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Do people "personally experience" global warming, and if so how, and does it matter?

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ABSTRACT

For most people, the direct and personally observable signals of climate change should be difficult to detect amid the variability of everyday weather. Yet, previous research has shown that some people believe they have personally experienced global warming. Through four related studies, our paper sheds light on what signals of global warming some people believe they are detecting, why, and whether or not it matters. These studies were conducted using population survey and climatic data from a single county in Michigan. Study 1 found that 27% of the county's adult residents felt that they had personally experienced global warming. Study 2 – based on content analysis of people's open-ended responses – found that the most frequently described personal experiences of global warming were changes in seasons (36%), weather (25%), lake levels (24%), animals and plants (20%), and snowfall (19%). Study 3 – based on NOAA climatic data – found that most, but not all, of these detected signals are borne out in the climatic record. Study 4 – using the survey data – found that personal experience of global warming matters in that it predicts perceptions of local risk of global warming, controlling for demographics, political affiliation, and cultural beliefs about national policy outcomes. We conclude that perceived personal experience of global warming appears to heighten people's perception of the risks, likely through some combination of direct experience, vicarious experience (e.g., news media stories), and social construction.

1. Introduction

Experience is the best teacher, it is said. The consequences of risks that we can see, hear and feel – the sting of a bee, a cut from broken glass, or a burn from time in the sun – create memorable impressions that shape individuals' subsequent behavior, and in their retelling, even that of others (Marx et al., 2007). Direct experience of climate change – inarguably a greater individual and societal threat than the previous three examples – is constrained by individuals' difficulties in detecting its effects amid the normal variation of daily weather (Marx et al., 2007; Moser and Dilling, 2011; Weber, 2010; Weber and Stern, 2011).

However the range of increasing impacts from climate change offers the possibility that individuals may recognize other signals less subject to everyday variability, such as shifts in species distribution, and the onset and length of the growing season. If individuals are able to personally experience adverse effects of climate change, those encounters should result in heightened recognition of its dangers, according to psychological literature on information processing (Weber, 2006). Yet physical environmental conditions are not the only drivers of perception. Perceived experiences of global warming can also be influenced by social environments, including culturally conveyed interpretations of how global warming will manifest. As evidence, cultural worldviews are predictive both of perceptions of environmental changes (Goebbert et al., 2012), and risk, including climate change (Kahan, 2012; Kahan et al., 2007, 2011b).

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This study examines both environmental conditions and cultural constructions in regards to how people perceive global warming experiences and risk. In a series of four studies based on a survey of residents of a county in Michigan, we examine whether individuals believe they have experienced global warming, and how they report to have experienced it, comparing their short narratives to local weather and environmental records for the past few decades. Finally, we evaluate whether perceptions of having experienced global warming make a difference in individuals' risk perceptions of its local impacts, above and beyond their political identification, and cultural beliefs about the benefits or risks of national climate policies. We also assess place attachment as a possible moderator for experience in interpretation of local environmental risks.

2. The potential for experiential processing of climate change

The role of experience in the public's assessment of climate change has received increasing attention over the past decade not only from anthropologists and geographers (Marin, 2010; West and Vásquez-León, 2003; West et al., 2008), but from decision scientists, psychologists, public policy experts, and political scientists (Dutt and Gonzalez, 2011; Marx et al., 2007; Scruggs and Benegal, 2012; Shum, 2012; Spence et al., 2011; Weber, 2006, 2010). Dual processing theories in cognitive and social psychology (Sloman, 1996; Slovic et al., 2004; Chaiken and Trope, 1999) have held out the hope that communication strategies that emphasize vivid elements of both direct and vicarious experience would be more successful than traditional methods of conveying climate science and risk through the provision of pallid and cognitively taxing statistical information (Marx et al., 2007).

Two types of processing are believed to originate within different structures of the brain. The first system is part of our wider evolutionary heritage with other species; it automatically and swiftly processes environmental stimuli (Weber et al., 2004) and is variously described as experiential, intuitive, automatic, natural, nonverbal, narrative, associative, or System 1 (Epstein, 1994; Kahneman, 2011; Stanovich and West, 2000). The second is purported to be the product of more recent human neurological evolution that facilitates rule-based reasoning, and is termed analytical, deliberative, verbal, rational, or System 2.

What we will term the experiential system automatically registers information from the environment in terms of frequencies and associations (Sloman, 1996), and tags it with overtones of negative or positive affect, and emotion (Zajonc, 1980). The affective responses associated with experiential processing may be particularly critical to human risk perception due to the facility with which they enable the rapid categorization and evaluation of information, and evoke a strong response (Slovic et al., 2004). In their risk-as-feelings hypothesis, Loewenstein et al. (2001) claimed that when cognitive and affective assessments differ in response to risk, affect becomes the primary influencer of behavior.

Using experimental and survey data on the relationship between temperature changes and climate change beliefs, researchers have found that both perceptions of having experienced warming, and physical data showing warmer temperatures and trends, are correlated with an increased belief in and concern about climate change, and support for policy (Joireman et al., 2010; Krosnick et al., 2006; Li et al., 2011; Risen and Critcher, 2011; Shum, 2011; Zahran et al., 2006).

The rich nature of people's experiential narratives of climate change may make ethnographic research accounts – many of them conducted in comparison to meteorological and climatic data – particularly suited to evaluation of whether individuals can actually detect environmental shifts over long periods of time, especially signals that may be unique to that place or society. Some of these accounts have indicated that people indeed can accurately identify climatic changes of a decade or more through direct experience (Marin, 2010; West and Vásquez-León, 2003; West et al., 2008). For example, a recent study of farmers from Burkina Faso found that they recognized decreases in rainfall that had been occurring over a 30-year period (West et al., 2008).

Recognition of environmental change should, arguably, be facilitated by an individuals' connection to a specific place or landscape. How people assess the conditions of the places they know and have meaning for them has historically been studied by researchers within the construct of place attachment, with contradictory results. Higher levels of place attachment have been correlated with both heightened perceptions of environmental change and degradation (Kyle et al., 2004), and with lower levels of perceived risks (Billig, 2006; Bonaiuto et al., 1996; Rollero and De Piccoli, 2010).

