"Is global warming affecting the weather?" Evidence for increased attribution beliefs among coastal versus inland U.S. residents.

Increasingly, researchers studying public beliefs about global warming have turned to the question of whether individuals have begun to perceive changes to their local climate conditions and to what extent they attribute these changes to the phenomenon of global warming. Perceptions of particular types of extreme events, i.e., extreme heat and droughts, have attracted the most attention, whereas the possible effects of place (such as proximity to coastal areas vulnerable to sea level rise) on public beliefs about the link between changes to weather patterns and global warming have been largely neglected. This study matches geo-located responses to a nationally-representative survey of U.S. residents with climate extremes data in order to investigate the social and physical factors shaping public views about the links between global warming and extreme weather. Specifically, regional-level Climate Extremes Indices (CEI) are modeled together with individual-level socio-demographic characteristics and an indicator of coastal residence to test whether the incidence of extreme events and proximity to the coasts, net of social and economic factors, correspond to increased perceptions that global warming has affected the weather. Results indicate that coastal shoreline county residence significantly predicts individuals' beliefs about the extent to which global warming is affecting the weather.

Keywords: Climate change; risk perceptions; coastal communities; survey research; climate extremes

Word count: 8,910

Introduction

The 2014 National Climate Assessment found that “Human-induced climate change has already increased the number and strength of some of these extreme events,” and that “[o]ver the last 50 years, much of the United States has seen an increase in prolonged periods of excessively high temperatures, more heavy downpours, and in some regions, more severe droughts,” (Melillo et al. 2014). While the scientific consensus about the reality and human causes of global warming has been well documented (Cook et al. 2016), the increasing scientific evidence linking meteorological events with global warming, or attribution science – does not have a similar level of certainty associated with it in the scientific literature (Trenberth et al. 2015; Stott et al. 2016). Climate scientists generally favor an approach that emphasizes how anthropogenic climate change may be magnifying extreme weather events, and recent studies point to changes in large-scale thermodynamic environments (i.e., anomalous sea surface temperatures) as fueling extreme temperatures and atmospheric moisture associated with extreme weather events, such as the 2012 superstorm Hurricane Sandy and the 2013 Colorado floods (Trenberth et al. 2015). That said, extreme weather events are by definition infrequent and a single event is not replicable so the attribution of anthropogenic climate change to any single extreme event, or even any extreme event type, is generally only possible through simulation (Trenberth et al. 2015).

Since attribution science is still relatively new and public understanding of the difference between weather and climate is limited (Capstick and Pidgeon 2014), it is likely that most individuals interpret local trends in weather-related phenomena through their own social circumstances, relative exposures to events, and evaluative predispositions about environmental issues and hazards. Individuals living near the U.S. coasts in particular have been and may become increasingly more exposed to the adverse impacts of severe weather events than many inland residents, but the extent to which and why individuals in these highly vulnerable areas perceive (or do not perceive) these impacts has not been comprehensively studied. Past research, however, has found some evidence suggesting that proximity to the coasts in other countries is correlated with beliefs about global warming and support for policies to address it (Milfont et al. 2014; Zahran et al. 2006; Carlton and Jacobson 2013). For example, a recent study using a national probability sample of New Zealanders found that people living nearest to the shoreline "expressed greater belief that [global warming] is real and greater support for government regulation of carbon emissions," controlling for age, education, gender, political orientation, and wealth status (Milfont et al. 2014).

Although there have been local and regional studies examining the link between risk perceptions, beliefs and attitudes, and proximity to the coasts (e.g., Zahran et al. 2006; Carlton and Jacobson 2013), there has been a relative dearth of research efforts aimed at examining the influence of geographic proximity to the coasts on residents' perceptions of the link between global warming and weather on a national scale in the United States. This research aims to investigate whether and the extent to which beliefs about the link between global warming and weather emerge from place-specific contexts rather than simply corresponding to ideological or sociodemographic characteristics of individuals alone. Specifically, this study will test three interrelated hypotheses about the nature of individual-level environmental risk perception formation:

H1: Individual-level sociodemographic characteristics exert a direct influence on individuals' perceptions about the link between global warming and weather events. Specifically, younger, higher educated, lower income, non-white, and politically liberal individuals will be more likely to attribute global warming to changes in weather events. Additionally, those who are more worried about global warming will be more likely to attribute weather changes to the phenomenon.

H2: Climate extremes, as measured by regional climate extremes indices, exert a direct influence on individuals' perceptions of the link between global warming and weather events. Specifically, individuals residing in regions with greater climate extremes will be more likely to attribute changes in weather events to global warming.

H3: There is geographic variation in individual-level perceptions about the link between global warming and weather events. Specifically, individuals residing nearest to the coasts will be more likely to attribute changes in weather events to global warming.

Review of Literature

In *Environmental Sociology,* John Hannigan argues for "an approach to environment and society that pivots on the concept of *emergence*," (2014). Emergence in the social sciences is understood as the concept "...that social organization and the production of knowledge are fundamentally fluid, dynamic, and adaptive," and "...that they percolate from the grassroots rather than pass from the top downwards," (Hannigan 2014). This concept provides a useful framework for understanding human-environmental interactions by framing perceptions of climate- and weather-related events as emergent properties stemming from place-specific, social, economic and physical characteristics. Guagnano and Markee (1995, 137) proposed the useful notion that "...attitudes, values, and beliefs have historical and cultural roots, and these roots may be specific to different regions of the United States, each of which has its own unique cultural heritage and tradition." Others have conceptualized similar constructs to place-based emergence in the social sciences, such as Gieryn's (2000) argument for an understanding of social phenomena as "emplaced," or rooted in the social, economic, and cultural aspects of geographic locations.

As concept in sociological theory and practice, place has generally has been defined and utilized in terms of three mutually necessary characteristics: 1) geographic location; 2) physical or material forms; and 3) meaning and value (Gieryn 2000). Place is embedded in geographic space, associated with material culture and the built or natural environment, and imbued with socially constructed meanings and values. As it relates to environmental attitudes and perceptions, prior research has most often utilized place by investigating the influence of individuals' sense of place or place attachments (Stedman 2002; Scannell and Gifford 2010(a); Scannell and Gifford 2013). Many studies examining place attachment have found significant and positive associations between various dimensions place attachment (i.e., natural vs. civic/built environment attachments) and environmental concern and conservation behaviors (e.g., Vorkinn and Riese 2001; Brehm et al 2006; Gosling and Williams 2010; Scannell and Gifford 2010(b)), but other efforts to examine place attachments have also revealed that deeper, place-based meanings and values exert an even stronger influence over environmental concern than attachments to place alone (Brehm et al. 2011).

Individuals' perceptions of place have also been construed in terms of "sense of place," which has been defined as a "collection of symbolic meanings, attachment, and satisfaction with a spatial setting held by an individual or group," (Stedman 2002; Stedman 2003). Such sense of place attributes have been found to contribute to pro-environmental attitudes and behaviors (Jorgensen and Stedman 2006; Brown and Raymond 2007; Walker and Ryan 2008; Larson et al. 2013). Deep attachment to place can also be rooted in biophilia, i.e., the innate or learned attraction to habitation in healthy and abundant environments, and/or topophilia, i.e., value- and meaning-laden attachments of individuals and social groups to place, and these two senses of place can either reinforce or challenge one another, particularly when changes to landscape features or the built environment are under consideration, i.e., green-space development in urban places (Stedman and Ingalls 2014). Sense of place and place attachment likely play substantial roles in the formation of individuals' perceptions of environmental risks, especially when those risks are related to hazards that can fundamentally alter the natural or physical characteristics of lived environments and thereby affecting individuals' continued sense of place and associated attachments to it. Perceptions of climate- and weather-related phenomena are particularly relevant to this discussion, especially in the context of climate change and the link between extreme weather event magnitude and global climatic change.

