 and 2010/11, over 40% of global warming skeptics cited personal

TABLE 4. Primary reason for the belief that global warming is occurring. Answers to the question, “What is the primary factor that has caused you to believe that temperatures on Earth are increasing?” F value = 3.36 and $P < 0.05$. Note that this was asked only of individuals who indicated that there is solid evidence of increasing global temperatures.

	Fall 2008	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012
Glaciers/polar ice melting	19%	N/A	22%	17%	21%	14%	15%	13%
Warmer temperatures	19%	N/A	15%	22%	17%	24%	21%	20%
Weather changes	18%	N/A	15%	17%	17%	24%	20%	19%
Scientific research	9%	N/A	14%	10%	9%	8%	11%	12%
Gore documentary	2%	N/A	<1%	<1%	<1%	<1%	<1%	<1%
Media coverage	15%	N/A	16%	14%	14%	12%	9%	8%
Declining species	<1%	N/A	N/A	1%	2%	2%	1%	<1%
Human activity	4%	N/A	5%	9%	7%	9%	10%	12%
Natural patterns	<1%	N/A	3%	2%	3%	4%	4%	3%
Not sure/other	12%	N/A	10%	10%	11%	5%	10%	13%

observations of weather and temperature as the primary reason they think temperatures on Earth are not increasing, as indicated in Table 5; in those cycles, responses such as “we are having a record cold winter” and “this winter is colder than ever” were very commonly provided as the main reason for skepticism. However, after the warm and largely snowless winter of 2011/12, only 20% of global warming skeptics pointed to personal observations as the primary reason they think global warming is not occurring.

Notably, as fewer global warming skeptics have cited their observations of weather as the primary reason for their position on this matter, a larger percentage of this group has turned to religious and political factors as the key reason why they do not think planetary temperatures are rising. Until spring 2012, 2% or less of Americans who did not think global warming is occurring cited some type of political factor as the main reason why they think global warming was not happening, but by the fall of 2012, 12% of global warming skeptics identified a political factor as the primary reason for their stance on this matter. Some examples from the spring 2012 NSEE are illustrative of this shift: a middle-aged man from Florida stated that the primary reason that he does not think global warming is occurring is that “politics take too

much part in the science,” while an elderly man in Georgia said that he did not think there is evidence of global warming because it was “nothing but political hype.”

Similarly, in the fall 2011, spring 2012, and fall 2012 surveys, an increasing percentage of respondents who did not think global warming is happening cited religious factors as the main reason to support their response (see Table 5). Among the responses that demonstrate this view was one from a middle-aged man in Kansas who said his primary reason for concluding that global temperatures are not rising was that “God handles the weather,” and another from an elderly woman in California who simply said that “the Bible” was the primary reason why she believed there was not evidence of global warming.

In addition to the open-ended questions regarding the primary reasons for individual views on the existence of global warming, the NSEE has regularly included a battery of questions asking respondents to rate the relative importance of various factors in determining their position. Regarding individuals who believe there is evidence of global warming, various factors are tested in terms of their impact on those beliefs. These include 1) declining glaciers and polar ice, 2) warmer temperatures in the respondent’s area, 3) computer models, 4) strength of hurricanes, 5) milder winters in the respondent’s

TABLE 5. Primary reasons for the belief that global warming is not occurring. Answers to the question, “What is the primary factor that makes you believe that temperatures on Earth are not increasing?” F value = 3.17 and $P < 0.05$. Note that this was asked only of individuals who indicated that there is NOT solid evidence of increasing global temperatures.

	Fall 2008	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012
Personal observation	42%	N/A	43%	29%	40%	33%	20%	21%
Natural patterns	19%	N/A	22%	32%	29%	22%	21%	24%
Lack of evidence	11%	N/A	13%	7%	8%	14%	11%	12%
Media has misled	3%	N/A	2%	3%	2%	2%	4%	3%
Evidence disproves	8%	N/A	9%	9%	5%	6%	10%	7%
Religious factors	<1%	N/A	4%	3%	4%	8%	10%	11%
Politically driven	2%	N/A	<1%	2%	1%	<1%	9%	12%
No particular reason	5%	N/A	4%	5%	3%	6%	6%	6%
Not sure/other	9%	N/A	3%	10%	10%	11%	10%	5%

TABLE 6. The effect of selected factors on an individual's belief that temperatures on Earth are increasing (percent indicating that the factor had a very large effect). F value = 4.23 and $P < 0.05$. Note this was asked only of individuals who indicated that there is solid evidence of increasing global temperatures.