3. Problems in accurate detection and attribution

"It is effectively impossible for laypeople to accurately discern a climate trend from their own casual observations of weather," stated Kempton et al. in 1996. Many subsequent authors have agreed with this assessment for all but the most severely impacted portions of the world (Marx et al., 2007; Moser and Dilling, 2011; Weber, 2010; Weber and Stern, 2011). Climate by definition is a statistical concept representing frequencies of surface variables assessed over months to millions of years (Solomon et al., 2007). The classical time period used to measure climate variability is 30 years (WMO, 2011), placing detection squarely in the realm of scientists, with their access to long-term datasets, statistical analytic techniques, and computer models.

Even if individuals can detect a signal for climatic changes within weather fluctuations, there are other challenges that they face in doing so. Changes manifest differently in different places (Hamilton and Keim, 2009) and over different geographic scales (Ruddell et al., 2012), with implications for individuals' experiences of them. Changes can appear more or less normative based on the length of the base time comparison period (Weber, 1997), and there may be systematic biases in the ways that humans process frequency information from experience, as opposed to statistical description (Camilleri and Newell, 2011; Hertwig et al., 2004; Hertwig and Erev, 2009). Lastly, the sociocultural context in which people experience weather and climate influences whether they notice and remember signals, what they believe they have experienced (Goebbert et al., 2012; Strauss and Orlove, 2003), and whether they perceive it as a risk (Kahan, 2012).

Culturally constructed climate change beliefs can strongly influence people's perceptions of their experience of global warming. Some of the earliest research on the relationship between personal experience and climate change beliefs was done with farmers (Weber, 1997; Weber and Sonka, 1994). In interviews in Illinois in 1993, Weber and Sonka found an expectation effect in the relationship between farmers' beliefs about global warming and the accuracy of their recall about temperature and precipitation (Weber, 1997, 2010). When April and July rainfall patterns during the previous seven years did not match expectations for conditions predicted under global warming, climate change belief was negatively correlated with accurate recollections of rainfall (−.43), and disbelief was positively correlated (+.34) (Weber, 1997). Alternately, when hotter July temperature trends over the previous five years matched warming expectations, climate change belief was positively associated with accurate recollections, and more than half of those who did not believe in climate change reported July temperatures had remained the same.

Ruddell et al. (2012) also identified the influence of social constructivism in their study of perceptions of neighborhood and regional temperatures in Phoenix, Arizona. At the neighborhood level, individuals' perceptions of temperature changes were more strongly related to modeled temperature data, while at the regional level, they were more strongly associated with social frames of reference, including gender, ethnicity and political conservatism.

Political ideology and cultural worldviews are two categories of variables known to strongly influence both climate beliefs and perceptions of environmental changes. In the United States, growing political polarization on climate change over the past decade has led to party affiliation and ideology becoming increasingly reliable indicators of climate change beliefs (Dunlap and McCright, 2008; Hardisty et al., 2010; McCright and Dunlap, 2011). In a recent multivariate analysis of the influence of political ideology and affiliation on global warming beliefs using pooled data from 10 national polls from within the last decade, McCright and Dunlap found that both ideology and party affiliation were statistically significant across all of their models, with regression coefficients ranging from .18 to .37 (2011).

According to Kahan and colleagues, which risks people selectively recognize can be explained by the cultural worldviews with which they self-identify (Kahan, 2012; Kahan et al., 2007, 2011a,b). Cultural cognition is a process in which individuals shape their beliefs to those predominate in their social group: a rational urge to maximize individual welfare at the expense of the collective welfare. Others have suggested that similar types of values described by cultural theory (Douglas and Wildavsky, 1983) and cultural cognition – hierarchy, egalitarianism, individualism and communitarianism – are found in cultures worldwide because they allow for a variety of forms of societal organization (Haidt and Kesebir, 2010). In this sense, policies that threaten the social order may also be perceived as risks to the collective good, and compete for space with other risks in the "finite pool of worry" (Hansen et al., 2004).

In studying the role of political ideology and cultural worldviews in shaping weather perceptions, Goebbert et al. (2012) found both were statistically significant predictors when holding constant localized physical measures of weather changes. The measures of actual weather change were statistically significant predictors only of perceptions of flooding and drought, but not of temperatures. The authors concluded that perceptions of local weather changes are a "complex mix of direct observation, ideology and cultural cognitions."

Even with these filters and challenges to direct perception of climate impacts, many people do feel they have personally experienced global warming. A series of nationally representative surveys conducted since 2008 has shown that 26–38% of the American adult public believe that they have personally experienced global warming, 4–7% believing so strongly (Leiserowitz et al., 2012). So what does this mean?

In this study we explore the extent to which residents in one county of the United States believe they have personally experienced global warming (Study I), characterize the types of changes they believe to have experienced in comparison to records of environmental conditions over the past decade or more (Studies II and III), and assess the relationship between beliefs about experiencing global warming and risk perceptions of local climate impacts (Study IV).

4. Study I: do people feel they have personally experienced global warming?

Three of the four studies reported here draw on data obtained from a mail survey that was fielded in Alger County, Michigan, which included three questions about residents' experiences with global warming: whether they had personally experienced it, where, and how (Akerlof, 2010). The measure of personally experiencing global warming is a single Likert-scale item slightly modified from one used by Leiserowitz et al. (2009). Additional survey questions addressed perceptions of risk from global warming to the county and its people; other issue-related attitudes and beliefs; and household energy use. This section details initial results of some of those measures that are later drawn upon for further analysis.

The survey was fielded from June 10 to September 8, 2010 and resulted in completed surveys from 765 adult residents (18 years or older). This represents a return rate of 57% calculated on a base number of 1336 surveys mailed to deliverable county addresses.