Past efforts to understand perceptions of climate- and weather-related phenomena have largely focused on single event-types and case studies, e.g., hurricanes, droughts, and floods (Kasperson and Dow 1993; Clark et al. 1998; Bullad and Wright 2009; Goebbert et al. 2012; Howe et al. 2014; Klinenberg 2015; Hamilton et al.. 2016b), or particular indicators of climate and weather, e.g., temperature, precipitation, or weather extremes (Hamilton and Keim 2009; Brulle et al. 2012; Howe and Leiserowitz 2013; Marquart-Pyatt et al. 2014; Cutler 2015; Shao 2016; Shao and Goidel 2016; Hamilton et al. 2018; Fownes and Allred 2019), and their social and biophysical correlates. Studies investigating the correlates of beliefs about global warming have incorporated local weather events and climatic data in order to understand whether and to what extent severe events have influenced individuals' perceptions about the reality and risks posed by global warming. Exploiting short-term variation in local weather conditions, a growing set of studies link climate beliefs and attitudes to temperature shifts (Hamilton and Keim 2009; Egan and Mullin 2012; Hamilton and Stampone 2013; Zaval et al. 2014; Shao et al. 2014; Shao et al. 2016; Fownes and Allred 2019); many fewer have considered coastal flooding (e.g., Spence et al. 2011). Physical vulnerability to climate-related impacts appears to increase global warming risk perceptions. Brody, Zahran, Vedlitz, and Grover (2008), for example, found that respondents residing in places most vulnerable to inundation from sea level rise perceived a greater risk from global warming than did those living on relatively higher ground or further away from the coastline. Additionally, Milfont et al. (2014) demonstrated a significant effect of proximity to the shore on beliefs about the reality of global warming and support for policies to address it.

Perceptions and experiences of actual weather may not always align as some segments of the public have become more sensitized to global environmental change than others. On the one hand, individuals' perceptions of unusual local weather may exert a stronger influence on their global warming risk perceptions than objectively-measured abnormal weather trends at the local-level (Shao 2016). This suggests that public perceptions of climate impacts may sometimes outpace local-level changes to weather patterns. On the other hand, strong socio-cultural filters can reduce or even override one's ability to detect local weather changes (e.g., Brulle et al. 2012; Myers et al. 2012; Kahan 2012; Howe and Leiserowitz 2013; McCright et al. 2014; Marquart-Pyatt et al. 2014; Howe 2018). Other studies (e.g. Goebbert et al. 2012) demonstrate that instrumental changes in the weather are better predictors of perceptions of drought and flooding than perceptions of local temperature changes. Changes in precipitation patterns also appear to be more easily detected by residents than changes in temperature (Marlon et al. 2018). Moreover, a number of studies find that individual-level political orientations overshadow regional-level climatic conditions in models predicting public beliefs about the immediacy and seriousness of global warming and climatic phenomena (Marquart-Pyatt et al. 2014, Hamilton et al. 2016a, and Hamilton et al. 2016b).

Using nationally-representative survey data, other recent studies have employed multilevel regression and post-stratification (MRP) to “downscale” or predict beliefs and perceptions at various sub-national levels. MRP models accurately predict global warming beliefs, risk perceptions, and policy preferences at the state, congressional district, metropolitan, and county levels (Howe et al 2015; Mildenberger et al. 2016; Mildenberger et al. 2017). Geographic variation in perceptions of both local events or phenomena and broader global warming has proven critically important to explaining potential differences in public attitudes about the immediacy of global warming as a threat and its impact on current trends in localized climatic or meteorological events. This place-based variation has been found to be related to variation in political support and local economic contexts, such as in places associated with the mining, oil, and gas industry (Olson-Hazboun et al. 2018). This indicates that local economic, social, and cultural circumstances are also critical to our understanding of risk perception formation.

Many past studies on subjects ranging from human health and public safety, to the environment and other domains, show that personal experience of a hazard significantly increases beliefs about the likelihood of future incidence and seriousness of such events (Kunreuther 1978; Smith and Tobin 1979; Mitchell 1984; Weinstein 1989). The link between personal experiences of climatic events and perceptions of risks associated with global warming, however, has found relatively limited support (McCright et al. 2014; Hornsey et al. 2016), and is likely due in part to the perceived spatial and temporal distance of global warming among the general public in the United States. On the international level, however, evidence suggests that changes to local climates have influenced perceptions of local change. Howe et al. (2013) investigated measured temperature changes alongside public perceptions of changes across 89 countries and found that those residing in places with rising average temperatures were more likely to perceive local warming.

Physical vulnerabilities to climate- and weather-related hazards have also been associated with climate change risk perceptions: people residing in places most vulnerable to inundation from sea level rise perceive a greater risk from global warming than do those living on relatively higher ground or further away from the coastline (Brody et al. 2008; Milfont et al. 2014). The subjective experience of climate-related extreme events is also related to the proximity to impacts as well as the magnitude of the impacts (Howe et al. 2014). Additionally, other research has found a multiplicative effect between county-level property damage from severe weather and individual-level household income on individuals' perceptions of climate risks and extreme weather, such that lower-income individuals living in places hardest hit by severe weather were much more likely to perceive climate impacts than their higher-income neighbors (Cutler 2015; 2016).

Though there have been many studies on individual beliefs and attitudes about environmental phenomena and their sociodemographic correlates, these studies have overwhelmingly focused on identifying and explaining what Van Liere and Dunlap (1980) referred to as the "social bases of environmental concern." From the "age, social class, residence, political, and sex hypotheses" (see Van Liere and Dunlap 1980) emerged a myriad of studies over the following decades charting the sociodemographic correlates of individual beliefs, attitudes, perceptions of risks, and norms of behavior with respect to environmental issues and problems, most notably in recent years the social and political dimensions of global warming beliefs. Less attention, however, has been given to the potential place-level socioeconomic factors, especially in conjunction with biophysical indicators that put some individuals in positions of increased risk for harm. Perceptions are an important determinant of responses to risks, so an improved understanding of the drivers of risk perceptions can clarify how severe climate- and weather-related event impacts may affect individuals and populations (Leiserowitz 2005; Thomas et al. 2007; Whitmarsh 2008; Weber 2010; Wilhelmi and Hayden 2010).

Individual-level values are also embedded in place-specific contexts and connected to locally-relevant phenomena, such as cultural milieu, history, economic vibrancy, and patterns of integration or segregation, among other factors (Guagnano and Markee 1995; Lorenzoni and Pidgeon 2006; Shwom et al. 2008; Hamilton and Keim 2009; Hamilton et al. 2010; Safford et al. 2012; Sampson 2012; Hamilton and Safford 2014). As has been shown above, place-based values and attachments relate to environmental beliefs and concerns, but to what extent individuals understand and perceive their own relative vulnerabilities is an important factor for policymakers and organizations involved in disaster preparation and response to consider. The link between perceived and measured vulnerabilities to environmental hazards has also been relatively underexplored (Brody et al. 2008; Wolf et al. 2010; Spence et al. 2011). Perceptions about climate change have been analyzed as correlates of personal values, worldviews, and other culturally-rooted cognitive processes at the individual level, but place-level factors have received relatively less attention. Where place-level factors have been assessed in prior research on perceptions of environmental risks, these studies have often focused on specific regions, such as perceptions of weather conditions among U.S. Gulf Coast residents or perceptions of environmental risk among Floridians (Shao and Goidel 2016; Carlton and Jacobson 2013).

