

## Weather, Climate, and Worldviews: The Sources and Consequences of Public Perceptions of Changes in Local Weather Patterns\*

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### ABSTRACT

This paper analyzes the changes Americans perceive to be taking place in their local weather and tests a series of hypotheses about why they hold these perceptions. Using data from annual nationwide surveys of the American public taken from 2008 to 2011, coupled with geographically specific measures of temperature and precipitation changes over that same period, the authors evaluate the relationship between *perceptions* of weather changes and *actual* changes in local weather. In addition, the survey data include measures of individual-level characteristics (age, education level, gender, and income) as well as cultural worldview and political ideology. Rival hypotheses about the origins of Americans' perceptions of weather change are tested, and it is found that actual weather changes are less predictive of perceived changes in local temperatures, but better predictors of perceived flooding and droughts. Cultural biases and political ideology also shape perceptions of changes in local weather. Overall, the analysis herein indicates that beliefs about changes in local temperatures have been more heavily politicized than is true for beliefs about local precipitation patterns. Therefore, risk communications linking changes in local patterns of precipitation to broader changes in the climate are more likely to penetrate identity-protective cognitions about climate.

### 1. Introduction

In nations that rely on representative political systems, policies intended to address climate change will ultimately depend on sustained public support. By design, representative political systems punish politicians for taking costly actions that are not high priorities for their constituents, making it very difficult to align the legislative and bureaucratic processes necessary for effective policy change (Sabatier and Jenkins-Smith 1993; Jones and Baumgartner 2004). Efforts to address climate change through

reductions in greenhouse gas emissions and adaptation efforts provide a challenging case for garnering and retaining public support because the science is complex and subject to political controversy, and because efforts to mitigate the effects or adapt to the impending changes may prove to be quite costly. How then might members of the public come to perceive climate change as a pressing issue requiring potentially costly policy responses?

Evidence has accumulated that people draw inferences about changes taking place in the broader climate from perceived changes in their own local weather patterns. While weather can be experienced, climate is a statistical construct (consisting of trends and averages) that individuals can observe only indirectly. Unusually hot summers and milder winters, prolonged periods of drought, or unusually frequent flooding appear to provide local weather "signals" to members of the public that the broader climate is changing (Spence et al. 2011; Leiserowitz et al. 2012; Egan and Mullin 2010; Hamilton and Keim 2009; Shwom et al. 2008). Unusual cold snaps, prolonged winters, and cooler summers appear

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to serve as signals to some individuals that predictions of “global warming” may be wrong (Schwartz 2012).<sup>1</sup> Thus, perceptions of local weather might be of substantial consequence for public views on climate change.

How, then, do perceptions of local weather patterns come to be? The obvious answer would seem to be that people experience the weather as a prominent feature of their everyday lives. By this account, individual’s *perceptions* of local weather patterns would be based on their experiences of actual weather in their local communities (Spence et al. 2011). On the other hand, human perceptions are notoriously prone to selective attention and biased assimilation of information (Kahneman and Tversky 1982; Lord et al. 1979; Gilovich et al. 2002; Weber 2006; Slovic 2010; Weber and Stern 2011), so it is plausible that other factors—such as individual-level characteristics, political and cultural orientations, or more general concerns about the environment—explain significant fractions of the variation in perceptions of weather patterns (Weber 1997). Indeed, recent research has begun to uncover the ways in which value orientations and cognition interact to shape the ways in which people comprehend the world around them (Douglas 1994; Kahan et al. 2007, 2011). The relative weight given to these factors by members of the public in shaping perceptions of local weather is very likely to influence support for policies designed to address climate change.

In this paper we address the question of what kinds of changes members of the American public perceive to be taking place in their local weather, and test a series of hypotheses concerning why they hold these perceptions. Using a combined dataset consisting of over 7000 interviews from annual nationwide surveys of Internet and telephone samples of the American public spanning the period from 2008 to 2011, coupled with geographically specific measures of temperature and precipitation changes over that same period, we are able to evaluate the relationship between *perceptions* of weather changes and *actual* changes in local weather. In addition, the survey data includes measures of demographic characteristics (age, education level, gender, income) as well as cultural worldview and political ideology. Thus, the data permit us to test rival hypotheses about the origins of Americans’ perceptions of weather change.

In the next section we consider several prominent explanations for variations in perceived local temperature changes. We explicitly contrast the expected effects

of deviations in actual temperatures and precipitation from long-term norms with those derived from cultural and political orientations. Next we describe the data used in our analysis, and use ordinal logit models to test our hypotheses about how Americans arrive at their perceptions of local weather changes. In the final section we discuss the implications of our findings for the evolution of public perceptions of changing weather patterns, and for public willingness to support policies designed to address climate change.

## 2. Perceptions of local weather

A range of studies have indicated that local weather patterns influence peoples’ views about climate change (Joireman et al. 2010; Egan and Mullin 2010; Hamilton and Keim 2009; Li et al. 2011; Schwartz 2012). Survey respondents in areas of warmer than average temperatures were more likely to believe, after controlling for demographics, partisanship, and ideology, that there is “solid evidence” that the average temperature on earth has been getting warmer (Egan and Mullin 2010). In areas that depend on winter weather for recreation and tourism (New Hampshire, western Maine, and Colorado) warmer winters were linked to an increase in public concern regarding global warming (Hamilton and Keim 2009). Relatively cool temperatures in parts of the United States in 2009 were connected to the recent drop in the percentage of Americans who believe that global temperatures are rising (Schwartz 2012). While these research findings link deviations in weather patterns to views on climate change, only recently has research begun to focus directly on how local weather is perceived (Li et al. 2011; Spence et al. 2011; Leiserowitz et al. 2012). This is important because perceptions of changes in patterns of local weather may diverge significantly from actual changes in weather patterns, and because perceptions of local weather may be more influential than actual weather in the formation of opinion about climate change. The relative importance of perceptions is indicated in research on local vulnerabilities to climate variation; the influence of perceived vulnerability to the effects of climate change has been found to exceed that of actual vulnerability in shaping perceptions of the threats posed by the changing climate (Zahran et al. 2006; Brody et al. 2008). Given the paucity of empirical research on the origins of weather perceptions, and the evidence regarding the importance of perceptions in shaping the perceived risks of climate change, in this analysis we focus directly on perceptions of local weather.