Survey Sampling International provided the random sample of 1598 listings from a frame of 4613 using address-based sampling. Each survey was addressed to "Alger County Resident" and instructions given for the adult with the most recent birthday to complete the questionnaire. The margin of sampling error was $\pm$3.4 percentage points within a 95% probability.

Geographically, the final sample closely resembles the zip code distribution for the initial mailing base of valid addresses (maximum difference of 3.6 percentage points, with most less than 1.0), one indicator of sample representativeness. According to U.S. Census Bureau (2010) data, 32.9% of total county housing units were used seasonally, recreationally or only occasionally. That this study was fielded during the summer months likely increased the number of seasonal residents who participated in the study, and increased the income and educational status of respondents. The largest disparity between Census 2010 data and the sample profile is in the distribution of educational attainment and age. Across educational attainment categories, the biggest difference is due to low representation in the "less than high school" category (11.4 percentage points); within age categories, the biggest difference is in the high representation of the 60–69 age group (11.9 percentage points).

4.1. Results and discussion

"Don't know" (37.3%) was the most frequent response to the question "Do you agree or disagree with the statement: 'I have personally experienced the effects of global warming'?" A similar proportion – more than a third of the respondents – disagreed (24.9% strongly disagree, 10.8% somewhat disagree), and approximately one quarter agreed that they had personally experienced global warming (5.7% strongly agree; 21.3% somewhat agree).

Of those who agreed ($n = 198$), two-thirds said they had experienced global warming locally in Alger County (66.7%), approximately one quarter elsewhere in the Upper Peninsula of Michigan (22.7%), about forty percent elsewhere in the United States (39.9%), and only five percent in some "other" location (5.6%). Multiple responses to this question were allowed.

As a point of comparison, 30% of respondents to a June 2010 nationally representative U.S. survey believed they had personally experienced global warming, and 70% did not (a "don't know" response option was not given) (Leiserowitz et al., 2010). Though other authors have found regional differences in perceptions of climate change (Hamilton and Keim, 2009), the percentage of Alger County respondents who say they have experienced global warming nationally is similar to that of the United States as a whole (27% vs. 30%).

5. Study II: in what ways to people feel they have personally experienced global warming?

The final question of the three-item module on respondents' personal experiences of global warming was open-ended: "In what ways have you personally experienced global warming?" Typical examples of participants' descriptions of their experiences included:

- Warmer winters, Less snow. Low lake levels. Early, spring weather. Less rain. Warmer summers. Ticks. Cougars (sightings). Turkey vultures.
- Mild winters, cold summers, heat waves, thunderstorms (above average).
- Weather patterns have changed considerably since I was a child. Hotter summers and milder winters.

In order to evaluate patterns of response, the short texts were analyzed using a computer search for high frequency words and phrases. These became the basis for a code sheet of 28 variables used in the content analysis. The lead author selected inter-reliability samples of approximately 30 textual units each for three coders to ensure adequate representation of all coded variables. A Krippendorff's α inter-reliability statistic (Hayes and Krippendorff, 2007) of .800 or above was obtained for 27 variables, and above .700 for one variable (precipitation specifics). Variables with an α above .800 are considered reliable, and those above .667 are suitable for "tentative conclusions" (Krippendorff, 2004).

Respondent descriptions of their experiences of global warming infrequently referred to specific places and could not be coded for location. Of those who answered the open-ended question however, 78% said that they had experienced changes due to global warming in Alger County.

Because respondents did not specify a location for each of the changes they ascribed to global warming in their open-ended responses, it cannot be assumed however which changes may be associated with any particular place.

5.1. Results and discussion

The most frequently described personal experiences of global warming were changes in seasons (36%), weather (25%), lake levels (24%), animals and plants (20%), and snowfall (19%) (Fig. 1). Many of the ways respondents described their experiences reflected facets of weather, but some also represented possible local climate change indicators less subject to the vagaries of daily weather, such as seasonal shifts and species changes. Weather experiences were coded across a number of categories, including general weather pattern changes, temperature and precipitation, and extreme weather. Extreme weather was defined by use of the specific term and inclusions of storms in the short text narratives. Only 7% of those who described their experiences mentioned that they had been seeing "extreme weather" or more storms as a result of global warming, though some respondents may have generalized these changes as shifts in weather patterns. (Heat waves were infrequently mentioned. The phenomenon was difficult to discern from descriptions of general temperature increases, and was coded under the latter.)

When the direction of precipitation or seasonal temperature changes was indicated, this information was coded. Respondents were most likely to perceive global warming as the cause of warmer summers (59%; summer temperatures, $n = 17$); less snowfall (78%; snowfall, $n = 27$); and less rain (52%; rainfall, $n = 21$). As noted, the numbers of respondents who described specific temperature and precipitation changes are small. The frequencies of the directional data thus should be viewed as only a suggestive finding.

Some respondents noted human impacts of global warming – both health and economics – but less frequently than environmental changes were noted. Of the 16 respondents who described human health impacts, increased likelihood of sunburn, sun