This research will link these insights from sociological and psychological studies exploring the individual-level influences on environmental attitudes and perceptions to the geographic literature on place-level differences in attitudes and perceptions by combining national survey data with multiple sets of data on place-level physical contextual factors and indicators of residence in communities along the U.S. coasts. In doing so, this study will address a gap in the literature, namely that coastal residence, in particular, may be an important yet previously unexplored factor influencing how certain among those in the general public have come to attribute local weather extremes to global warming. .

Methods

Data utilized in this research comes from the Climate Change in the American Mind (CCAM) surveys conducted by the Yale Program on Climate Change Communication and the George Mason University Center for Climate Change Communication. CCAM surveys have tracked public beliefs and attitudes about global warming and a wide range of associated issues and topical areas, such as risk perceptions, media consumption habits, policy preferences, and many others. Samples were drawn from GfK's KnowledgePanel®, an online panel recruited using probability sampling via random digit dialing and address-based mail techniques which cover essentially all resident phone numbers and mail addresses in the United States. Survey questionnaires were self-administered by respondents through a web-based environment. Those sampled who chose to join the panel but did not have access to the internet at home were loaned personal computers and provided with internet access in order to participate so that the web-based design would not systematically exclude certain segments of the population. Post-survey weights were applied to demographic variables to match the US Census Bureau's norms. Survey weights were also applied to the statistical analyses presented in this study.

There have been eighteen waves of CCAM data collected since the fall of 2008. While some items have been tracked throughout CCAM's deployment, most survey questions have been asked more selectively. In this study, two survey items are used to construct a single ordinal indicator of belief about the link between global warming and the weather. The two survey questions read as follows:

2. Which statement below best reflects your view? [Global warming is affecting the weather in the United States, Global warming is not affecting the weather in the United States, Global warming isn't happening, Don't know, Prefer not to answer].

3. [If "Global warming is affecting the weather"] How much do you think global warming is affecting the weather in the United States? [A lot, Some, A little, Don't know, Prefer not to answer].

These items were assessed on six CCAM survey waves – April 2013, December 2013, April 2014, March 2016, November 2016, and May 2017. Sample sizes and response rates for all waves are reported in Table 1. Survey waves were pooled for the purposes of these analyses, but an indicator for survey wave was included in order to test any potential temporal effects. The dependent variable derived from these items was treated as ordered categorical, with categories ordered as follows:

1. Global warming isn't happening.
2. Global warming is not affecting the weather.
3. Don't know.
4. Global warming is affecting the weather. Don't know (how much).
5. Global warming is affecting the weather – a little.
6. Global warming is affecting the weather – some.
7. Global warming is affecting the weather – a lot.

[Table 1 near here]

Individual-level independent variables included respondents' age, (*1, 18-29; 2, 30-44; 3, 45-59; 4, 60+*), gender (*0, Male; 1, Female*), educational attainment (1, less than high school; 2, high school or equivalent; 3, some college/2-year Associate's degree; 4, Bachelor's degree or higher), household income (1, less than $25,000; 2, $25,000-$34,999; 3, $35,000-$49,999; 4, $50,000-$74,999; 5, $75,000-$99,999; 6, $100,000+) race and ethnicity (1, White, non-Hispanic; 2, Hispanic; 3, Black, non-Hispanic; 4, Other race or multiracial, non-Hispanic), and political ideology (1, very liberal; 2, somewhat liberal; 3, moderate; 4, somewhat conservative; 5, very conservative). Descriptive statistics for survey-based, individual-level characteristics are provided in Tables 2 and 3. Place-level independent variables included two indicators of weather extremes derived from NOAA's Climate Extremes Index (CEI) and an indicator of coastal shoreline county residence developed using data from the National Geodetic Survey's Continually Updated Shoreline Project (CUSP). CUSP data is available for download at the regional level through NOAA's Shoreline Data Explorer online and captures all national shoreline boundaries, including Alaska, Pacific Islands, Great Lakes, Gulf of Mexico, North Atlantic, Southeast and Caribbean, and West Coast.

[Table 2 near here]

NOAA's CEI was accessed and data downloaded via the National Centers for Environmental Information (NCEI) website. The CEI is defined as follows:

> *"the arithmetic average of the following five of six indicators of the percentage of the conterminous U.S. area: 1) The sum of (a) percentage of the United States with maximum temperatures much below normal and (b) percentage of the United States with maximum temperatures much above normal, 2) The sum of (a) percentage of the United States with minimum temperatures much below normal and (b) percentage of the United States with minimum temperatures much above normal, 3) The sum of (a) percentage of the United States in severe drought (equivalent of the lowest tenth percentile) based on the Palmer Drought Severity Index (PDSI) and (b) percentage of the United States with severe moisture surplus (equivalent to*

the highest tenth percentile) based on the PDSI, 4) Twice the value of the percentage of the United States with a much greater than normal proportion of precipitation derived from extreme (equivalent to the highest tenth percentile) 1-day precipitation events, 5) The sum of (a) percentage of the United States with a much greater than normal number of days with precipitation and (b) percentage of the United States with a much greater than normal number of days without precipitation, and 6) The sum of squares of U.S. landfalling tropical storm and hurricane wind velocities scaled to the mean of the first five indicators," (Gleason et al 2008).

Beginning in 2011, NCEI introduced a regional CEI measure (RCEI), which calculates CEI values for each of the nine Standard U.S. Regions (Northeast, Southeast, Ohio Valley, Upper Midwest, South, Upper Rockies and Plains, Southwest, Northwest, and West). Two RCEI indicators included in this preliminary analysis are the 3-month average RCEI value attached to each respondent for the three months preceding the date of survey administration and the 30-year anomaly of the average RCEI for that same period. Descriptive statistics for climate extremes data are reported in Table 4. Geocoded survey responses were matched to the 3-month average and RCEI anomalies by locating respondents by region and assigning the RCEI metrics to their case identifiers in the survey data set through a data merge and matching by region.

CUSP data were accessed online using NOAA's Shoreline Data Explorer. Shoreline shapefiles were matched to the U.S. Census TIGER/Line® county boundary shapefiles using ArcMap software. Geolocated CCAM survey responses enabled the identification of survey respondents who resided in counties that either overlapped or shared boundaries with CUSP national shoreline data. Using this information, a dichotomous indicator was created for shoreline county residence. Finally, dummy variables for survey wave were included to control for potential temporal effects of the month and year in which the surveys were administered.

Additionally, a CCAM-specific nine-region variable was included to handle the potential for spatially autocorrelated data and take into account additional geographic variation.

[Table 3 near here]

A mixed effects ordered logistic regression was conducted to assess the effects of individual characteristics on belief that global warming is affecting the weather (Model 1), individual characteristics, risk perceptions, and ideology on the DV (Model 2), and the factors in Model 2 plus place characteristics (Model 3). A mixed effects model was chosen to account for variation in the potential relationships between place-based climate indicators and the DV in different parts of the country. Analyses were re-run using a multilevel mixed-effects linear regression and results remained largely unchanged. The strength of effects decreased slightly, but significance and directionality were unaffected, suggesting that results are sufficiently robust.