	Fall 2008	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Range	Mean absolute deviation
Declining glaciers and polar ice	63%	N/A	57%	63%	61%	56%	57%	60%	7	2.8
Warmer temperatures in your area	42%	N/A	30%	48%	33%	39%	41%	42%	12	5
Computer models	30%	N/A	25%	22%	28%	18%	18%	22%	12	4.2
Strength of hurricanes	47%	N/A	30%	39%	30%	31%	24%	26%	23	6.3
Milder winters in your area	36%	N/A	19%	32%	17%	24%	35%	34%	19	9.6
Declining number of polar bears and penguins	40%	N/A	44%	44%	40%	46%	40%	39%	6	2.3
Severe droughts in areas across the United States	47%	N/A	29%	41%	29%	35%	29%	39%	18	6

area, 6) declining numbers of polar bears and penguins, and 7) severe droughts across areas of the United States (see Table 6).

Over the seven iterations of the NSEE when this battery has been tested, weather-related factors such as warmer local temperatures, milder winters, hurricane strength, and drought severity have shown the greatest fluctuations. For example, experiences with warmer local temperatures and milder winters were more likely to be cited as having a “very large” effect on one's belief that global warming is occurring when respondents were questioned after a warmer season (e.g., the winter of 2011/12 and summer of 2008) and less likely to be cited after colder seasons (e.g., the winters of 2009/10 and 2010/11). Conversely, factors such as declining polar ice and species showed less volatility over the course of the various versions of the NSEE.

Table 7 looks more closely at the effect that perceptions of mild winters have on a respondent's belief that global warming is occurring. In the spring 2012 survey, respondents were twice as likely (35%–17%) as their counterparts in the spring of 2011 to say that milder winters in their area had a very large effect on their position regarding global warming. In turn, respondents were less than half as likely (14%–37%) to indicate that mild winters had “no effect” on their belief that temperatures on Earth are increasing.

As noted above, the winter of 2010/11 was ranked 80 out of 114 in terms of the warmest winters in U.S. history, while 2011/12 was ranked 4 out of 117.

Individuals who did not believe there was solid evidence of global warming were also asked what effect personal observations of weather in the respondent's area had on their view that the planet was not warming. As Table 8 indicates, personal observations of weather diminished in importance among factors that contribute

to skepticism about global warming following the abnormally warm winter of 2012 and the record-breaking heat of the summer of 2012.

6. Evidence regarding the relationship between actual weather and opinion

In the previous section, we have described evidence that many Americans are linking weather conditions with their views on the existence of global warming; respondents to the NSEE regularly cite their experiences with weather (e.g., snowy and cold winters, warm temperatures) as the primary reason for their position on this matter. What prior studies from the NSEE have not yet established, however, is whether or not actual weather conditions immediately affect both overall belief levels and the likelihood that individuals will cite weather as a key factor in establishing those beliefs. Recent studies by Hamilton and Stampone (2013), Egan and Mullin (2012), T. Deryugina (2012, unpublished manuscript), and Scruggs and Benegal (2012) have demonstrated that temperature and/or precipitation patterns in the period before an interview is conducted are related

TABLE 7. The effect of milder winters on the individual belief that global warming is occurring. Answers to the question, “Have milder winters in your area had a very large, somewhat large, not too large, or no effect on your view that the earth is getting warmer?” F value = 6.42 and $P < 0.05$. Note that this was asked only of individuals who indicated that there is solid evidence of increasing global temperatures.

	Spring 2010	Spring 2011	Spring 2012
Very large	19%	17%	35%
Somewhat large	38%	25%	33%
Not too large	15%	19%	18%
No effect	26%	37%	14%
Not sure	2%	1%	1%

TABLE 8. The effect of personal observations on an individual's belief that temperatures on Earth are not increasing. F value = 2.97 and $P < 0.05$. Note that this was asked only of individuals who indicated that there is NOT solid evidence of increasing global temperatures.