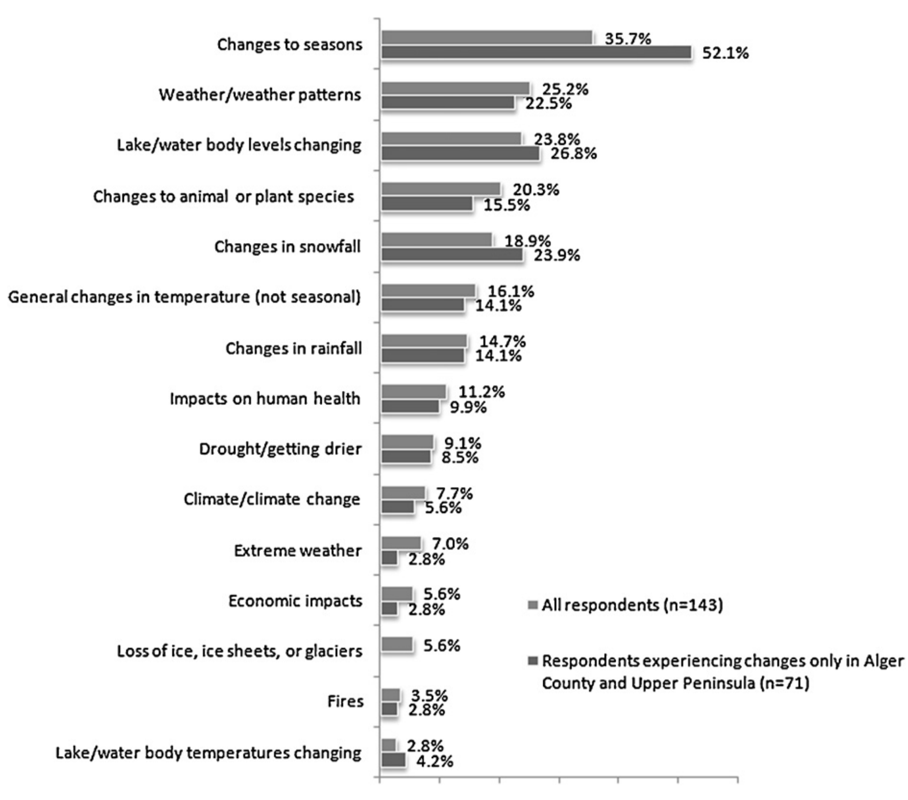

Fig. 1. Percentages of respondents citing specific types of experienced impacts from global warming.

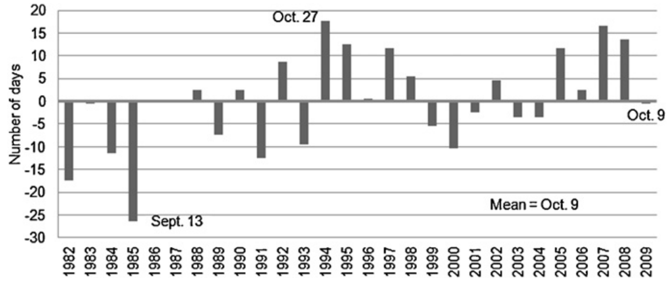

Fig. 2. Anomalies from the mean, 1982–2009, of first frost dates of the year recorded in Munising, MI (NCDC, 2010a).

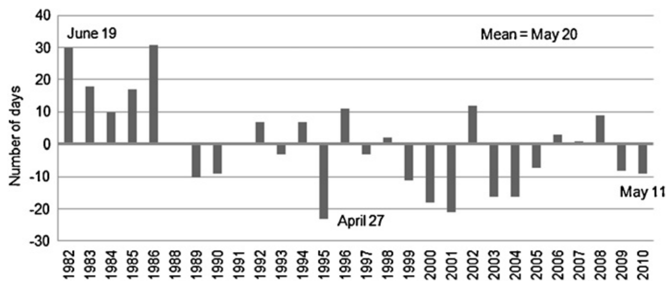

Fig. 3. Anomalies from the mean, 1982–2010, of last frost dates of the year recorded in Munising, MI (NCDC, 2010a).

exposure, and skin cancer were the most frequently cited, followed by increased breathing problems, higher rates of disease, and more allergies.

Few differences distinguished those respondents who said they had experienced changes *only* within Alger County or elsewhere in the Michigan's Upper Peninsula ($n = 71$) from everyone who had experienced global warming ($n = 143$). The differences between the full and partial (local and Michigan Upper Peninsula) sample were within five percentage points or less, with two exceptions. Members of the local impacts sample were more likely to have identified changes in seasons (52%) than were members of the full sample (36%); and not surprisingly, no member of the local impacts sample mentioned loss of ice sheets and glaciers.

Interestingly, those respondents who felt they had personally experienced global warming but *did not* answer the open-ended question describing how they had experienced it were 11 percentage points less likely than those who answered the open-ended question to have named their county as one of the sites in which they had noticed differences (67%). This may suggest that local climate impacts are more salient and more easily recalled.

6. Study III: are the self-reported local experiences of global warming evident in the local historical data records?

We accessed historical data for the region to ascertain the environmental conditions that Alger County residents were likely to have experienced over the past few decades, giving particular attention to more recent events as they are likely to be perceived as of higher overall frequency than less recent ones (Hertwig, 2004), and evaluating records that corresponded to residents' perceptions of experienced climatic changes. These included first and last frost dates, storm frequencies, mean high water levels for Lake Superior, and snowfall amounts and monthly depth maximums.

The data consisted of National Climatic Data Center land surface records for Munising (NCDC, 2010a); storm event frequencies for Alger County (NCDC, 2010b); and mean water levels for Lake Superior taken in nearby Marquette, MI (NOAA, 2010). Munising is the largest city within Alger County, accounting for 49.2% of the survey respondents. The closest available lake level data to the county were from Marquette in the adjoining county to the west. Anomalies from mean values across the data time series allow for visual evaluation of years which are below and above average (Figs. 2–7). The data are not to suggest that the variability can be ascribed to climate change, or that any trends over the few decades of time that are available for some of the data records – and are likely to be salient to residents – are statistically significant over longer periods.

The local data was limited in both its length and completeness; missing data frequently occurred even within recent records. The geographic specificity of the data is important however due to likely differences in conditions caused by factors such as proximity to Lake Superior.

6.1. Results and discussion

Three of the four ways in which respondents indicated they had personally experienced global warming in Alger County – changes in seasons, storm events, and lake levels – were consistent with available physical data (Figs. 2–7). The fourth impact – snowfall – was in the opposite direction most frequently described by respondents – i.e., the record shows higher snowfalls in the three years prior to the survey but respondents reported less snow (Fig. 6). Regions downwind of Lake Superior are experiencing increased lake effect snow from higher levels of evaporation as a result of less ice cover over the lake during the winter (Burnett et al., 2003; Karl et al., 2009; Kunkel et al., 2009).