Weather is, of course, more than temperature, yet scholars have thus far focused on the effects of variations in local temperatures on beliefs about climate

<sup>1</sup> For example, Rush Limbaugh’s lectures (as can be seen in many YouTube clips) on what he refers to as the climate change “hoax” and “fraud” often prominently feature unexpectedly cold weather events.

change (Egan and Mullin 2010; Joireman et al. 2010; Li et al. 2011; Schwartz 2012). This is as one would expect, because temperature has been directly referenced in the widely used descriptor “global warming” and is highlighted in the now-famous “hockey-stick” graph of rising global average temperatures (as prominently displayed in Al Gore’s film *An Inconvenient Truth*). But other dimensions of weather—notably patterns of precipitation that result in droughts and floods—are of great importance in characterizations of climate change and may also act as potent signals to individuals about larger trends in climate. Therefore a multidimensional characterization of weather—including those related to changes in precipitation as well as temperature—would seem to be necessary to adequately characterize the implications of perceptions of local weather. Our approach is to measure the manner in which Americans perceive changes in the incidence of floods and drought, as well as temperature, in their local areas.

How then might people come to perceive changes in their local weather patterns? The seemingly obvious answer is that they use their senses, perhaps augmented by attention to local weather reporting (Bray and Shackley 2004). By that account we would expect to see a positive correlation between recorded and perceived changes in local temperatures and precipitation patterns.

A second category of explanations rests on the individual-level characteristics of those perceiving the weather. It is reasonable to conjecture that education levels, age, and perhaps even gender are associated with perceptions of weather (Finucane et al. 2000). Educational achievement might be associated with variations in the acquisition and interpretation of data, with higher levels providing the kind of weather “numeracy” that facilitates understanding of average changes (see, e.g., Handmer and Proudley 2007); age might reasonably be expected to add experience and historical perspective; and gender may be associated with differential exposure of respondents to weather conditions.

A third set of explanations for perceptions of local weather is broadly cultural and political in nature. Issues that have a bearing on deeply held societal norms and consequential public policies might become entangled with preferences about the role of government in society. The assertion that the climate is changing as a result of human activities, and that addressing it will require a substantial intervention by governments into the otherwise private affairs of individuals and businesses, will have a substantial ideological valence (Rothman and Lichter 1987; Douglas and Wildavsky 1982; Leiserowitz 2005). A large body of research has confirmed that political ideology plays a substantial role in shaping perceptions of climate change, with conservatives (and,

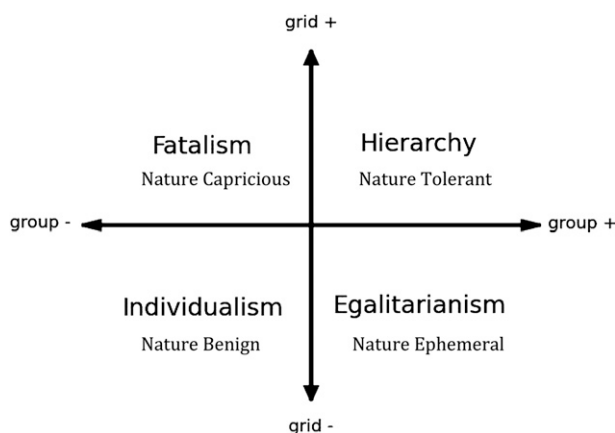


FIG. 1. Grid/group cultural types and associated myths of nature.

more recently, the “Tea Party”) tending to perceive climate to be stable and benign, and therefore requiring little or no government intervention (Leiserowitz et al. 2011; McCright and Dunlap 2011; Weber and Stern 2011; Krosnick et al. 2006; Dietz et al. 2007; Dunlap and McCright 2008). Beyond ideology, cultural worldview has been found to play a consistent and predictable role in determining perceptions of climate change (Kahan et al. 2011). Our interest is in whether these kinds of relationships hold with respect to perceived local weather.

### 3. Cultural theory and myths of nature

Among the promising approaches for understanding and predicting perceptions of risks are those evolving from anthropologist Mary Douglas’ “grid-group” cultural theory (Douglas 1986; Douglas and Wildavsky 1982), although the specification of the theory has significant variants [e.g., note the diversity of approaches taken in Dake (1991), Wildavsky and Dake (1990), Rayner (1992), Adams (1995), Kahan et al. (2010), and Ripberger et al. (2011)]. Cultural theory generally posits that people can be usefully classified according to two dimensions of sociality. “Group” is defined as the degree to which people define themselves as members of social groupings and the degree to which “the individual’s life is absorbed in and sustained by group membership” (Douglas and Wildavsky 1982, p. 206). The “grid” dimension taps the degree to which individuals perceive their lives to be circumscribed by externally imposed rules and prescriptions. Grid is “an explicit set of institutionalized classifications [that] keeps [individuals] apart and regulates their interactions” (Douglas and Wildavsky 1982, p. 192). When the grid and group dimensions are overlaid, they produce a matrix of four primary or “ideal” cultural types: Hierarchs,

Individualists, Egalitarians, and Fatalists (Thompson et al. 1990). These are illustrated in Fig. 1.

Individualists have low group identity and feel bounded by few structural prescriptions. They prefer a society with few rules and regulations, and feel little obligation to define themselves in terms of group memberships. Individualists value personal liberties, and presumably would be reluctant to embrace personal and business restrictions in exchange for addressing purported threats of climate change (Kahan et al. 2011).