[Table 4 near here]

Results

Respondent socio-demographic characteristics are detailed in Table 2. Median age for respondents was 54 years of age, with a range of 18 to 94. About half of respondents were male (50.30%) and half female (49.7%). About seventy-five percent of respondents were white, non-Hispanic (74.95%), roughly ten percent Hispanic (9.74%), slightly under nine percent black, non-Hispanic, and less than five percent other, non-Hispanic or two or more races, non-Hispanic. Slightly more than one-third of respondents had a Bachelor’s degree or higher, while about thirty percent had some college or an Associate’s degree, about twenty-seven percent had a high school diploma or equivalent, and about seven percent had less than a high school diploma. Roughly seventeen percent of respondents had household incomes of $125,000 or more, twelve percent between $100,000 and $124,999, fifteen percent between $75,000 and $99,999, nineteen percent between $50,000 and $74,999, twenty-two percent between $25,000 and $49,999, and fifteen percent had less than $25,000 in household incomes.

Results from the mixed effects ordered logistic regression are presented in Table 4. Odds ratios are reported for the ease of interpretation. Odds ratios are relative to 1.0, where a positive effect is indicated by an odds ratio greater than 1.0 and a negative effect is indicated by an odds ratio below 1.0. Positive associations refer to the multiplicative effects of a "global warming is affecting the weather - a lot" response for a single unit increase in the independent variable versus any other response to the dependent variable, holding other independent variables constant, whereas negative associations refer to the multiplicative effects on the odds of a "global warming isn't happening" response on the other end of the spectrum versus any other response to the dependent variable. Respondents' region of residence is set as the second-level random effect in order to test for spatial variability unaccounted for among the fixed effects and to handle the potential spatial autocorrelation of place-based indicators in the first level of the model.

[Table 5 near here]

Among demographic characteristics, respondents' age, gender, education, and race and ethnicity were all significantly associated with their beliefs about whether and to what extent global warming is affecting the weather (Model 2; Table 5). Odds of a "global warming is affecting the weather a lot" response was higher among older respondents (3.4% increased odds for a unit increase in age), female respondents (33.8% increased odds for female versus male), more highly educated respondents (12% increased odds for a unit increase in education), Hispanic respondents (60.7% increased odds for Hispanic versus White, non-Hispanic), Black or African American respondents (22.2% increased odds for Black, non-Hispanic versus White, non-Hispanic), and non-White, non-Hispanic respondents identifying with another race (33.6% increased odds for Other, non-Hispanic versus White, non-Hispanic). Interestingly, the effect of Hispanic ethnicity echoes recent research that indicates Hispanics and Latinx are much more engaged with the issue of global warming than non-Hispanic/Latinx, have greater climate risk perceptions, and that their risk perceptions also correspond to higher levels of civic engagement on the issue (Leiserowitz et al. 2017; Ballew et al. 2019). Moreover, the effects of Black and other non-White racial identities are also mirrored by past research that has indicated higher climate change health risk perceptions among racial and ethnic minorities, whom are also generally more vulnerable to the harms posed by climate change (Akerlof et al. 2015; Harlan et al. 2015).

After their addition in Model 3, however, worry about global warming and political ideology were the strongest predictors of beliefs that global warming is affecting the weather and these variables mediate some of the demographic effects in Model 2 (Table 5). The political ideology finding is consistent with a rich literature on political orientation, values, and beliefs and attitudes about global warming (Van Liere and Dunlap 1980; Slovic 1993; Dietz et al 2005; Leiserowitz 2005; Wood and Vedlitz 2007; Hamilton 2008; Malka et al. 2009; Kahan et al. 2011; Mildenberger et al. 2017). On the other hand, the result that worry about global warming influences belief that global warming is affecting the weather raises a “chicken-and-egg” problem (whether worry influences belief that global warming is affecting the weather, or vice versa), which this research is not able to unpack and investigate further due to the constraints of the cross-sectional survey design and sampling strategy (but see Myers et al. (2012) for a structural equation modeling approach to understanding the "chicken-and-egg" problem of directional influence between climate change belief, belief certainty, and personal experience with climate change.

Among the place-level indicators, coastal shoreline county residence significantly predicted beliefs about the effect of global warming on the weather. The odds of a "global warming is affecting the weather a lot" response was 14.8% higher among individuals living in coastal shoreline counties versus all other counties represented in the sample. On the other hand, neither the 3-month RCEI value nor the 30-year RCEI anomaly had any significant impacts on beliefs about the effect of global warming on the weather. Therefore, the significant association of coastal shoreline county residence, net of ideological and sociodemographic factors and actual climate and weather extremes, suggests that residents of coastal areas believe they are experiencing the effects of climate- and weather-related phenomena in ways that relate to factors that are not captured by the sociodemographic and biophysical characteristics included in this study. However, this effect of coastal shoreline county residence is limited insofar as it does not provide any context about how specifically coastal shoreline county residents actually experience the impacts of weather and climate change in their everyday lives.

This finding may indicate that physical proximity to coasts may be an important predictor of global warming risk perceptions due perhaps to the unique issues facing coastal communities, such as extreme high winds, storm surges, coastal flooding, and coastal erosion. Identifying the different perceptions found in coastal versus inland areas is particularly important given the existing and worsening risks posed by global warming to coastal communities, towns, and cities across the United States. Interestingly, however, this effect is not moderated by ideological orientation – the interaction between ideology and coastal shoreline residence was not significantly predictive of attribution beliefs. In other words, coastal shoreline residence influences attribution beliefs about equally across the ideological spectrum (Figure 1). However, the coastal proximity effect appears to dissipate among those who identify as “somewhat” or “very” liberal – both coastal shoreline and inland liberals had similarly high mean responses to the attribution scale.

[Figure 1 here]

Discussion

The combined sociological concepts of place and emergence can provide a useful framework for understanding how individuals perceive the environment, changes to it, and the potential risks of environmental hazards. Specifically, individuals’ perceptions of the environment and environmental hazards or risks may emerge out of a combination of place-specific contexts and individual characteristics. While the methodological approach and results of this research cannot address all of the possible place-level factors that influence perceptions of environmental risks, it is worthy of note for future research that the significant effect of coastal shoreline residence, net of political-ideological and other sociodemographic factors, may indicate that coastal communities have experienced the effects of a changing climate. Future studies should consider mixed method approaches, including qualitative or ethnographic methods, to better understand all of the place-level factors that contribute to this coastal proximity effect, including how coastal residents may have already begun to perceive these impactsand why they are attributing at least some of the changes to global warming.

Several results in this analysis verify the extant literature on the correlates of environmental beliefs and attitudes. First, political ideology significantly influences perceptions about the link between global warming and the weather. Those who identify as politically liberal are much more likely to believe that global warming has had an impact on the weather than their politically conservative counterparts. This is consistent with numerous studies across social science disciplines and decades of research on beliefs and attitudes about the environment in general and global warming specifically (Van Liere and Dunlap 1980; Stern and Dietz 1994; Leiserowitz 2006; Hamilton 2008; Kahan 2012; McCright and Dunlap 2013). This research extends this established link between political ideology and environmental perceptions by demonstrating that political-ideological characteristics also relate to how much individuals attribute global warming to changes in local weather. Interestingly, however, this research also adds to the literature finding less consistent effects of sociodemographic factors by providing evidence that older, female, and Hispanic individuals are more likely to link global warming to changes in local weather patterns, controlling for political ideology. While a "white male conservative" effect on environmental risk perceptions has been established (Finucane et al. 2000; Flynn et al. 1994; Kahan et al. 2007; Kalof et al. 2002; McCright and Dunlap 2013), this study adds new insight to research on race, ethnicity, and environmental perceptions by suggesting that apart from other racial and ethnic groups, Hispanics are much more likely to perceive a causal link between global warming and local weather (Macias, 2016). Future research might extend this line of inquiry by investigating how and why Hispanic individuals and communities seem to be more concerned about the impacts of global warming, particularly with respect to weather events at the local level.