First and last frost dates signal the onset of winter, and the arrival of spring. During the 28-year period represented in Fig. 2, three out of four of the first frost dates that occurred the latest in

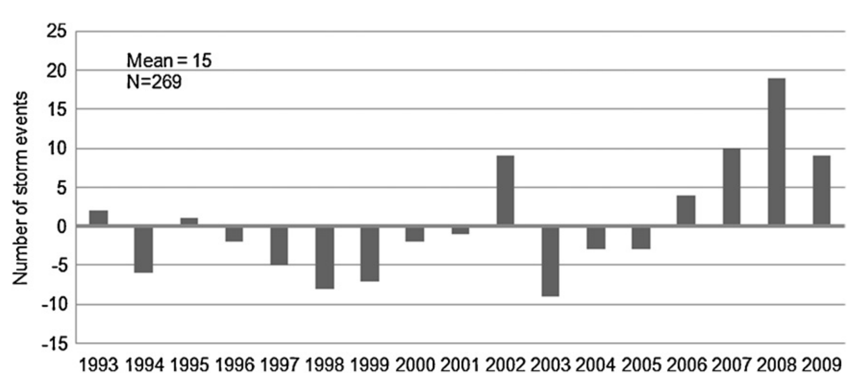

Fig. 4. Anomalies from the mean, 1993–2009, of number of storm events in Alger County (NCDC, 2010b).

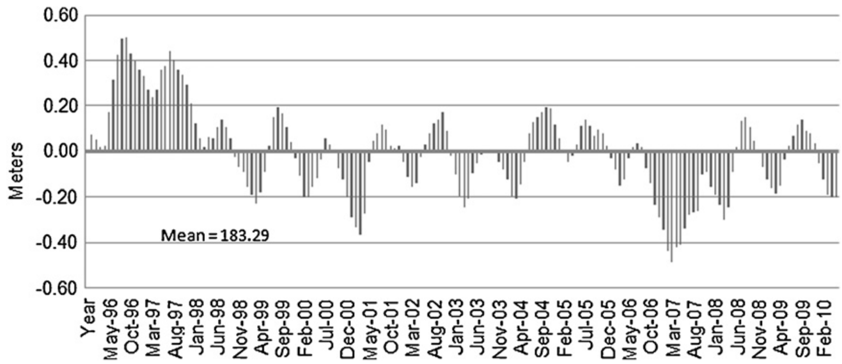

Fig. 5. Anomalies from the mean, 1996–2010, of mean high water level measured relative to the International Great Lakes Datum (IGLD) in meters in Marquette, MI (NOAA, 2010).

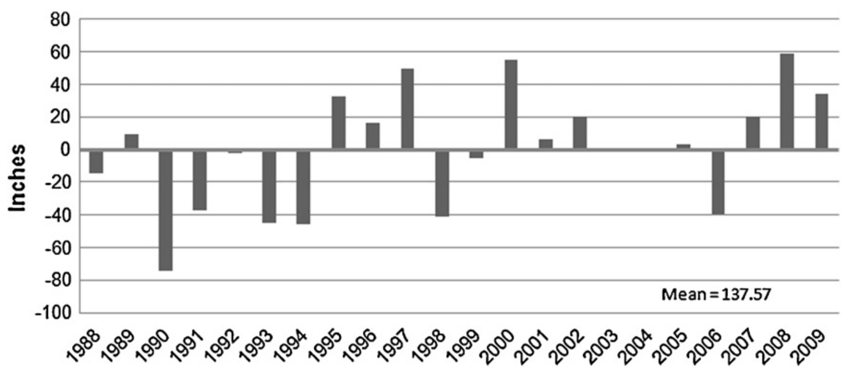

Fig. 6. Anomalies from the mean, 1988–2009, of total inches of snowfall in Munising, MI yearly from November to March (NCDC, 2010a).

the year, effectively shortening winter, were within five years of surveying residents, and most likely to be fresh in their memories: 2007 (October 26), 2008 (October 22), and 2005 (October 21). Conversely, the earliest dates of the first frost were in the early 1980s (1982, 1985). The range in first frost dates spanned 44 days over the 28 years.

In the years 2001 (April 29), 2000 (May 1), 2004 (May 3) and 2003 (May 4) winter ended more quickly than on average over the 29-year span (Fig. 3). While in the early 1980s frosts lingered until mid- and late-June, after the turn of the century they were more likely to end in May, about a month earlier with a total range of 54 days.

From 1993 to halfway through 2010, there were 269 storm events recorded in Alger County (Fig. 4). Within the four years predating the survey, respondents encountered the highest frequencies of storms that they had experienced in almost two decades. Listed in order, the five stormiest years in the 17 years were 2008 (34), 2007 (25), 2002 (24), 2009 (24), and 2006 (19).

Given country residents had seen comparatively high frequencies of storms in the years immediately prior to the survey, surprisingly few people's narratives specifically mentioned extreme weather or storms. Extreme weather (including storms) was about as likely to be mentioned by respondents as economic impacts. Some references by residents to changes in weather and weather patterns – the second largest coded category – could also have encompassed changes in storm frequencies, as we previously noted, but it is impossible to read beyond the sometimes general wording that survey participants used.

Lake Superior's water levels – as measured in Marquette, MI – were at their highest during the late 1990s, and their lowest during the past decade (2007, 2001, 2008 and 2006) (Fig. 5). The lake levels ranged from a high of 183.8 meters to a low of 182.8 from January 1996 through May 2010. The one-meter difference represents more than three feet, and is within the norm of two-meter historical variability, characterized by seasonal cycles of .4–.45 meter amplitude (Lofgren et al., 2002). Outflow from Lake

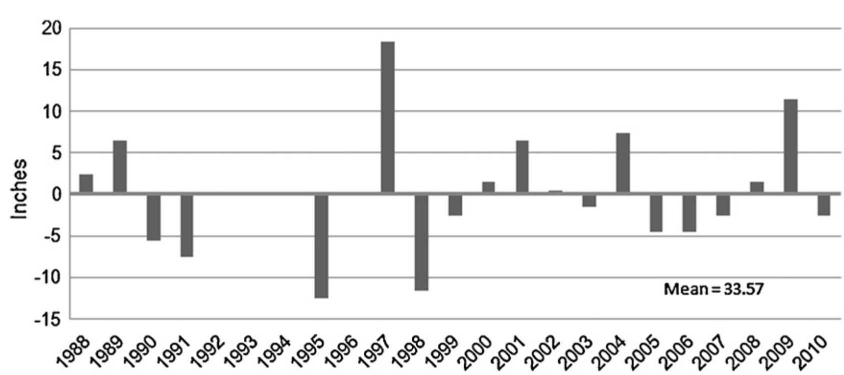

Fig. 7. Anomalies from the mean, 1988–2010, of maximum monthly snow depth in inches in Munising, MI (NCDC, 2010a).