In contrast, Hierarchs are characterized by high group identity and perceive themselves to be subject to binding social prescriptions. They place substantial weight on the welfare of the group, tend to be aware of whether others are members of the group are outsiders, and place great value on procedures, lines of authority, social stability, and order. Hierarchs are generally trusting of those in authority within their group, and to have faith in technologies that are vetted by authorized by experts. They are also inclined to distrust social and political “adventures” that depart from traditionally sanctioned social structures and lines of authority.

Egalitarians, by contrast, have strong group identities but prefer equality of status within the group. Egalitarians reject concentration of power and wealth, and tend to distrust experts representing those in positions of authority. The potentially hazardous byproducts of industrial technologies (such as greenhouse gas emissions) generated by profit-seeking private businesses are seen to pose particularly high risks.

Fatalists are the least “active” cultural type. They consider themselves subject to binding external constraints, yet they feel excluded from membership in important social groups. Believing that they have little control over their lives, they view their fate to be more a matter of chance than choice. Because they are less inclined to actively engage in social processes such as political action, we did not include measures of fatalists in this analysis.

Based on the grid/group combinations, cultural theory posits four distinct “myths of nature”<sup>2</sup> that are consistent with the biases inherent in the four ways of life as noted in Fig. 1 (Grendstad and Selle 2000; Thompson et al. 1990). The individualists’ myth of “nature benign” holds that nature is robust, resilient, and therefore largely impervious to human actions. The nature benign myth thus supports

individualists’ preference for few restrictions on their entrepreneurial way of life. In contrast, the egalitarians’ “nature ephemeral” myth holds that nature is fragile, and that great care and caution are required to maintain the natural equilibrium. Human actions that threaten that equilibrium—such as environmental pollutants produced by profit-seeking firms—pose substantial dangers to everyone, and are thus seen as justifiably restricted for the good of all.

The hierarchs’ “nature tolerant” myth occupies a middle ground between nature benign and nature ephemeral. According to this myth, nature is generally tolerant of well-regulated human actions, but excessive human intrusion can have large and disastrous consequences for the natural world. Therefore hierarchs tend to pay close attention to the cautions raised by the experts sanctioned by their group, and heed the regulatory restrictions on intrusions into nature imposed by legitimate authorities. Finally, the fatalists’ “nature capricious” myth holds that both nature’s beneficence and disasters occur largely at random, and human behavior is largely irrelevant.

Cultural theory has been shown to be a reliable predictor of environmental attitudes (Ellis and Thompson 1997), and more specifically of attitudes concerning global climate change (Pendergraft 1998; Kahan et al. 2011). In addition, a number of studies have linked views on climate change to the myths of nature associated with grid/group cultural theory (Douglas et al. 2003; Verweij et al. 2006). Therefore, to the extent that perceptions of variations in key dimensions of local weather (temperatures, floods, droughts) have become connected to perceived environmental risks and to climate change in particular, we hypothesize that cultural dispositions will have a significant bearing on the degree to which patterns of local weather are seen as benign (holding steady) and prompting little concern, or potentially threatening (changing) and cause for concern. Specifically, we expect egalitarians to disproportionately perceive potentially threatening weather anomalies to be rising, and individualists to tend to see weather patterns as holding steady. Hierarchs, who depend on sanctioned authority, are more likely to be conflicted, given the polarized nature of the broader public discussion of climate change. Building on these theoretical foundations, we specify and test a set of hypotheses about local weather perceptions based on grid/group cultural theory.

#### 4. Data and methods

The objective of this study is to assess Americans’ perspectives on weather changes over the past several years. We employ survey data collected in two different modes: 1) online survey interviews with independent cross sections of the American public taken in 2008

<sup>2</sup> The characterization of these views of nature as “myths” underscores the point that the perspective of each cultural type represents a *partial* vision of reality. The concordant myth is generalized among those who share a cultural type because that vision is consistent with the biases of that cultural type.

( $n = 1767$ ), 2009 ( $n = 1698$ ), 2010 ( $n = 1890$ ), and 2011 ( $n = 2004$ ) combined with 2) a nationwide telephone survey conducted in 2008 ( $n = 608$ ). The survey data included zip code measures for each respondent, which allowed us to add measurements of geographically defined departures from long-term (30 yr) temperatures and precipitation for each respondent. The Internet and telephone platforms provide a regional and demographic cross section of the adult population (ages 18 and over) of the United States.<sup>3</sup> The companion 2008 telephone survey employed a random-digit dialing protocol and obtained a cooperation rate of 60.7%. The Internet surveys, implemented in all years, utilized the SurveySpot panel maintained by Survey Sampling, Inc. of Fairfield, CT.<sup>4</sup> The Internet surveys were fielded in May and/or June of each year, and the 2008 phone survey was fielded in March–June 2008. The survey questions and ordering were nearly identical in each of the surveys, and the results obtained in the online and companion phone versions were consistent.<sup>5</sup> The consistent results across modes found in our surveys replicate the findings in other multimode surveys (Li et al. 2004; Berrens et al. 2003). For purposes of the analysis shown here, the data were combined into a single survey dataset consisting of a total of 7968 responses.<sup>6</sup> Because our interest in this analysis is in modeling associations among the variables,

<sup>3</sup> The comparisons of the respondent characteristics with Census data for the appropriate years showed the samples to provide very close approximations of gender, age, and regional distributions of the U.S. population. See the supplemental material for a detailed comparison of Census and sample characteristics.

<sup>4</sup> SSI's SurveySpot members are recruited exclusively using permission-based techniques. Unsolicited e-mail is not employed. The membership of SurveySpot is continuously changing, but at the time of our samples it consisted of approximately two million households with about five million household members. Only one member in each household can participate in the SurveySpot panel. SSI maintains a subpanel of approximately 400 000 members whose demographics are roughly proportioned to national census characteristics. Our sample was randomly drawn from the 400 000 census balanced subpanel. The cooperation rate for the 2011 survey, based on the proportion of respondents who initially accessed the survey that completed the survey, was 55.93%.