In addition to these individual-level effects, this study also finds an important association between place of residence and individual perceptions of the relationship between global warming and weather. Those living in coastal counties bordering national shorelines are more likely than their inland-residing counterparts to attribute changes to local weather to the broader phenomenon of global warming. This result remains significant even after controlling for strong individual-level predictors of environmental perceptions such as political ideology. Importantly, the effect among coastal shoreline residents cannot not be entirely attributed to higher populations of more politically liberal or left-leaning individuals, since the analysis controls for political ideology. Individuals living nearest to the coasts may be experiencing global warming differently or more immediately than inland residents and therefore attribute a larger effect of global warming on changes to local weather patterns. On the other hand, no significant effect is observed from the 3-month average RCEI or the 30-year RCEI anomaly on perceptions of the link between global warming and weather. Past studies utilizing other types of measures of RCEI were also unable to demonstrate any significant effect of RCEI on beliefs about global warming, or that any effect fades quickly in the aftermath of extreme weather events (Brulle et al. 2012; Marquart et al. 2012; Konisky et al. 2016; Lyons et al. 2018). These results indicate either 1) that RCEI is not the most appropriate measure for assessing local impacts of extreme or unusual weather and/or 2) that residents of coastal communities bordering shorelines may experience local climatic changes through factors in their everyday lives not captured by a biophysical indicator such as RCEI, such as "sunny day flooding," rapid loss of marshlands, erosion, and property or infrastructure damage from increased sea level rise and tidal action.

Future research should consider incorporating measures that capture some of these specific examples of phenomena affect the coasts, but may also consider selecting particular coastal locations for case studies and more in-depth qualitative work. It may also suggest that social and economic circumstances particular to coastal communities have a role in increasing their residents' risk perceptions surrounding the issue global warming. For instance, coastal communities bordering shorelines often host industries and sectors of employment that may be more vulnerable to the impacts of extreme or unusual weather events, such as tourism, commercial and recreational fishing, or domestic and international trade. While this research was not able to unpack these possibilities, future studies might consider more in-depth field work or ethnographic methods of research to better understand the particular characteristics of coastal shoreline communities that may play a role in influencing coastal residents' perceptions of the risks associated with extreme weather and global warming.

Returning to the sociological concepts of place and emergence, future research should consider using this combined framework to understand how place-to-place variation in environmental risk perceptions is formed despite (or perhaps in compliment to) the powerful influence of individual-level values and political predispositions. For example, individual ideological and sociodemographic characteristics clearly play a major role in determining individuals' beliefs and attitudes about environmental phenomena, but such individual-level characteristics are embedded in place-specific contexts, such as local sociocultural and political milieus, economic vitality, infrastructure, or the aesthetics of the natural and/or built environment, and thus emerge out of the interplay between individuals' personal characteristics and the conditions of the larger community. In coastal communities in particular, residents may have a unique sense of place that is related to the intersection between the aesthetic quality of the natural environment and the cultural or material quality of the coastal economy.

This sense of place may be augmented, however, by individuals' relative position in terms of socioeconomic status, race/ethnicity, or political-ideological orientation, such that these individual-level, socio-demographic characteristics influence choices to interact in different ways with the natural and built environments of the coasts. Therefore, research investigating perceptions of environmental risks should correspondingly assess the potential local-level impacts to vulnerable populations, communities, and economies. One key limitation of this study is that the coastal shoreline county indicator does not itself provide any detailed information about how coastal residents experience global warming and local weather. While it appears that coastal shoreline residence is related to increased perceptions of a causal link between global warming and weather, more research is needed to identify the specific place-based characteristics relevant to coastal residents' experiences of global warming and extreme or unusual weather. There is enormous diversity and heterogeneity among the places represented within the coastal shoreline county indicator and this research cannot unpack any of the intricacies related to this specific place-to-place variation. Therefore, future research should aim to illuminate the lived experiences of coastal shoreline residents and their communities in the context of a changing climate.

Acknowledgements

This research utilizes data from the Climate Change in the American Mind surveys, conducted by the Yale Program on Climate Change Communication and the George Mason University Center for Climate Change Communication. Survey data collection was funded by 11th Hour Project, the Energy Foundation, the Grantham Foundation, the MacArthur Foundation, and the V.K. Rasmussen Foundation.

References

Akerlof, K., Delamater, P., Boules, C., Upperman, C., & Mitchell, C. 2015. “Vulnerable populations perceive their health as at risk from climate change.” *International Journal of Environmental Research and Public Health*. 12(12): 15419-15433.

Ballew, M. T., Goldberg, M. H., Rosenthal, S. A., Cutler, M. J., & Leiserowitz, A. 2019. “Climate Change Activism Among Latino and White Americans.” *Frontiers in Communication*. 3: 58.

Borick, Christopher P. and Barry G. Rabe. 2010. "A Reason to Believe: Examining the Factors That Determine Individual Views on Global Warming." *Social Science Quarterly.* 91(3):777-800.

Brehm, J. M., Eisenhauer, B. W., & Krannich, R. S. 2006. “Community attachments as predictors of local environmental concern: The case for multiple dimensions of attachment.” *American behavioral scientist*. 50(2): 142-165.

Brehm, J. M., Eisenhauer, B. W., & Stedman, R. C. 2013. “Environmental concern: Examining the role of place meaning and place attachment.” *Society & Natural Resources*. 26(5): 522-538.

Brody, Samuel D., Sammy Zahran, Arnold Vedlitz and Himanshu Grover. 2008. "Examining the Relationship between Physical Vulnerability and Public Perceptions of Global Climate Change in the United States." *Environment and Behavior.* 40(1):72-95.

Brown, G., & Raymond, C. 2007. “The relationship between place attachment and landscape values: Toward mapping place attachment.” *Applied geography*. 27(2): 89-111.

Brulle, Robert J., Jason Carmichael and J. Craig Jenkins. 2012. "Shifting Public Opinion on Climate Change: An Empirical Assessment of Factors Influencing Concern over Climate Change in the Us, 2002–2010." *Climatic Change*. 114(2):169-88.

Bullard, Robert D. and Beverly Wright. 2009. *Race, Place, and Environmental Justice after Hurricane Katrina: Struggles to Reclaim, Rebuild, and Revitalize New Orleans and the Gulf Coast*: Westview Press.

Carlton, S. J., & Jacobson, S. K. 2013. “Climate change and coastal environmental risk perceptions in Florida.” *Journal of environmental management*. 130: 32-39.

Clark, George E., Susanne C. Moser, Samuel J. Ratick, Kirstin Dow, William B. Meyer, Srinivas Emani, Weigen Jin, Jeanne X. Kasperson, Roger E. Kasperson and Harry E. Schwarz. 1998. "Assessing the Vulnerability of Coastal Communities to Extreme Storms: The Case of Revere, Ma., USA." *Mitigation and Adaptation Strategies for Global Change.* 3(1):59-82.

Cook, John, Naomi Oreskes, Peter T. Doran, William R.L. Anderegg, Bart Verheggen, Ed W. Maibach, J. Stuart Carlton, Stephan Lewandowsky, Andrew G. Skuce and Sarah A. Green. 2016. "Consensus on Consensus: A Synthesis of Consensus Estimates on Human-Caused Global Warming." *Environmental Research Letters.* 11(4):048002.

Cutler, Matthew J. 2015. "Seeing and Believing: The Emergent Nature of Extreme Weather Perceptions." *Environmental Sociology.* 1(4):293-303.

Cutler, Matthew J. 2016. "Class, Ideology, and Severe Weather: How the Interaction of Social and Physical Factors Shape Climate Change Threat Perceptions among Coastal Us Residents." *Environmental Sociology*:1-11.