	Fall 2010	Fall 2011	Spring 2012	Fall 2012
Very large	38%	40%	23%	31%
Somewhat large	29%	26%	18%	28%
Not too large	14%	14%	31%	18%
No effect	18%	16%	28%	21%
Not sure	<1%	1%	2%	2%

to respondents' views on the existence of global warming. The studies by Egan and Mullin, Deryugina, and Scruggs used data from Gallup and Pew for various periods between 2001 and 2010, however, and thus were unable to consider any effects that weather may have had on the modest rebound in Americans' acceptance of global warming as described in Table 1. Only Hamilton and Stampone (2013) have used post-2010 data with their study, utilizing data from the Granite State Poll in New Hampshire that was gathered in a period between 2010 and 2012.

We attempt to begin to fill this gap by examining the impact that snowfall patterns may have had on public acceptance of global warming in the periods following winters in the United States between 2009 and 2012. As discussed earlier, these winter seasons were notable for their dramatic differences in temperature and snowfall. The NSEE findings after the winters of 2009/10 and 2010/11 indicated declining global warming acceptance compared to the findings from the survey iterations conducted during the previous fall. However, the findings from the survey conducted after winter 2011/12 demonstrate higher levels of public belief that global warming is occurring than were found during fall 2011 (see Table 2).

The development of weather measures is necessary in order to test the effect of actual weather conditions on individual perceptions of global warming. While it is important to examine both temperature and precipitation levels in the season preceding an interview, we are particularly interested in the effect that variation from normal seasonal snowfall might have on an individual's views regarding evidence of global warming's existence. Unlike the growing body of literature that connects temperature changes with beliefs and concern regarding global warming (Scruggs and Benegal 2012; Egan and Mullin 2012; Akerlof et al. 2012; Hamilton and Stampone 2013; Shao et al. 2014), there has been less work that provides evidence on the relationship between snowfall and views on global warming. Hamilton and Keim (2009) provide the closest evidence that snow

conditions affect views on global warming with their findings that winter warming in rural counties in New Hampshire, Colorado, and Maine affects perceptions of local impacts of climate change. However, this study does not employ direct measures of snowfall itself. Our anticipation is that respondents will be more likely to perceive evidence of global warming after seasons where there is less snowfall than normal in the area in which they reside and less likely to see evidence of global warming following snowier-than-average winter seasons.

The NWS measures snowfall and temperature at its weather stations throughout the United States and records seasonal snowfall totals. The NWS also calculates a 30-yr seasonal average for station locations for the period between 1980 and 2010. We calculate the departure from the 30-yr average for any given season as the annual seasonal snowfall divided by the average seasonal snowfall. Thus, if a station received exactly its seasonal average in a particular season, it would be given a measure of 1, and if it received twice as much as the average season, it would be given a score of 2. Areas that receive no annual snowfall are scored as a 1 since there is no variation from an average season. For temperatures, we measure the variation of actual mean temperatures from the 30-yr NWS station average for the winter season (January–March) preceding the interview.

The next step in our process was to match snowfall and temperature data for NWS stations to the individual respondents in the NSEE surveys. The NSEE dataset includes zip codes for 1938 respondents from the spring 2010, 2011, and 2012 iterations. Utilizing the NWS web portal, we locate the nearest weather station for the zip code of the respondent and then append the corresponding snowfall data to the respondent's survey record. Before moving on to a logistical regression that controls for other factors that may affect an individual's beliefs regarding global warming (e.g., party affiliation, political ideology, and age), it is valuable to look at the bivariate relationships between seasonal snowfall levels and both individual perceptions of global warming and the impact of mild winters on those perceptions.

In Table 9, we present the relationship between seasonal snowfall levels and individual views on evidence of global warming. Seasonal snowfall levels are categorized into five groups based on the amount of snow that has fallen in relation to seasonal averages. We find that the greatest likelihood (64%) of an individual indicating that there is solid evidence of global warming occurs when snowfall in that individual's area is less than 50% of the average snowfall for that location. Conversely, when snowfall in a respondent's area exceeds 150% of

TABLE 9. The relationship between views on evidence of global warming and seasonal snowfall levels in relation to average snowfall. Chi square is 24.08, $P < 0.002$, and $n = 1908$.