<sup>5</sup> Phone surveys were implemented in 2008 ( $n = 608$ ), 2010 ( $n = 529$ ), and 2011 ( $n = 593$ ), although only the 2008 telephone survey included the full list of questions employed in this analysis. The phone surveys in 2010 and 2011 included only a subset of the survey questions, and were designed to permit us to track the consistency of the Internet and telephone survey results on key questionnaire items over time. See the supplemental material for more information on the surveys.

<sup>6</sup> We included dummy variables representing the survey mode in all of our models to determine whether the estimates based on the telephone data differed significantly from those based on the online data. In no cases were the results statistically significant. These model results can be obtained from the authors upon request.

TABLE 1. Perceptions of local weather changes: 2008–11.

Weather	Increased	Stayed the same	Decreased
Temperature	47.6%	38.8%	13.6%
Droughts	36.6%	46.0%	17.4%
Floods	31.7%	51.1%	17.2%

rather than inferring population means from the sample data, our models were run using unweighted data. For more details on the data collection methods, questionnaire,<sup>7</sup> samples, and data, see the supplemental material (available online at <http://dx.doi.org/10.1175/WCAS-D-11-00044.s1>).

## 5. Perceptions of weather change

To measure the respondents' perceptions of local weather changes, we asked the following three questions:

Temperature: In your personal experience, over the past few years have average temperatures where you live been rising, falling, or staying about the same as previous years?

Drought: In your personal experience, over the past few years has drought where you live been more frequent, less frequent, or stayed about the same as previous years?

Floods: In your personal experience, over the past few years has flooding where you live been more frequent, less frequent, or stayed about the same as previous years?

For purposes of this analysis, responses were recoded with a value of  $-1$  (falling),  $0$  (staying the same), or  $+1$  (rising). Table 1 shows the pattern of responses for each weather type.

As evident in Table 1, nearly half of the respondents over 2008–11 perceived local temperatures to have risen over the past few years. A plurality of respondents (46%) indicated that drought conditions had stayed about the same in recent years, while a slight majority (51.1%) saw the frequency of floods as having remained unchanged.

<sup>7</sup> Because the questionnaire included items on climate change as well as weather perceptions, the 2011 version of the survey used an experimental design to test for possible "priming" effects of question order. The results of the experiment found no substantively or statistically significant priming effects. Details of the experimental results are included in the supplemental materials.



TABLE 2. Cultural orientation scale question wording. Indicator variables are in bold.

Cultural orientation	Question wording response scale: 1 = Strongly disagree to 7 = Strongly agree	Scale alpha
Egalitarian	<b>egal1</b> What society needs is a fairness revolution to make the distribution of goods more equal. <b>egal2</b> Society works best if power is shared equally. <b>egal3</b> It is our responsibility to reduce differences in income between the rich and the poor.	0.77
Hierarchist	<b>hier1</b> The best way to get ahead in life is to work hard to do what you are told to do. <b>hier2</b> Society is in trouble because people do not obey those in authority. <b>hier3</b> Society would be much better off if we imposed strict and swift punishment on those who break the rules.	0.67
Individualist	<b>indiv1</b> Even if some people are at a disadvantage, it is best for society to let people succeed or fail on their own. <b>indiv2</b> Even the disadvantaged should have to make their own way in the world. <b>indiv3</b> We are all better off when we compete as individuals.	0.70

To match local weather changes to the locations of the survey respondents, all respondents were asked for the zip code of their primary residences. Next, to identify local departures from longer-term average temperature and precipitation at the time of the surveys, the National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) reanalysis (Kalnay et al. 1996) and Palmer Drought Severity Index (PDSI; Palmer 1965) data were used as proxy variables for local temperature and precipitation patterns, respectively. (For a description of the PDSI, see <http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/palmer.html#drought>.) Respondents' zip codes were linked to latitude and longitude pairs through 2010 Census Gazetteer files (available online from <http://www.census.gov/geo/www/gazetteer/places2k.html>) and then to the local temperature and precipitation data at the date of the interview for each zip code region.<sup>8</sup>

To match the survey question wording regarding perceived temperatures to the recorded temperatures near respondents' residences, we adopted the following method.<sup>9</sup> First, to approximate the survey language of weather conditions over "the past few years," we calculated the average temperature within each zip code region over the 3-yr period preceding the date at which

each survey was conducted. Second, to approximate the question wording comparing recent temperature to "previous years," we calculated the 30-yr average temperatures for each zip code region preceding the date at which the survey was collected. Third, the departures of temperatures in the past few years (prior 3-yr average) from those in previous years (prior 30-yr average) were calculated for each respondent based on their zip code and survey date. By this method, positive values reflect recent (3-yr average) temperatures that are warmer than the average for previous years (the 30-yr average) for the zip code region and date for each survey.

A similar procedure was used to calculate departures of precipitation in the past few years from those in previous years. The PDSI values for each zip code were used as a proxy for the incidence of floods and drought conditions at the time of the survey implementation.<sup>10</sup> Survey respondents within zip code regions with an average PDSI for the three years preceding the survey that falls below the average for the previous 30 years are assumed to have had an increased likelihood of drought conditions at the time the survey was conducted. Respondents in zip code regions in which the average PDSI values over the previous three years exceeded the 30-yr average are assumed to have experienced a higher likelihood of flooding.

<sup>8</sup> The zip code tabulation area (ZCTA) file was used to link zip codes with the latitude/longitude location of each respondent. The NCEP–NCAR reanalysis data are stored on a 2.5° latitude × 2.5° longitude grid and the PDSI data are stored by climate division. The ground validation used for each respondent corresponds to the closest great arc distance calculated between the reanalysis grid point/center point of the climate division to the respondents' latitude/longitude location.

<sup>9</sup> While a more precise question wording would have been preferable, the terminology generally matches the 3-yr to longer-term comparisons that are implicit in the reanalysis and PDSI data.