Dietz, T., A. Fitzgerald and R. Shwom. 2005. "Environmental Values." *Annual Review of Environment and Resources*. 30:335-72. doi: 10.1146/annurev.energy.30.050504.144444.

Egan, Patrick J. and Megan Mullin. 2012. "Turning Personal Experience into Political Attitudes: The Effect of Local Weather on Americans' Perceptions About Global Warming." *The Journal of Politics*. 74(3):796-809.

Fownes, J. R., & Allred, S. B. 2019. “Testing the Influence of Recent Weather on Perceptions of Personal Experience with Climate Change and Extreme Weather in New York State.” *Weather, Climate, and Society*. 11(1): 143-157.

Gieryn, Thomas F. 2000. "A Space for Place in Sociology." *Annual Review of Sociology.* 26(1):463-96.

Goebbert, Kevin, Hank C. Jenkins-Smith, Kim Klockow, Matthew C. Nowlin and Carol L. Silva. 2012. "Weather, Climate, and Worldviews: The Sources and Consequences of Public Perceptions of Changes in Local Weather Patterns." *Weather, Climate, and Society.* 4(2):132-44.

Gosling, E., & Williams, K. J. 2010. “Connectedness to nature, place attachment and conservation behaviour: Testing connectedness theory among farmers.” *Journal of environmental psychology*. 30(3): 298-304.

Guagnano, Gregory A. and Nancy Markee. 1995. "Regional Differences in the Sociodemographic Determinants of Environmental Concern." *Population & Environment.* 17(2):135-49.

Hamilton, L. C. 2008. "Who Cares About Polar Regions? Results from a Survey of Us Public Opinion." *Arctic Antarctic and Alpine Research*. 40(4):671-78. doi: 10.1657/1523-0430(07-105)[Hamilton]2.0.Co;2.

Hamilton, L. C., C. R. Colocousis and C. M. Duncan. 2010. "Place Effects on Environmental Views." *Rural Sociology.* 75(2):326-47. doi: 10.1111/j.1549-0831.2010.00013.x.

Hamilton, L. C., J. Hartter, T. G. Safford and F. R. Stevens. 2014. "Rural Environmental Concern: Effects of Position, Partisanship, and Place." *Rural Sociology*. 79(2):257-81. doi: 10.1111/ruso.12023.

Hamilton, L. C., J. Hartter, B. D. Keim, A. E. Boag, M. W. Palace, F. R. Stevens and M. J. Ducey. 2016a. "Wildfire, Climate, and Perceptions in Northeast Oregon." *Regional Environmental Change.* 16(6):1819-32. doi: 10.1007/s10113-015-0914-y.

Hamilton, L. C. and B. D. Keim. 2009. "Regional Variation in Perceptions About Climate Change." *International Journal of Climatology.* 29(15):2348-52. doi: 10.1002/joc.1930.

Hamilton, L. C. and T. G. Safford. 2014. "Environmental Views from the Coast: Public Concern About Local to Global Marine Issues." *Society & Natural Resources.* 28(1):57-74. doi: 10.1080/08941920.2014.933926.

Hamilton, L. C. and M. D. Stampone. 2013. "Blowin' in the Wind: Short-Term Weather and Belief in Anthropogenic Climate Change." *Weather, Climate, and Society.* 5(2):112-19. doi: 10.1175/Wcas-D-12-00048.1.

Hamilton, Lawrence C., Cameron P. Wake, Joel Hartter, Thomas G. Safford and Alli J. Puchlopek. 2016b. "Flood Realities, Perceptions and the Depth of Divisions on Climate." *Sociology.* 50(5):913-33.

Hamilton, L. C., Lemcke-Stampone, M., & Grimm, C. 2018. “Cold winters warming? Perceptions of climate change in the North Country.” *Weather, Climate, and Society*. 10(4): 641-652.

Hannigan, John. 2014. *Environmental Sociology*: Routledge.

Harlan, S. L., Pellow, D. N., Roberts, J. T., Bell, S. E., Holt, W. G., & Nagel, J. 2015. "Climate justice and inequality." *Climate change and society: Sociological perspectives*. 127-163.

Hornsey, Matthew J., Emily A. Harris, Paul G. Bain and Kelly S. Fielding. 2016. "Meta-Analyses of the Determinants and Outcomes of Belief in Climate Change." *Nature Climate Change*. 6(6):622-26.

Howe, P. D., H. Boudet, A. Leiserowitz and E. W. Maibach. 2014. "Mapping the Shadow of Experience of Extreme Weather Events." *Climatic Change.* 127(2):381-89. doi: 10.1007/s10584-014-1253-6.

Howe, P. D. and A. Leiserowitz. 2013. "Who Remembers a Hot Summer or a Cold Winter? The Asymmetric Effect of Beliefs About Global Warming on Perceptions of Local Climate Conditions in the Us." *Global Environmental Change-Human and Policy Dimensions* 23(6):1488-500. doi: 10.1016/j.gloenvcha.2013.09.014.

Howe, Peter D., Ezra M. Markowitz, Tien Ming Lee, Chia-Ying Ko and Anthony Leiserowitz. 2013. "Global Perceptions of Local Temperature Change." *Nature Climate Change*. 3(4):352-56.

Howe, Peter D., Matto Mildenberger, Jennifer R. Marlon and Anthony Leiserowitz. 2015. "Geographic Variation in Opinions on Climate Change at State and Local Scales in the USA." *Nature Climate Change.* 5(6):596-603. doi: 10.1038/nclimate2583 http://www.nature.com/nclimate/journal/v5/n6/abs/nclimate2583.html#supplementary-information.

Howe, Peter D. 2018. "Perceptions of seasonal weather are linked to beliefs about global climate change: evidence from Norway." *Climatic Change.* 148(4): 467-480.

Jorgensen, B. S., & Stedman, R. C. 2006. “A comparative analysis of predictors of sense of place dimensions: Attachment to, dependence on, and identification with lakeshore properties.” *Journal of environmental management*. 79(3): 316-327.

Kahan, Dan M., Hank Jenkins-Smith and Donald Braman. 2011. "Cultural Cognition of Scientific Consensus." *Journal of Risk Research*. 14(2):147-74.

Kahan, D. 2012. “Why we are poles apart on climate change.” *Nature News*. 488(7411): 255.

Kasperson, Roger E. and Kirstin Dow. 1993. "Hazard Perception and Geography." *Advances in Psychology*. 96:193-222.

Klinenberg, Eric. 2015. *Heat Wave: A Social Autopsy of Disaster in Chicago*: University of Chicago Press.

Konisky, D. M., Hughes, L., & Kaylor, C. H. 2016. “Extreme weather events and climate change concern.” *Climatic change*. 134(4): 533-547.

Kunreuther, Howard. 1978. *Disaster Insurance*. New York: Wiley.

Larson, S., De Freitas, D. M., & Hicks, C. C. 2013. “Sense of place as a determinant of people's attitudes towards the environment: Implications for natural resources management and planning in the Great Barrier Reef, Australia.” *Journal of environmental management*. 117: 226-234.

Leiserowitz, Anthony A. 2005. "American Risk Perceptions: Is Climate Change Dangerous?". *Risk Analysis*. 25(6):1433-42.

Leiserowitz, Anthony. 2006. "Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values." *Climatic Change.* 77(1):45-72.

Leiserowitz, A., Cutler, M., & Rosenthal, S. 2017. “Climate Change in the Latino Mind.” Yale University. New Haven, CT: Yale Program on Climate Change Communication.