	There is evidence of global warming ($n = 1093$)	There is no evidence of global warming ($n = 586$)	Not sure ($n = 229$)
Less than 50% annual snowfall ($n = 496$)	64%	24%	13%
50.1% to 99.9% of annual snowfall ($n = 380$)	57%	31%	12%
Nonsnow area/average snowfall ($n = 353$)	57%	32%	10%
100.1%–150% of snowfall ($n = 308$)	52%	36%	12%
150.1% of snowfall or higher ($n = 371$)	51%	34%	15%

the seasonal average, only 51% state that there is solid evidence that temperatures on Earth are increasing.

We supplement this analysis with an examination of whether actual weather conditions increase the likelihood that survey respondents will cite weather factors as playing a large role in determining their views on the existence of global warming. This entailed consideration of the relationship between snowfall levels and the degree to which individuals attribute their belief in global warming to mild winter weather conditions in their area (see Table 10). We find that individuals are most likely to indicate that mild winters had a very large effect on their position that there is solid evidence of global warming when snowfall is less than 50% of normal levels. In turn, they are most likely to say that mild winters had no effect when snowfall exceeded 150% of the seasonal average.

This analysis leads us to consider the effect of snowfall on individual views regarding evidence of global warming, while controlling for many of the other factors that the literature links to beliefs regarding global warming. In particular, we control for gender, party affiliation, educational attainment, and age given their emphasis in a good deal of the emerging literature on this topic. We also control for temperature deviations in the local area of the respondent. Based on previous studies, we anticipate the following relationships between these factors and views on the existence of global warming: females, Democrats, higher-educated individuals, and younger Americans will be more likely to believe that there is solid evidence of global warming than males, Republicans, those with lower educational attainment, and older Americans. In terms of local temperatures, we anticipate

that below average winter temperature in an individual's area will result in a lower probability that the individual will believe that there is evidence of global warming. We list these variables and the measures in Table 11.

In the test of this model, the dependent variable is the response to the NSEE 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 four decades?" We label no as a 0 and yes as a 1.

Table 12 presents the results of two logistic regression models for the various independent variables and selected interactions among these variables, confirming that many of the factors that the literature suggests do indeed influence the likelihood that an individual will believe that temperatures on Earth are rising. Most notably, the results are consistent with many other studies (Dunlap and McCright 2008; Borick and Rabe 2010; Zia and Todd 2010; McCright and Dunlap 2011; Lachapelle et al. 2012) that find partisan affiliation and political ideology to be potent predictors of one's views on global warming.

The findings in this study also confirm previous work that has shown that gender (McCright 2010), educational attainment (Hamilton 2011), and age (Saad 2009) make the belief that global warming is occurring more likely with women, those with college degrees, and younger Americans than with men, the less educated, and older Americans (see Table 12).

Finally, the logistic regression provides evidence that snowfall departures from normal in the season preceding the NSEE interviews affect the likelihood that an individual will see evidence that temperatures on Earth

TABLE 10. The relationship between the effect of perceived mild winters on views regarding global warming and seasonal snowfall levels. Chi square is 32.634, $P < 0.037$, and $n = 1887$.

	Very large effect ($n = 566$)	Somewhat large ($n = 657$)	Not too large ($n = 211$)	No effect ($n = 353$)	Not sure ($n = 94$)
Less than 50% annual snowfall	37%	31%	12%	17%	6%
50% to 99.9% of annual snowfall	30%	36%	13%	16%	4%
Nonsnow area/average snowfall	29%	35%	7%	21%	6%
100.1%–150% of snowfall	21%	36%	18%	23%	3%
150.1% of snowfall or higher	22%	36%	15%	25%	2%

TABLE 11. Variable definitions.

Dependent variable: "From what you've read and heard, is there solid evidence that the average temperature on Earth has been getting warmer over the past four decades?"

Yes (57%)
 No (31%)
 Not Sure (12%)

Independent variables

Gender: Male (48%) or Female (52%)

Education: What is your highest level of education?

Less than high school graduate (5%)
 High school graduate (32%)
 Some college or technical school (28%)
 College graduate (23%)
 Graduate or professional degree (11%)

Age: In which category does your current age fall?