<sup>10</sup> We recognize that the PSDI is an imperfect indicator of local flood conditions, inasmuch as the measure was developed as a drought indicator. However, in periods of long-term above normal moisture (identified by positive values of departures in the 3-yr average from the 30-yr average PDSI), flooding is more likely. Therefore, we use negative values of the PSDI departure as a proxy for times and regions with more frequent drought conditions, and positive values as a surrogate to identify times and regions in which flooding would have been more frequent.

To capture political and cultural orientations, the surveys included measures of political ideology (a seven-point scale ranging from strong liberal to strong conservative) and indicators of egalitarian, hierarchist, and individualist cultural orientations. Our measurement approach is similar to that used in Dake (1991) and Ripberger et al. (2011). The wording of these questions is shown in Table 2, and more extensive discussion of the survey questionnaire is included in the supplemental materials. All of the cultural orientation measures were indices based on three indicators for the cultural type, and each achieved a scale alpha within acceptable ranges. The surveys also included measures of respondent demographics (age, gender, race/ethnicity, education level, and income).

## 6. Modeling perceptions of local weather

We tested a set of hypotheses concerning the sources of perceived changes in local weather, including deviations in local temperatures and precipitation from long-term means, individual-level demographic attributes, political ideology, and cultural worldview. Each of these hypotheses was tested using an ordinal logit model, coupled with model comparisons focused on the significance and explanatory power of each set of explanatory variables. The dependent variable in each of our models is the respondent's perception of local weather change, with a value of  $-1$  indicating temperature/droughts/floods have decreased,  $0$  indicating they stayed the same, and  $1$  indicating that they had increased.

The independent variables are introduced in a sequence of three steps. First, we introduce the measures of recorded local weather change. Second, we add the individual-level characteristics, testing for relationships between perceived local weather changes and age, gender, education level, and household income (a proxy for socioeconomic status).<sup>11</sup> Finally, we include the measures of political ideology and culture. The sequential inclusion of variables is intended to make evident the possible colinearity among the competing explanations, and to show the contribution of the addition of each set of explanatory variables to model fit.<sup>12</sup>

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<sup>11</sup> While we could derive competing conjectures about the directions of these effects, we use them here chiefly as control variables. We would have preferred to have been able to include a measure of the number of years the respondent had lived within their resident zip code in order to account for differences in experience and familiarity with local weather patterns. Unfortunately the survey questionnaires did not include such a measure.

<sup>12</sup> A correlation matrix of all of the independent variables is included in the supplementary materials.

For the temperature change models, we hypothesize a positive and significant relationship between local temperature deviations and respondents' perceptions of temperature change. We also hypothesize that more conservative respondents will be less likely to have perceived temperatures as rising in recent years. We expect that respondents with higher individualist scores will be less likely to perceive temperatures as having risen, and those with higher egalitarian scores will be more likely to see temperatures as having risen. We have no prior expectation concerning respondents with hierarch leanings.<sup>13</sup>

We employ a similar modeling structure for drought and flood perception. For the drought perception models we expect a negative and significant relationship between deviations on the PDSI and perceptions of drought, because an increasing negative deviation on the Palmer index indicates increasingly dry soil conditions. For the flood models we expect the reverse; a positive and significant relationship between PDSI deviations and flood perceptions, since increasingly positive deviations imply greater precipitation and soil moisture. In terms of our other explanatory variables, our expectations match those of the temperature models; we conjecture that as respondents become increasingly conservative they will be less likely to perceive droughts and/or floods to be increasing. In terms of cultural bias, we expect that respondents who score higher on the individualist scale to be less likely to perceive droughts and/or floods as increasing, whereas those with a higher score on the egalitarian scale to be more likely to perceive drought and/or floods as increasing.

The results of the perceived temperature models are shown in Table 3. The second column contains the estimated ordinal logit model coefficient for the departures of recent recorded local temperatures from the 30-yr average; the third column includes the individual-level attributes; and the fourth adds the ideology and culture variables. Indicators of statistical significance and model fit for each sequential stage of the model are also included.

As shown in column 2 of Table 3, the recorded departures of the 3-yr average temperatures from the 30-yr average are nominally positive, but significant only at the 0.1 level. Adding the individual-level demographic variables substantially improves prediction, as indicated by the declining Bayesian information

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<sup>13</sup> We also controlled for the year in which the survey was administered by inserting separate dummy variables for each year. There was no substantive effect on any of the variables of interest, so the year variables were omitted from the final model.

TABLE 3. Ordered logistic regression models of perceived change in local temperatures. Standard errors are in parentheses.

	Weather model	Demographics	Ideology/culture
Actual temp (3 yr – 30 yr)	0.148 <sup>a</sup> (0.077)	0.153 <sup>a</sup> (0.079)	0.052 (0.081)
Age		–0.007 <sup>d</sup> (0.002)	–0.001 (0.002)
Gender (male = 1)		–0.182 <sup>d</sup> (0.050)	–0.076 (0.051)
Race (white = 1)		–0.074 <sup>b</sup> (0.042)	–0.008 (0.043)
Education level		0.072 <sup>d</sup> (0.021)	0.069 <sup>c</sup> (0.021)
Income (10-K units)		–0.024 <sup>d</sup> (0.006)	–0.007 (0.007)
Ideology (1–7 scale)			–0.173 <sup>d</sup> (0.018)
Egalitarian (1–7 scale)			0.194 <sup>d</sup> (0.019)
Hierarch (1–7 scale)			0.036 (0.022)
Individualist (1–7 scale)			–0.103 <sup>d</sup> (0.021)
BIC	12 691.53	11 951.01	11 407.19
Pseudo $R^2$	0.002	0.012	0.207
$N$	6385	6019	5917

<sup>a</sup> Significant at  $p < 0.10$ .<sup>b</sup>  $p < 0.05$ .<sup>c</sup>  $p < 0.01$ .<sup>d</sup>  $p < 0.001$ .

criterion (BIC)<sup>14</sup> and the increased pseudo  $R^2$ ; males, older respondents, and those with higher incomes appear to be significantly *less* likely to perceive temperatures to have risen, while those with higher education levels are more likely to perceive local temperatures to be above long-term normal.