Lorenzoni, Irene and Nick F. Pidgeon. 2006. "Public Views on Climate Change: European and USA Perspectives." *Climatic Change.* 77(1):73-95.

Lyons, B. A., Hasell, A., & Stroud, N. J. 2018. "Enduring extremes? Polar vortex, drought, and climate change beliefs." *Environmental Communication*. 12(7): 876-894.

Macias Thomas. 2016. "Environmental risk perception among race and ethnic groups in the United States." *Ethnicities.* 16: 111-129.

Marlon, Jennifer R., Sander van der Linden, Peter D. Howe, Anthony Leiserowitz, Lucia S.H. Woo, and Kenneth Broad. 2018. "Detecting local environmental change: the role of experience in shaping risk judgments about global warming." *Journal of Risk Research*: 1-15.

Malka, Ariel, Jon A. Krosnick and Gary Langer. 2009. "The Association of Knowledge with Concern About Global Warming: Trusted Information Sources Shape Public Thinking." *Risk Analysis*. 29(5):633-47.

Marquart-Pyatt, S. T., A. M. McCright, T. Dietz and R. E. Dunlap. 2014. "Politics Eclipses Climate Extremes for Climate Change Perceptions." *Global Environmental Change-Human and Policy Dimensions*. 29:246-57. doi: 10.1016/j.gloenvcha.2014.10.004.

McCright, A. M. and R. E. Dunlap. 2013. "Bringing Ideology In: The Conservative White Male Effect on Worry About Environmental Problems in the USA." *Journal of Risk Research*. 16(2):211-26. doi: 10.1080/13669877.2012.726242.

McCright, A. M., R. E. Dunlap and C. Y. Xiao. 2014. "The Impacts of Temperature Anomalies and Political Orientation on Perceived Winter Warming." *Nature Climate Change.* 4(12):1077-81. doi: 10.1038/Nclimate2443.

Melillo, Jerry M., T.T. Richmond and G. Yohe. 2014. "Climate Change Impacts in the United States." *Third National Climate Assessment.*

Mildenberger M, Howe P, Lachapelle E, et al. 2016. “The distribution of climate change public opinion in Canada.” *PloS one* 11: e0159774.

Mildenberger, Matto, Jennifer R. Marlon, Peter D. Howe and Anthony Leiserowitz. 2017. "The Spatial Distribution of Republican and Democratic Climate Opinions at State and Local Scales." *Climatic Change*:1-10.

Mitchell, James K. 1984. “Hazard Perception Studies: Convergent Concerns and Divergent Approaches During the Past Decade,” in T.F. Saarinen, D. Seamon and J.L. Sell (eds.). *Environmental Perception and Behavior: An Inventory and Prospect.* Research Paper No. 209. Department of Geography, University of Chicago, Chicago: 33-59.

Myers, T. A., E. W. Maibach, C. Roser-Renouf, K. Akerlof and A. A. Leiserowitz. 2012. "The Relationship between Personal Experience and Belief in the Reality of Global Warming." *Nature Climate Change.* 3(4):343-47. doi: 10.1038/Nclimate1754.

Olson-Hazboun, Shawn K., Peter D. Howe, and Anthony Leiserowitz. 2018. “The Influence of Extractive Activities on Public Support for Renewable Energy Policy.” *Energy Policy* 123 (December): 117–26. https://doi.org/10.1016/j.enpol.2018.08.044.

Sampson, Robert J. 2012. *Great American City: Chicago and the Enduring Neighborhood Effect*: University of Chicago Press.

Safford, T. G., J. D. Ulrich and L. C. Hamilton. 2012. "Public Perceptions of the Response to the Deepwater Horizon Oil Spill: Personal Experiences, Information Sources, and Social Context." *Journal of Environmental Management.* 113:31-39. doi: 10.1016/j.jenvman.2012.08.022.

Safford, T. G. and L. C. Hamilton. 2012. "Demographic Change and Shifting Views About Marine Resources and the Coastal Environment in Downeast Maine." *Population and Environment.* 33(4):284-303. doi: 10.1007/s11111-011-0146-0.

Scannell, L., & Gifford, R. 2010(a). "Defining place attachment: A tripartite organizing framework." *Journal of environmental psychology*. 30(1): 1-10.

Scannell, L., & Gifford, R. 2010(b). "The relations between natural and civic place attachment and pro-environmental behavior." *Journal of environmental psychology*. 30(3): 289-297.

Scannell, L., & Gifford, R. 2013. "Personally relevant climate change: The role of place attachment and local versus global message framing in engagement." *Environment and Behavior*. 45(1): 60-85.

Shao, Wanyun. 2016. "Are Actual Weather and Perceived Weather the Same? Understanding Perceptions of Local Weather and Their Effects on Risk Perceptions of Global Warming." *Journal of Risk Research.* 19(6):722-42.

Shao, Wanyun, James C. Garand, Barry D. Keim and Lawrence C. Hamilton. 2016. "Science, Scientists, and Local Weather: Understanding Mass Perceptions of Global Warming." *Social Science Quarterly.* 97(5):1023-57.

Shao, W. Y., B. D. Keim, J. C. Garand and L. C. Hamilton. 2014. "Weather, Climate, and the Economy: Explaining Risk Perceptions of Global Warming, 2001-10." *Weather, Climate, and Society.* 6(1):119-34. doi: 10.1175/Wcas-D-13-00029.1.

Shao, W., & Goidel, K. 2016. "Seeing is believing? An examination of perceptions of local weather conditions and climate change among residents in the US Gulf Coast." *Risk Analysis*. 36(11): 2136-2157.

Shwom, R., A. Dan and T. Dietz. 2008. "The Effects of Information and State of Residence on Climate Change Policy Preferences." *Climatic Change*. 90(4):343-58. doi: 10.1007/s10584-008-9428-7.

Smith, Keith and Graham A. Tobin. 1979. "Human Adjustment to the Flood Hazard." School of Geosciences Faculty and Staff Publications. 43. http://scholarcommons.usf.edu/geo_facpub/43.

Slovic, Paul. 1993. "Perceived Risk, Trust, and Democracy." *Risk Analysis.* 13(6):675-82.

Spence, Alexa, Wouter Poortinga, Catherine Butler and Nicholas Frank Pidgeon. 2011. "Perceptions of Climate Change and Willingness to Save Energy Related to Flood Experience." *Nature Climate Change.* 1(1):46-49.

Stedman, R. C. 2002. "Toward a social psychology of place: Predicting behavior from place-based cognitions, attitude, and identity." *Environment and behavior*. 34(5): 561-581.

Stedman, R. C. 2003. "Is it really just a social construction?: The contribution of the physical environment to sense of place." *Society &Natural Resources*. 16(8): 671-685.

Stedman, R. C., & Ingalls, M. 2014. "Topophilia, biophilia and greening in the red zone." Pp 129-144 in *Greening in the red zone*, edited by Keith G. Tidball and Marianne E. Krasny. Springer, Dordrecht.

Stern, P. C. and T. Dietz. 1994. "The Value Basis of Environmental Concern." *Journal of Social Issues*. 50(3):65-84.

Thomas, David S.G., Chasca Twyman, Henny Osbahr and Bruce Hewitson. 2007. "Adaptation to Climate Change and Variability: Farmer Responses to Intra-Seasonal Precipitation Trends in South Africa." *Climatic Change.* 83(3):301-22.

Van Liere, Kent D. and Riley E. Dunlap. 1980. "The Social Bases of Environmental Concern: A Review of Hypotheses, Explanations and Empirical Evidence." *Public Opinion Quarterly.* 44(2):181-97.