18–29 (21%)
 30–44 (27%)
 45–64 (31%)
 65 and older (20%)

Party: Which of the following best describes your political party affiliation?

Democrat (38%)
 Independent or Other Party (34%)
 Republican (28%)

Snowfall: Seasonal snowfall in inches divided by the 30-yr snowfall average for the NWS station closest to the zip code of the respondent.

Temperature: Seasonal temperature variations from the 30-yr average in degrees Fahrenheit for the NWS station closest to the zip code of the respondent.

are increasing. If snowfall in an individual's area is greater than average, the likelihood that an individual in that area would believe that there is evidence of global warming decreases. These findings are consistent with the recent studies by [Egan and Mullin \(2012\)](#), [T. Deryugina \(2012, unpublished manuscript\)](#), and [Hamilton and Stampone \(2013\)](#), among others, that have linked public acceptance of global warming to local weather conditions. Notably, the results in model 2 align with recent research by [Hamilton and Stampone \(2013\)](#) that finds an interaction between partisanship and weather to be an important predictor of individual beliefs regarding global warming. In particular, independents appear to be more likely than either Democrats or Republicans to have their stance on the existence of global warming affected by both seasonal variations in snowfall and temperatures. This finding suggests that in the absence of the strong ideological leanings or party attachment that have been shown to influence views on the existence of global warming, individuals may be more likely to adjust their position on this matter in relation to their experiences with weather. Thus, the findings of the logistical regressions pertaining to snowfall and temperature are consistent with the information that Americans have provided through the NSEE that weather conditions play a key role in their formulation of positions on the existence of global warming.

7. Conclusions

The fairly substantial shifts in American public views on global warming between 2008 and 2012 have been widely discussed both in the popular press and scholarly circles. This study serves to further establish the significant role that weather has played in these short-term fluctuations in public opinion regarding global warming that have been observed during that period. First, the study shows that individuals regularly refer to weather-related factors when explaining how they arrived at their conclusions that the planet is either warming or not warming. As weather shifted over the course of recent winters, many Americans referenced those weather conditions as key factors in their determination of the reality of global warming. As public acceptance of global warming waned after the winters of 2009/10 and 2010/11, an increasing number of Americans reported that their very recent experiences with harsh winters led them to conclude that global warming was not occurring. Then, after the unusually warm and relatively snowless winter of 2011/12, the percentage of Americans who believed in global warming increased, with many citing recent weather experience as a primary factor for their views.

The study also finds that the self-reported importance of weather in shaping views of global warming is accompanied by increasing evidence that actual weather conditions shape the process by which individuals arrive at their conclusions regarding the existence of global

TABLE 12. Results of logistic regression of the determinants of beliefs regarding global warming. $N = 1679$.

Dependent variable	No = 0; yes = 1	Model 1 odds ratio	Model 2 odds ratio
Gender		1.393*	1.28*
Education		1.300*	1.41*
Age		0.896**	0.905**
Party	Democrat (base category)		
	Independent	0.621*	0.732*
	Republican	0.211*	0.328*
Party education	Democrat (base category)		
	Independent		0.723*
	Republican		0.423*
Snowfall		0.872*	0.910*
Party snowfall	Democrat (base category)		
	Independent		0.852*
	Republican		0.988
Temperature		1.013**	1.019**
Party temperature	Democrat (base category)		
	Independent		1.115*
	Republican		0.987
Region	Northeast (base category)		
	South		0.954
	Midwest		0.975
	West		0.996

* $p < 0.01$.** $p < 0.05$.

warming. The results of this study, along with research by [Hamilton and Stampone \(2013\)](#), [Egan and Mullin \(2012\)](#), [T. Deryugina \(2012, unpublished manuscript\)](#), and [Scruggs and Benegal \(2012\)](#), help to build the case that the weather itself is changing the way Americans think about climate. But unlike the majority of previous studies, our findings suggest that experiences with seasonal weather, rather than more short-term weather (i.e., at the time of interview), may also be influencing individual views regarding the existence of global warming. This finding raises questions about possible seasonal interactions between other stable predictors of views on global warming beyond political party affiliation and ideology, such as energy use, efficacy, or institutional trust.