Superior is regulated by the International Joint Commission, but lake levels also respond to a number of climatic variables (GLERL, 2011). NOAA has assessed recent Lake Superior water levels as below the long-term mean.

Change in the quantity of snowfall was the last variable we assessed, using two different dimensions: a measure of snow as precipitation (Fig. 6), and maximum monthly snow depth (Fig. 7). Almost 80% of respondents who mentioned personally experiencing changes in the amount of snow wrote that it had lessened over time. There was no evidence of this trend in the physical data, and indeed the most recent three years had snowfall well above the mean for the 22-year period. The largest snowfall totals from November to March were in 2008 (196 in.), 2000 (192 in.), 1997 (188 in.) and 2009 (172 in.). The measures of snowfall accumulation over a period of 23 years were more mixed, with three of the five most recent years slightly under the mean maximum monthly accumulation, and two years above it.

There are a number of possible explanations why individuals' perceptions of "less snow" might not appear to be supported by snowfall records in the years just prior to the survey. With warmer temperatures, snow accumulation may lessen even with larger snowfalls. There was a large difference between maximum monthly accumulations between 2009 (11 in. over the mean) and 2010 (almost 3 in. below the mean), however there was no evidence of a sustained trend toward lower accumulations. Another possible explanation is that individuals' mental models of climate change may be of melting ice, not heavier snowstorms (Swim, 2010), leading to an expectancy effect similar to that found by Weber and Sonka (Weber, 1997; Weber and Sonka, 1994).

Hamilton and Keim's 2009 study of regional variations in perceived local climate change effects found that "snow-country areas" – northern New Hampshire, central Colorado and western Maine – had the largest increases in winter warming over a 38-year period, and registered the highest levels of public concern. Alger County, Michigan is sited farther north than either of these other regions of the United States and experiences high winter snowfall: a mean of almost 11.5 feet of snowfall a year (1988–2009) and a mean maximum monthly winter snow depth of almost 3 feet (Fig. 6). Yet unlike the regions Hamilton and Keim studied, another climate change consequence – increased lake effect snow due to declines in ice cover on Lake Superior (Burnett et al., 2003; Karl et al., 2009; Kunkel et al., 2009) – may also be influencing winter conditions in the Michigan county with opposite results for snowfall. Less than one quarter of the Michigan respondents mentioned changes in snowfall, suggesting it is not as salient as changes to seasons, weather patterns, and even lake levels. In this case, the climate change signal may appear less clear.

7. Study IV: does perceiving personal experience of global warming matter?

To examine how well two dimensions of experiential belief – having experienced global warming, and having experienced it in the county – predicted individuals' risk perceptions of impacts to the county from climatic changes, we conducted a series of hierarchical regression analyses controlling for gender, age, education, income, political affiliation, and cultural worldviews (Tables 1 and 2).

To create cultural worldview variables we employed six dichotomous measures of perceived societal outcomes – both positive and negative – that some people associate with national policies to mitigate global warming (Leiserowitz et al., 2009). The chosen surrogate measures in this study capture similar constructs as cultural cognition's hierarchy and individualism scales, e.g. the beneficial or threatening nature of policy solutions to culturally

Table 1
Characteristics of independent variables.

Independent variables	Question/scale and coding	Mean	SD
Belief in having experienced global warming	Do you agree or disagree with the statement: "I have personally experienced the effects of global warming"? [Strongly disagree (1), somewhat disagree (2), don't know (3), somewhat agree (4), strongly agree (5)]	2.72	1.19
Experienced global warming in the county	If you have experienced global warming, where have you personally experienced it? [Alger County (1,0), Elsewhere in Upper Michigan (1,0), Elsewhere in the United States (1,0), Other (1,0)]	.22	.41
Positive societal outcomes from climate policy	Range of factor values −5.35 to 2.36 (see Table 2) *If our nation takes steps to reduce global warming, it will* ... 1. Improve people's health; 2. Save many plant and animal species from extinction; 3. Create green jobs and a stronger economy; 4. Interfere with the free market; 5. Cost jobs and harm our economy; 6. Cause energy prices to rise. [False (1); True (2)]	−.08	2.47
Negative societal outcomes from climate policy	Range of factor values −2.49 to 4.16 (see Table 2) *If our nation takes steps to reduce global warming, it will* ... 1. Improve people's health; 2. Save many plant and animal species from extinction; 3. Create green jobs and a stronger economy; 4. Interfere with the free market; 5. Cost jobs and harm our economy; 6. Cause energy prices to rise. [False (1); True (2)]	.01	1.98
Place attachment	7-item scale, $\alpha = .631$, range 0 to 7 1. I have negative feelings for this place (Alger County). [True (0), False (1)] 2. I have no particular feeling for this place. [T (0), F (1)] 3. I do not think of myself as being from this place. [T (0), F (1)] 4. What happens in this place is important to me. [T (1), F (0)] 5. I have an emotional attachment to this place – it has meaning to me. [T (1), F (0)] 6. I am willing to invest my talent or time to make this an even better place. [T (1), F (0)] 7. I am willing to make financial sacrifices for the sake of this place. [T (1), F (0)]	5.80	1.27
Republican	Yes (1), No (0)	.17	.37
Democrat	Yes (1), No (0)	.32	.47
Independent	Yes (1), No (0)	.32	.47
Other party affiliation	Yes (1), No (0)	.05	.22
No party affiliation	Yes (1), No (0)	.14	.35
Income	(1) less than $10,000 to (9) $150,000 or more	3.46	1.73
Education	(1) less than high school to (5) advanced degree beyond 4-year degree	2.93	1.08
Age	(1) 18–29 to (7) 80+	4.43	1.45
Gender	Female (1), Male (0)	.50	.50

Table 2
Characteristics of dependent variable.