Vorkinn, M., & Riese, H. 2001. “Environmental concern in a local context: The significance of place attachment.” *Environment and behavior*. 33(2): 249-263.

Walker, A. J., & Ryan, R. L. 2008. “Place attachment and landscape preservation in rural New England: A Maine case study.” *Landscape and urban planning*. 86(2): 141-152.

Weber, Elke U. 2010. "What Shapes Perceptions of Climate Change?". *Wiley Interdisciplinary Reviews: Climate Change.* 1(3):332-42.

Weinstein, Neil D. 1989. "Optimistic Biases About Personal Risks." *Science.* 246(4935):1232-34.

Whitmarsh, Lorraine. 2008. "Are Flood Victims More Concerned About Climate Change Than Other People? The Role of Direct Experience in Risk Perception and Behavioural Response." *Journal of Risk Research.* 11(3):351-74.

Wilhelmi, Olga V. and Mary H. Hayden. 2010. "Connecting People and Place: A New Framework for Reducing Urban Vulnerability to Extremeheat." *Environmental Research Letters*. 5(1):014021.

Wolf, Johanna, W. Neil Adger, Irene Lorenzoni, Vanessa Abrahamson and Rosalind Raine. 2010. "Social Capital, Individual Responses to Heat Waves and Climate Change Adaptation: An Empirical Study of Two Uk Cities." *Global Environmental Change.* 20(1):44-52.

Wood, B. Dan and Arnold Vedlitz. 2007. "Issue Definition, Information Processing, and the Politics of Global Warming." *American Journal of Political Science.* 51(3):552-68.

Zaval, Lisa, Elizabeth A. Keenan, Eric J. Johnson and Elke U. Weber. 2014. "How Warm Days Increase Belief in Global Warming." *Nature Climate Change.* 4(2):143-47.

Table 1. Survey Wave Information

Survey wave	Sample	N (unweighted)	Response Rate
April 2013	2,222	1,045	47%
December 2013	3,453	830[1]	48%
April 2014	3,389	1,384	48%
March 2016	2,459	1,317	55%
November 2016	2,636	1,226	51%
May 2017	2,506	1,266	51%

1. In December 2013 the sample was split for experimental design purposes. The sample we retained for these analyses were surveyed using the term "global warming," which is the standard language used across all CCAM surveys. The other half of the sample were surveyed using the term "climate change" for experimental purposes.

Table 2. Respondent socio-demographics.

Demographic characteristic	N	Descriptive Statistics
Age	5,286	Mean = 52, Median = 54, Range = 18-94
Gender	5,286	49.7% Female, 50.3% Male
Race/Ethnicity	5,286	74.95% White, 9.74% Hispanic, 8.91% Black, 3.58% Other, 2.82% Two or more races
Education	5,286	6.87% Less than high school, 26.73% High school/GED, 29.53% Some college/Associate's, 36.87% Bachelor's or higher
Income	5,286	< $25k - 14.95% $25-$49k - 21.6% $50-74k - 19.32% $75-99k - 14.68% $100-124k - 12.32% $125k or > - 17.14%

Table 3. Independent Variables from CCAM Surveys.

Variable	Range	Mean (Standard Deviation)	N
Individual-level Characteristics			
Age	1 (18-24), 2 (25-34), 3 (35-44), 4 (45-54), 5 (55-64), 6 (65-74), 7 (65+)	4.22 (1.70)	5,286
Gender	0 (Male), 1 (Female)	1.50 (0.50)	5,286
Education	1 (<high school), 2 (high school), 3 (some college), 4 (Bachelor's or higher)	2.95 (0.95)	5,286
Household Income	1 (<$25,000), 2 ($25,000-$34,999), 3 ($35,000-$49,999) 4 ($50,000-$74,999), 5 ($75,000-$99-999), 6 ($100,000+)	3.38 (1.68)	5,286
Race/ethnicity	1 (White, non-Hispanic), 2 (Hispanic), 3 (Black, non-Hispanic), 4 (Other/Multiracial)	1.56 (1.12)	5,286
Ideology	1 (Very conservative), 2 (Somewhat conservative), 3 (Moderate), 4 (Somewhat liberal), 5 (Very liberal)	2.87 (1.07)	5,286
Worried about GW	1 (Not at all worried), 2 (Not very worried), 3 (Somewhat worried), 4 (Very worried)	2.53 (0.966)	5,286
Coastal Shoreline County, Census Division, and CCAM Survey Wave			
Coastal Shoreline County	0 (non-coastal shoreline), 1 (coastal shoreline)	0.36 (0.48)	5,286
Census Division	1 (New England), 2 (Mid-Atlantic), 3 (East-North Central), 4 (West-North Central), 5 (South Atlantic), 6 (East-South Central), 7 (West-South Central), 8 (Mountain), 9 (Pacific)	N/A	5,286
Survey Wave	Six dichotomous indicators for each wave of participation	--	--

Table 4. Climate Extremes Index (CEI) Indicators

Variable	Range	Mean (Standard Deviation)	N
3-month average CEI	2.42 – 66.84	31.62 (16.67)	5,247
30-year CEI anomaly	-15.8 – 47.64	12.101 (17.15)	5,247

Table 5: Weighted Mixed Effects Ordered Logistic Regression of "Global Warming Affecting the Weather" on Individual- and Place-level Factors

	Model 1	*Model 2*	*Model 3*
Independent Variables	*Odds Ratio (95% conf.)*	*Odds Ratio (95% conf.)*	*Odds Ratio (95% conf.)*
Individual characteristics			
Age	1.035** (1.006 - 1.065)	1.034* (1.005 - 1.064)	1.110*** (1.077 - 1.144)
Gender (Female)	1.336*** (1.212 - 1.472)	1.338*** (1.214 - 1.475)	1.158* (1.045 - 1.283
Education	1.127*** (1.068 - 1.190)	1.120*** (1.062 - 1.183)	.979 (.925 - 1.037)
Household Income	.986 (.954 - 1.018)	.983 (.952 - 1.015)	.983 (.950 - 1.017)
Hispanic	1.656*** (1.422 - 1.928)	1.607*** (1.378 - 1.873)	1.144 (.973 - 1.344)
Black, non-Hispanic	1.293*** (1.105 - 1.513)	1.222** (1.042 - 1.432)	1.060 (.894 - 1.258)
Other, non-Hispanic	1.415*** (1.153 - 1.736)	1.336** (1.086 - 1.644)	.942 (.757 - 1.173)
Multiracial, non-Hispanic	1.031 (.668 - 1.590)	.984 (.632 - 1.532)	.864 (.545 - 1.370)
Worried about GW			4.923*** (4.575 - 5.297)
Ideology			1.504*** (1.421 - 1.592)
Survey Wave	NS	NS	NS
Place characteristics			
Coastal Shoreline County		1.324*** (1.184 - 1.482)	1.148** (1.027 - 1.284)
3-month RCEI		.950 (.909 - .993)	.979 (.939 – 1.023)
30-year RCEI anomaly		1.053 (1.007 - 1.100)	1.022 (.980 – 1.022)
Random Intercept			
	Std. Dev. (95% conf.)	*Std. Dev. (95% conf.)*	*Std. Dev. (95% conf.)*
Census Division	.025*** (.007 - .088)	.010** (.002 - .057)	.003+ (.000 - .044)
N	5,286	5,247	5,247
Wald chi^2	104.15***	132.81***	2,559.44***
+-p<0.1 *-p<.05, **-p<.01, ***-p<.001			

Figure 1. Mean Scale Responses to "Global Warming Affecting the Weather" by Ideological Orientation and Coastal Shoreline versus Inland Residence