Addition of the ideological and cultural variables to the model (as shown in column 4) results in a significant improvement in model fit, with the BIC declining from 11 890.69 to 11 320.27 and the pseudo  $R^2$  increasing from 0.012 to 0.207. As expected, the estimated coefficient for political conservatism is negative and statistically significantly related to temperature perceptions. The cultural worldview variables also performed as expected. On average, as respondents' egalitarian score increased so did the likelihood that the respondent perceived recent temperatures to be above long-term

TABLE 4. Ordered logistic regression models of perceived change in local drought. Standard errors are in parentheses.

	Weather model	Demographics	Ideology/culture
Palmer Index (3 yr – 30 yr)	–0.290** (0.017)	–0.291** (0.017)	–0.305** (0.017)
Age		–0.001 (0.002)	0.004* (0.002)
Gender (male = 1)		–0.118* (0.050)	–0.056 (0.051)
Race (white = 1)		–0.036 (0.041)	–0.001 (0.042)
Education level		0.051* (0.021)	0.042* (0.021)
Income (10-K units)		–0.003 (0.006)	0.007 (0.007)
Ideology (1–7 scale)			–0.108** (0.018)
Egalitarian (1–7 scale)			0.091** (0.019)
Hierarch (1–7 scale)			0.031 (0.022)
Individualist (1–7 scale)			–0.093** (0.021)
BIC	12 485.12	11 822.42	1157.53
Pseudo $R^2$	0.112	0.214	0.262
$N$	6242	5886	5789

\*  $p < 0.05$ .\*\*  $p < 0.001$ .

normal. Individualist scores had the opposite effect; a higher individualist score decreased the likelihood of perceiving recent temperature to have been higher than long-term normal. The hierarch score was not significantly related to perceived temperatures. In addition, note that the inclusion of the political ideology and culture variables caused the estimated coefficients for temperature departures and the demographic attribute measures to diminish in magnitude and (in most cases) lose statistical significance. Education level remained statistically significant, and was positively related to perceptions that local temperatures had risen in recent years.

Next we turn to the models of drought perceptions, as shown in Table 4.

Deviations in the PDSI are significantly related to perceptions of drought. As expected the slope is negative, indicating that as drought severity increases (which is indicated by a negative score on the Palmer Index) the likelihood of perceived drought frequency also increases. When the demographic variables are added to the model, the PDSI deviations remain significant predictors of perceived incidence of drought. Males are less likely to perceive increased incidence of drought, whereas those with higher education are more likely to perceive more frequent droughts.

<sup>14</sup> We employ the BIC rather than the Akaike information criterion (AIC) because the former accounts for variation in sample size. Our models differ modestly in sample size because of item-missing data.



TABLE 5. Ordered logistic regression models of perceived change in local flooding. Standard errors are in parentheses.

	Weather model	Demographics	Ideology/ culture
Palmer Index (3 yr – 30 yr)	0.182 <sup>a</sup> (0.077)	0.230 <sup>c</sup> (0.017)	0.227 <sup>c</sup> (0.017)
Age		–0.007 <sup>c</sup> (0.002)	–0.005 <sup>b</sup> (0.002)
Gender (male = 1)		–0.188 <sup>c</sup> (0.050)	–0.156 <sup>b</sup> (0.051)
Race (white = 1)		–0.064 (0.042)	–0.039 (0.042)
Education level		0.067 <sup>b</sup> (0.021)	0.068 <sup>b</sup> (0.021)
Income (10-K units)		–0.000 (0.007)	–0.006 (0.007)
Ideology (1–7 scale)			–0.053 <sup>b</sup> (0.018)
Egalitarian (1–7 scale)			0.082 <sup>c</sup> (0.019)
Hierarch (1–7 scale)			0.049 <sup>a</sup> (0.022)
Individualist (1–7 scale)			–0.031 (0.021)
BIC	12 940.45	11 739.90	11 517.48
Pseudo $R^2$	0.085	0.194	0.232
$N$	6407	5900	5804

<sup>a</sup>  $p < 0.05$ <sup>b</sup>  $p < 0.01$ <sup>c</sup>  $p < 0.001 \pm$ 

When the ideology and cultural variables are added to the model, we again find that the deviations in the Palmer Index remain significant. The addition of the culture and ideology measures provides a modest improvement in model fit, as indicated by changes in the BIC and the pseudo  $R^2$ . Increasing scores on the conservatism and individualism measures are significantly related to perceiving drought to be less frequent. An increasing egalitarian score, on the other hand, is associated with the perception that local drought has increased in frequency.

Finally, we examine the flood perception models displayed in Table 5.

Similar to the drought models, the PDSI deviations are a significant predictor of flood perceptions, with positive departures on the Palmer Index associated with a greater likelihood of seeing flooding to have been more frequent in recent years. In the demographics model, respondents who are older and male are less likely, on average, to perceive flooding to be occurring more frequently in their area; those with more education perceived floods to be more frequent. When ideology and culture are added to the model, model fit again improves modestly. The coefficient for political conservatism is

negative and significant with regard to flood perceptions. Egalitarians tend to perceive floods to be occurring more frequently. Individualism scores, unlike those for the models temperature and drought models, are not statistically significant. The hierarch scores are positive and statistically significant.