To be certain, weather is not the only factor that shapes one's views on the existence of global warming, just as snowfall and temperature levels are only one component in how one might view weather patterns. While significant, the changes observed in American public opinion over the past 4 years have likely involved fewer than one-quarter of the nation's population. It appears that most Americans have not changed their views on the existence of global warming during this

period, despite the volatile weather observed in recent years. Partisan and ideological fault lines may be particularly significant in sustaining consistent responses from large sectors of the citizenry. Indeed, the relatively small impact that weather anomalies have on partisan views regarding global warming speaks to this point. Nevertheless, a nontrivial segment of the population has had their views on climate shaped by experiences with weather. If indeed the heat, drought, and extreme storms that have defined recent years, and 2012 in particular, becomes the new normal it is reasonable to expect that public acceptance of global warming will remain relatively high and continue recent trends toward growth in coming years.

What is unclear is what effect higher levels of public acceptance of global warming will have on policymaking at the national and subnational levels. The decline in belief coincided with the fall of global warming on the policy agendas of the federal and many state governments. This has left a patchwork of federal and state policies and no broad strategy, such as was advanced in the first half of the 111th Congress in 2009, has resurfaced in subsequent years. ([Rabe 2011](#)). Indeed,

recent trends toward stabilization and decline in American greenhouse gas emissions appear far more attributable to economic decline and the emergence of shale gas than any federal or subfederal policy. While reduced public acceptance of global warming by itself cannot explain global warming policy patterns, it seems fairly reasonable to believe that it has been a contributing factor. If weather has driven the rebound in American acceptance of global warming, then perhaps it will be the weather that may create the conditions by which governments more fully engage or retreat from this issue. As Proust suggested, a change in the weather may indeed be sufficient to recreate the world and ourselves.

Acknowledgments. We would like to thank Erick LaChapelle from the University of Montreal and two anonymous reviewers for their constructive comments and suggestions regarding this study.

APPENDIX A

Question Wording for National Surveys regarding Global Warming

The following questions are used to measure public acceptance of global warming among residents of the United States.

Pew survey: “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?”

Gallup survey: “Which of the following statements reflects your view of when the effects of global warming will begin to happen? They have already begun to happen, they will start happening within a few years, they will start happening within your lifetime, they will not happen within your lifetime but they will affect future generations, or they will never happen.”

Stanford survey: “You may have heard about the idea that the world’s temperature may have been going up slowly over the past 100 years. What is your personal opinion on this—do you think this has probably been happening, or do you think it probably has not been happening?”

NSEE survey: “From what you’ve read and heard, is there solid evidence that the average temperature on Earth has been getting warmer over the past four decades?”

Yale/George Mason survey: “Recently, you may have noticed that global warming has been getting some attention in the news. Global warming refers to the idea that the world’s average temperature has been increasing over the past 150 years, may be increasing more in the future, and that the world’s climate may change as a result. What do you think? Do you think that global warming is happening?”

TABLE B1. NSEE overview.

Survey iteration	Fielding dates	Sample size	Margin of error
Fall 2008	8–24 Sep 2008	603	±4%
Fall 2009	21 Sep–20 Oct 2009	988	±3%
Spring 2010	22 Mar–9 Apr 2010	726	±4%
Fall 2010	15 Nov–9 Dec 2010	916	±3.5%
Spring 2011	18 Mar–5 Apr 2011	712	±4%
Fall 2011	4–21 Dec 2011	887	±3.5%
Spring 2012	27 Mar–14 Apr 2012	729	±4%
Fall 2012	26 Sep–11 Oct 2012	917	±3.5%

APPENDIX B

NSEE Methodology

The NSEE from the University of Michigan and Muhlenberg College is conducted through a telephone survey of residents of the United States. Individual households and cell phones throughout the United States are selected randomly for inclusion in the studies. The sample of phone numbers used in the surveys has been generated by Genesys Sampling Systems of Ft. Washington, Pennsylvania. All surveys except for the fall 2008 survey included both landline and cell phone segments.

Percentages throughout the survey have been rounded upward at the 0.5 mark; thus, many totals in the results will not equal 100%. The results reported for each iteration of the survey have been weighted by the following categories: age, gender, educational attainment, race, and region. The data used for the logistical regression have been weighted to 2010 U.S. Census population estimates. [Table B1](#) presents fielding dates and sample sizes for each iteration.

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