Dependent variable	Question/scale and coding	Mean	SD
Perceptions of local global warming risk	8-item scale, α = .958, range −1.97 to 1.39 *Over the next 20 years in Alger County, how likely do you think it is that global warming will cause each of the following?* 1. Forest fires; 2. Public health problems; 3. Lower lake levels; 4. Arrival of new plants and animals; 5. Declines in populations of current plants and animals; 6. Droughts; 7. More insects such as ticks and mosquitoes [Very unlikely (1), somewhat unlikely (2), neither likely nor unlikely (3), somewhat likely (4), very likely (5), don't know (6)] 8. Global warming will harm ... people in Alger County. [Strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), strongly agree (5), don't know (6)]	.00	.983

preferred forms of social organization and the roles of the individual within society (Kahan et al., 2011b).

Due to the binary nature of the societal outcome measures, an exploratory factor analysis was conducted on a tetrachoric correlation matrix (Uebersax, 2006), using varimax rotation to develop the scales (Table 3). Two factors were identified, each with eigenvalues over the Kaiser criterion of 1. Together they explain 77.29% of the variance. The first factor represents positive perceptions of societal impacts from climate policies; the second factor represents negative perceptions. Factor scores were created from sums of the standardized variables, weighted by the factor loadings (DiStefano et al., 2009). Mean substitution was used in the final factor scores to replace missing data.

The final two regression models include place attachment to the county (Williams, 2000) in order to assess both a main and interaction effect with experience on local risk perceptions. The scale measures residents' place attachment to their county based on their emotional associations, and willingness to invest time and financial resources in it. Three of the items in the attachment scale were reverse coded, and the seven binary measures were summed.

We also tested for an interaction effect between place attachment and experience expecting that high – as opposed to low – levels of emotional connection with the county would more strongly motivate perceptions of local global warming risks as levels of belief in having experienced changes increased.

The dependent variable in the regression models was a measure of perceived local risk from global warming derived from eight items that assessed potential impacts from climate change to the county and its residents (Table 2). Of the risk scale items, lower lake levels (56.7%), droughts (52.3%), and declines in populations of current plants and animals (50.5%) were the most frequently identified likely local impacts from global warming. Less than half of respondents thought forest fires, arrival of new plants and animals, public health problems and more insects such as ticks and mosquitoes were probable. The final item in the risk scale asked whether people in the county will be harmed from global warming; less than half of respondents agreed (43.2%).

Table 3
Rotated factor loadings for perceptions of policy implications.

Items[a]	Positive	Negative
If our nation takes steps to reduce global warming, it will ...		
1. Improve people's health	**.95**	−.21
2. Save many plant and animal species from extinction	**.91**	−.26
3. Create green jobs and a stronger economy	**.80**	−.41
4. Interfere with the free market	−.16	**.76**
5. Cost jobs and harm our economy	−.48	**.80**
6. Cause energy prices to rise	−.20	**.69**
Eigenvalues	3.95	1.15
Percent of variance	44.47	32.82
Cronbach's α	.85	.68

KMO = .780, individual items > 71; Bartlett's test of sphericity $\chi^2(15) = 3276.09$, $p < .001$; $n = 611$.
[a] Based on theoretical relevance and prior analysis of nine policy outcome measures, three were not included in the two scales: help free us from dependence on foreign oil; improve our national security; and help protect national parks, forests and wildlife refuges.

Each of the local risk perception measures used a combination of "neither/nor" as a middle option, and "don't know" at the end of the responses. Only 62% of the sample did not have at least one don't know response across all eight items. In order to reduce the loss of data, "don't know" was combined with the middle "neither/nor" values (Pidgeon et al., 2005). As a check on possible bias introduced by recoding, the hierarchical regression was also run with "don't know" responses as missing data. The final model adjusted R^2 value was 7% higher, but the significance and relative size of the standardized regression coefficients remained the same.

7.1. Results and discussion

After controlling for demographics, political party affiliation, and cultural beliefs about climate policy outcomes, the hierarchical regression demonstrated that (1) believing oneself to have personally experienced global warming and (2) experiencing it locally were statistically significant predictors of perceptions of global warming's local risks (Table 4). The standardized regression coefficients for the two experience variables were sizable in the final models (Models 4–6), although smaller than that of perceived benefits from climate policy outcomes.

Of the demographic variables assessed, only gender was significant in the final models. Women were more likely to perceive local risks from climate, but the variable's coefficient was much smaller than the other variables. In Model 2, Republican and Democratic Party affiliation were significant predictors of risk perceptions; in Model 3 (which added the cultural cognition scales), only Republican Party affiliation remained significant. No party affiliation measures were significant in the final models. Neither place attachment for the county, nor an interaction between place attachment and personal experience, was statistically significant.

These findings are highly congruent with the cultural cognition literature, in which individuals' perceptions of risks are driven more strongly by the beliefs of their group than they are by risk information (Kahan et al., 2011b), arguably including direct experience of climate change. Indeed, in our study the relationship between measures of cultural cognition and the perceived local risks of climate change were so strong that they superseded the influence of political party affiliation.

Perceptions of positive outcomes from national global warming policy were more predictive of local risk perceptions than were perceived negative outcomes. This is likely because the negative outcome measures less capably captured the cultural frames used to argue against climate policy adoption, than the positive outcome measures did for pro-policy cultural frames. The negative outcome measures had a slightly lower Cronbach's alpha (.68 vs. .85), and smaller factor loadings than the positive measures (Table 3). Even so, the combined negative outcome scale narrowly missed

Table 4
Hierarchical regression models predicting perceptions of local risk from global warming.