## 7. Discussion

Of particular interest for this research is the role played by cultural dispositions, as characterized by grid/group theorists, in shaping perceptions of changes in local weather and—by implication—perceptions of climate change. Other scholars have found that political ideology and partisanship are consistent predictors of attitudes about climate change (Leiserowitz et al. 2011; McCright and Dunlap 2011; Krosnick et al. 2006; Dietz et al. 2007; Dunlap and McCright 2008). The analysis presented here assesses whether cultural dispositions, consistent with Mary Douglas' grid-group theory (Douglas and Wildavsky 1982), can substantively add to the explanation of public perceptions and understanding of ongoing changes in local weather. As described above, cultural dispositions are hypothesized to interact with cognition to shape the way that data are recognized and processed, acting to insulate individuals from the implications of recognizing circumstances that would (if acknowledged) undermine their preferred ways of life. The results of our analyses show that—alongside political ideology—cultural biases are predictive of perceived weather changes in the ways that cultural theorists would predict. But cultural dispositions do not affect perceptions of all three dimensions of local weather equally; the effects of the culture measures on perceived temperature changes are substantively larger than those for perceived changes in local flooding and drought. Equally interesting, the effect of actual weather changes in local areas is *least* potent in shaping perceptions of temperature changes; indeed, in the fully specified models the effect of recent departures from long-term temperature averages is both negligible and statistically insignificant, while the departure of the Palmer Index from long-term average is a consistent and potent predictor of perceived changes in local floods and drought. To illustrate these results, we converted the odds ratios of the temperature model to probabilities.<sup>15</sup> Specifically, we examine the predicted probability of perceiving

<sup>15</sup> To simplify the analysis, these results display the predicted probability of a logit model where perceptions of temperature increases are equal to 1 and stayed the same and decreased are equal to 0.

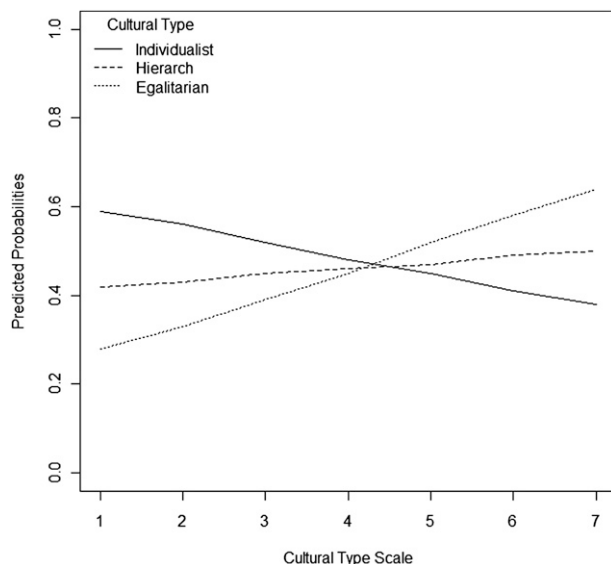


FIG. 2. Predicted probability of perceiving local temperatures as increasing by affinity to cultural type.

temperatures to have increased ( $Y = 1$ ) varying the scores of each cultural type from 1 to 7. All other variables in the model were held at their mean. Figure 2 shows the results.

As shown, those that score a 1 on the individualism scale obtained a predicted probability of perceiving local temperatures to be rising of 0.59, whereas a score of 7 resulted in a probability of 0.38. On the egalitarian

scale, a score of 1 and a score of 7 is associated with probabilities of perceiving local temperatures to be rising of 0.28 and 0.64, respectively. While the individualists and egalitarians took seemingly opposing viewpoints, hierarchs are largely in the middle on this issue, as evidenced by the relatively flat slope.

By contrast, Fig. 3 shows the effects of actual departures of dimensions of local weather from long-term averages on probabilities of perceiving local weather to have changed. As is evident in Fig. 3, temperature departures have little effect on perceptions of local temperature change, while deviations in precipitation and moisture have substantial effects on perceptions of flooding and droughts.

Our results indicate that while perceptions of temperature change may have become heavily implicated in cultural identity protection, perceptions of changes in flooding and drought are linked to culture much more loosely. Moreover, actual temperature deviations appear to have negligible effects on perceptions of temperature change, whereas changes in the conditions that lead to floods and drought have a direct and substantial bearing on perceived changes in these aspects of local weather.

Note that the nature of average temperatures, and the change in these averages over time, may make direct observation of these changes more complex and uncertain than is true for precipitation. In other words, one might conjecture that changes over time in patterns of heat and cold are less readily perceived than are changes in patterns of precipitation (or its absence). If so, this

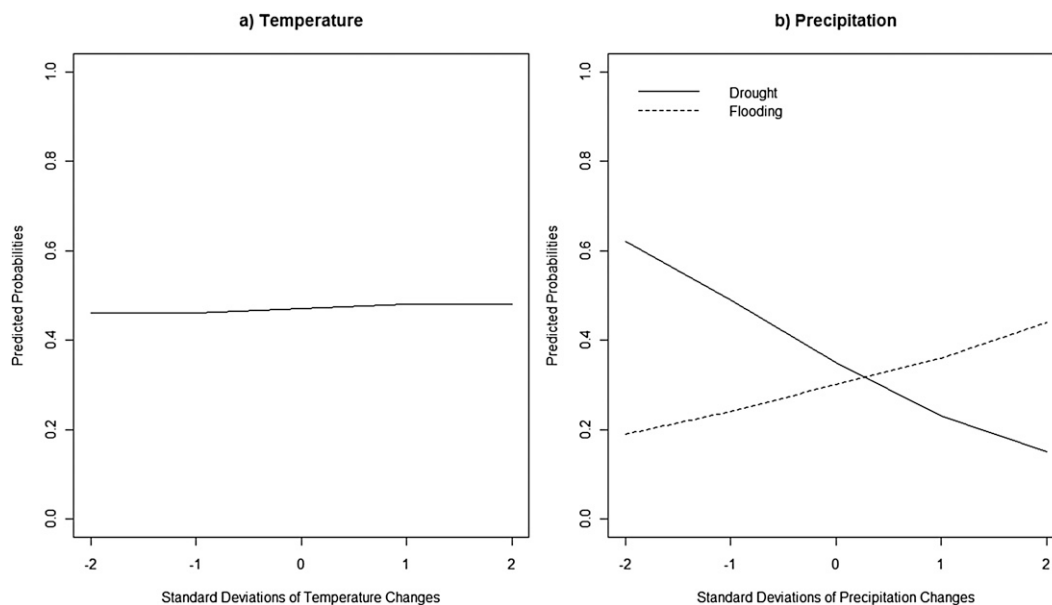


FIG. 3. Predicted probability of perceiving local temperature, drought and floods as increasing by departures from long-term averages.

might contribute to the relatively small (and insignificant) estimated coefficient for actual average temperature changes as a predictor of perceived changes, in comparison to those for average changes in the Palmer Index in the flood and drought models. For our purposes, however, the implications remain that actual temperature changes have less influence, and cultural disposition more, in shaping perceived temperature changes while actual changes in precipitation patterns have more influence, and cultural dispositions less, in shaping perceived flood and drought perceptions.

We caution that the wording of the questions employed for our dependent variables may have reduced model precision. Recall that the question wording concerning changes in local temperatures was as follows: “In your personal experience, over the past few years have average temperatures where you live been rising, falling, or staying about the same as previous years?” Similar wording was used for drought and flooding. By contrast, actual weather changes were captured more precisely: we measured the departure of the average temperature for the respondent’s location over the three years prior to the date of the interview from the long-term (30-yr) average for that location. It is reasonable to conjecture that survey respondents may have considered different time spans when evaluating change “over the past few years” and therefore the correspondence of perceived and actual temperature (and incidence of flooding and drought) may be underestimated in our models. And, to be sure, in future research we will test different question wording to assess this possibility. Nevertheless the central findings of this analysis are comparative: actual temperature changes are *less* predictive of our measures of perceived temperature changes than is true for the cases of floods and drought. And the estimated effects of the culture measures on perceived temperature changes were *greater* for perceived temperature changes than they were for perceived changes in flooding or drought. In short, while it is possible that our measures have resulted in an underestimate of the connection between perceived and actual temperature changes, the differences across temperature, drought, and flooding appear to us to be robust findings.

Our inquiry is motivated by the question of how public support is generated for complex, controversial, and potentially costly policies to address such problems as global climate change. We noted that, within modern representative political systems, substantial and persistent public support is necessary for sustained public policies of this kind. Based on prior research that has demonstrated local weather patterns to be an important ingredient of climate change attitudes, our research

focused on identification of those factors that influence perceptions of changes in local weather. Our primary contribution is to show that perceptions of changes in local weather patterns are themselves the result of a complex mix of direct observation, ideology, and cultural cognitions, and that the mix is markedly different across the distinct dimensions of local weather.

## 8. Conclusions

Where do Americans get their perceptions of local weather changes? Our findings suggest the contentious nature of the climate change debate has influenced the way in which Americans perceive their local weather. This effect is most evident in the temperature models, where actual temperature deviations proved to be a relatively weak predictor of perceptions of temperature change. Our conjecture is that temperature change has been made politically and culturally salient by the arguments about global warming. The implications for those who would increase public understanding of weather and its relationship to broader climate issues are substantial. Arguments over temperature are complex because the term “global warming” has been integrated into arguments over cultural identity and—perhaps—because the on-the-ground experience of temperature includes sufficient variation to readily permit social construction.

However, a somewhat more reassuring finding is that public perceptions of changes in flooding and drought are systematically and sensibly related to the recorded changes in precipitation and soil moisture taking place around them. Other factors—notably ideology and cultural orientation—significantly shape these perceptions as well and will undoubtedly continue to compete with weather and climate “facts” for primacy in shaping public opinion. Recall however that the estimated effect of recorded local moisture changes remained consistent and potent across all models of perceived drought and flooding. These results indicate that Americans’ perceptions of some dimensions of local weather are anchored more deeply in facts about the weather, but the influence of these facts competes with those of personal, ideological, cultural, and issue-oriented lenses. This is consistent with the literature on public opinion formation (see, e.g., Kahan and Braman 2003; Herron and Jenkins-Smith 2006; Kahan et al. 2011), and it suggests that public support for policies to address climate change will necessarily rely on an interactive mix of perceived facts and value-based cognitions (Kahan et al. 2012).

One aim of this study was to evaluate the implications of Douglas’ (1986, 1994) cultural theory for public

apprehension of weather. We found that cultural orientations based on grid/group distinctions are a strong and potent predictor of weather perceptions. Our results demonstrated, as theory would suggest, that individualists tied to the nature benign myth are less likely to see temperatures as having risen and less likely to see droughts as increasing. In contrast, egalitarians—who are more likely to see nature as fragile—saw temperatures as rising, and both droughts and floods as increasing. Hierarchs, whose myth of nature holds that nature is tolerant within bounds but less robust than the nature benign myth, and not as fragile as the nature ephemeral myth, occupied the space between the individualists and the egalitarians.

But the role of culture (and ideology) in shaping perceived weather changes appears to be substantially weaker for floods and droughts than it is for temperatures. One implication is that, in efforts to characterize the ongoing and predicted changes in local weather, focusing on temperature is more likely to raise the kinds of identity defenses that cultural orientations (and ideologies) can mount. On the other hand, focusing on changes in patterns of drought and flooding may well gain greater purchase and, by implication, contribute to a more nuanced understanding of larger pattern of changes in the global climate.

Substantial continuing work is required to more fully appreciate and understand geospatial patterns in perceived weather, including variations in the regional, urban/rural, and economic characteristics of the local areas in which the respondents reside. In addition to future research on geospatial patterns, continuing work should concentrate on changes in local weather perceptions over time and across seasons. It may prove to be the case that some aspects of weather, by virtue of the manner in which people directly experience them, are less susceptible to the kinds of social constructions that have become so familiar in the climate change debate. Finally, much more work is needed on the direction of causal influence between perceived local weather patterns and beliefs about climate change. As Weber (1997) has observed in her work on farmers' perceptions of weather, beliefs about climate change may be driving weather perceptions as much (or more than) the other way around. A greater understanding of the implications of future awareness of changing local weather patterns for attitudes about climate change will require that we improve understandings of the causal relationships involved. Indeed, that is one of the central foci in our research program and—we hope—of other social science teams concerned with the societal implications of weather and climate.

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