Independent variables	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	β	t	β	t	β	t	β	t	β	t	β	t
(Constant)		.89		.88		.33		.06		.09		0.11
1. Gender	.22	5.64***	.19	4.90***	.08	2.45*	.07	2.58*	.07	2.60*	.07	2.59*
2. Age	−.05	−1.14	−.06	−1.55	−.04	−1.07	−.03	−.95	−.03	−.92	−.03	−.95
3. Education	.01	.23	.03	.63	−.01	−.27	−.03	−1.12	−.03	−1.11	−.03	−1.11
4. Income	−.16	−3.75***	−.15	−3.67***	−.08	−2.31*	−.05	−1.77	−.05	−1.78	−.05	−1.78
5. Republican (vs. no party)			−.14	−2.66**	−.09	−2.00*	−.06	−1.45	−.06	−1.45	−.06	−1.44
6. Democrat (vs. no party)			.17	2.89**	.06	1.32	.05	1.16	.05	1.19	.05	1.20
7. Independent (vs. no party)			.00	.01	.01	.19	.00	.10	.00	.09	.01	.12
8. Other party affiliation[a] (vs. no party)			−.02	−.44	−.01	−.39	.00	.01	.00	.00	.00	.01
9. Positive societal outcomes from climate policy					.65	11.73***	.44	8.30***	.44	8.33***	.44	8.27***
10. Negative societal outcomes from climate policy					.10	1.92	.08	1.73	.08	1.75	.08	1.74
11. GW personal experience							.29	8.00***	.29	7.98***	.29	7.98***
12. Experience GW in county							.17	5.56***	.17	5.60***	.17	5.60***
13. Place attachment									−.02	−.78	−.02	−.79
14. Place attachment × personal exp.											−.01	−.28
R^2	.08		.14		.43		.56		.56		.56	
Adj R^2	.07		.13		.42		.55		.55		.55	
ΔF	13.24***		10.95***		153.86***		84.21***		.61		.08	
n = 610												

[a] We also tested political affiliation as an ordinal predictor (Republican–Independent–Democrat) within the regression analysis. It did not change the results: Both experience variables remained statistically significant, and the overall amount of model explained variance did not substantially change.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

statistical significance – .01 in Model 3 and .03 in subsequent models.

That respondents' experiential beliefs about climate change added 13 percentage points in explained variance to respondents' local risk perceptions – on top of the variance explained by demographics, political affiliation, and cultural policy outcome beliefs – suggests that perceptions of having experienced global warming are not entirely socially constructed. This interpretation is consistent with both the results of our Study III which indicates that residents' experiential perceptions may be reflective, at least in part, of physical signals in the environment, and with the findings of Goebbert et al. (2012), who showed that perceptions of environmental changes were influenced by physical conditions as well as demographics, political ideology, and cultural worldviews.

Research that uses the cultural cognition scales in conjunction with experiential perception and physical climate change variables is needed to further unpack the role that these variables play in perceptions of local climate change risks.

8. Conclusion

Weather and climate play a vital role in individuals' perceptions and interpretations of the world they live in. Climatic conditions – patterns of precipitation, temperature, humidity, atmospheric pressure and winds – inform individual and societal beliefs, narratives, and rituals (Strauss and Orlove, 2003; West and Vásquez-León, 2003). In turn, humans imbue this facet of the natural world with culturally constructed meaning. Public perceptions of local risks from global warming are ever more important as communities face decisions about how to best adapt to coming changes. This study demonstrates the important role that belief in personal experience of global warming, particularly in one's community, may play in influencing those risk perceptions, above and beyond the effects of political polarization and cultural issue frames.

Most respondents in this study did not believe they had personally experienced global warming, or did not know if they had or had not. Less than 6% reported that they strongly agreed they had personally experienced global warming. Another 21% were inclined to believe that they had personally experienced global warming, but were less sure. This may reflect the difficulty of detecting and attributing trends within normal random weather variability to which numerous authors have pointed (Marx et al., 2007; Moser and Dilling, 2011; Weber, 2010; Weber and Stern, 2011).

Those respondents who reported believing that they had experienced global warming frequently described the changes in terms of weather, but they were also apt to point out changes that may reflect manifestations of long-term climatic impacts less subject to daily variability, and thus inaccurate interpretations. Changes in seasons – the most frequently mentioned effect attributed to global warming – have direct implications for widely experienced annual events, such as tree blooming periods, species migrations and planting gardens. The appearance of new species, or disappearance of familiar ones – also one of the five most likely forms of global warming experience – may be indications that species' habitats are shifting north (National Park Service, 2007).

Recent data records confirmed evidence of the types of changes that respondents most frequently mentioned: first and last frost dates had moved both later and earlier in the year, making for shorter winters within recent years; storm events increased in the past four years compared to the mean; and lake levels were below the mean. Alternately, county residents' beliefs that global warming had resulted in less snow did not appear to be supported by either literature on lake effect snow, or recent data, potentially lending support for recency biases in interpretation of maximum snow depths, or effects from cultural beliefs about expected manifestations of global warming (e.g., less snow in winter).

Finally, in the final piece to the study, we explained more than half the variance in local risk perceptions with a final regression model that included both belief in personal experience of global warming, and having experienced it within the county. This indicates that belief in personal experience of global warming accounts for distinct variance in people's risk perception that cannot be fully explained by their demographics, political party affiliation, or surrogate measures for cultural worldviews. Tantalizingly, this could be an indication that a small percentage of the general public are able to tap into aspects of direct experience of global warming that influence their local perceptions of climate change risk, apart from their political and cultural identities. Further research is needed, but if this finding is robust, it could mean that experientially processed information about global warming impacts might play an effective role in engaging audiences even against a backdrop of extreme political polarization, or "collective irrationality" (Kahan et al., 2011b).

Author contributions

K.A. planned and led the survey research, content analysis, secondary source data analysis and writing of the article. K.A. and E.W.M. conceptualized the article. D.F., A.C. and A.N. coded the open-ended survey responses. All contributed to the article.

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