

Short Communication

Regional variation in perceptions about climate change

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ABSTRACT: A 2007 survey covering rural areas in nine US states provides data on perceived local impacts of climate change. Perceptions vary from region to region, with a pattern suggesting links to real climate – specifically to winter warming in snow country. A multivariate analysis using mixed-effects ordered logit regression confirms a significant perception-temperature relationship, net of individual background and ideological characteristics, and of regional variations. These findings invite more detailed research. Copyright © 2009 Royal Meteorological Society

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1. Introduction

Recent physical data show that climate change is in progress, but with noteworthy regional and interannual variations (IPCC, 2007a, 2007b, 2007c, 2007d). A 2007 survey covering rural areas in nine US states provides data on regional variations in *perceptions* about climate change. Perceptions appear different from region to region, with a pattern suggesting links to real climate.

The Community and Environment in Rural America (CERA) survey, carried out by Carsey Institute researchers in 2007, aimed to learn how people in different rural areas viewed changes in their communities, local environments and in their own lives. The first stage involved telephone interviews with 7842 people living in 19 rural counties of 9 states (Figure 1). Following an examination of data on all US counties, these 19 were chosen to represent geographically and socioeconomically diverse types of rural places. They represent a broad range of physical climates within the conterminous United States as well.

Random-sample telephone interviews with about 100 questions covered topics ranging from respondents' personal background and experiences (such as family, jobs, education and life situation) to their migration history and views about their local government and community. We calculated probability weights to offset design bias arising from household size, and made minor adjustments toward census age/sex/race distributions within each region. Site selection, sampling methods, question wording and basic

results are described in a report by Hamilton *et al.* (2008); also see (Hamilton, 2007a, 2007b).

2. Regional Variation

CERA results showed strong regional contrasts. For example, 47% of the respondents from Colorado mountain counties, but only 7% from Kansas farm counties, agreed that urban sprawl or rapid development had major effects on their family or community over the past 5 years. Regional perceptions about sprawl correlate with objectively measured population growth.

The *sprawl* question was among a set of five items that included one on climate change:

I'm going to read a list of environmental issues that might be problems in some rural places. With regard to the place where YOU live, for each issue I'd like to know whether you think this has had no effect, had minor effects or had major effects ON YOUR FAMILY OR COMMUNITY OVER THE PAST 5 YEARS?

*Conversion of farmland to other uses
Loss of forestry jobs or income
Water quality or supply problems
Global warming or climate change
Urban sprawl or rapid development of the countryside*

Question wording was deliberately broad, to encompass variations in local conditions. Figure 2 shows responses to the *climate* question by region. Major or minor effects were reported by 70% of northern New Hampshire respondents, and 63% of those in western Maine, but only 48% from Kansas.

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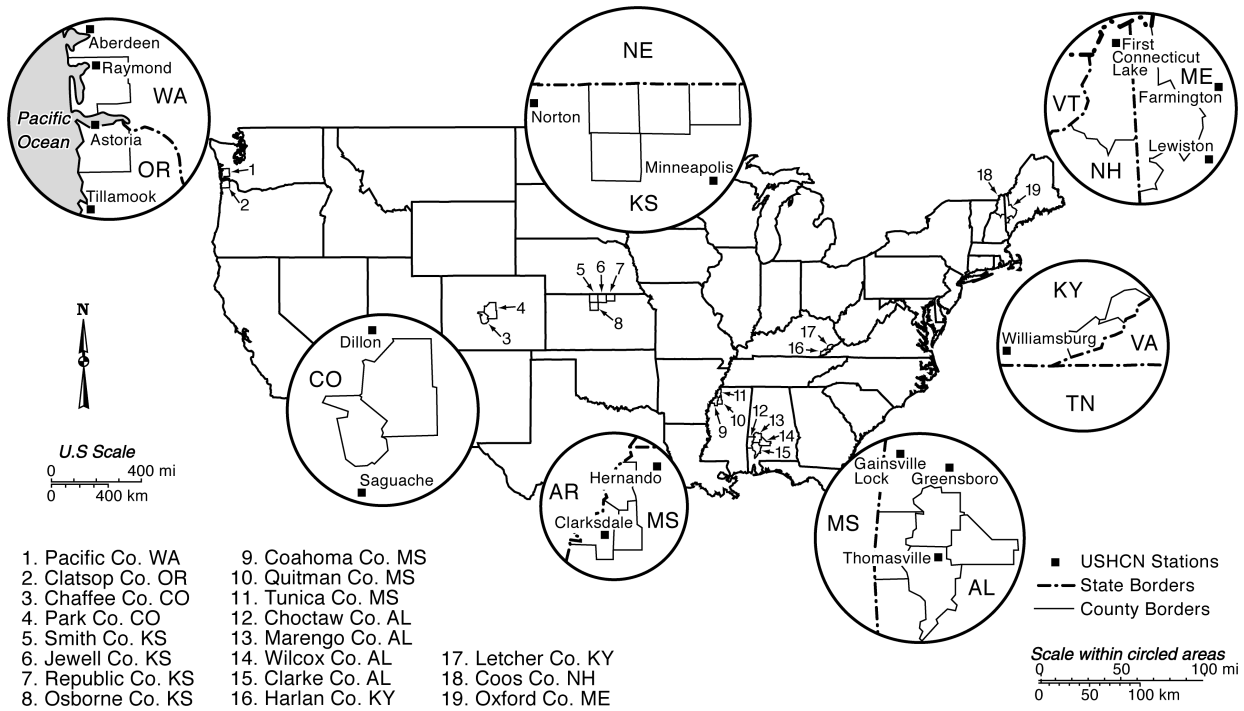


Figure 1. Counties sampled by the 2007 CERA telephone surveys, representing selected rural regions. Insets show climate stations used from the United States Historical Climate Network.

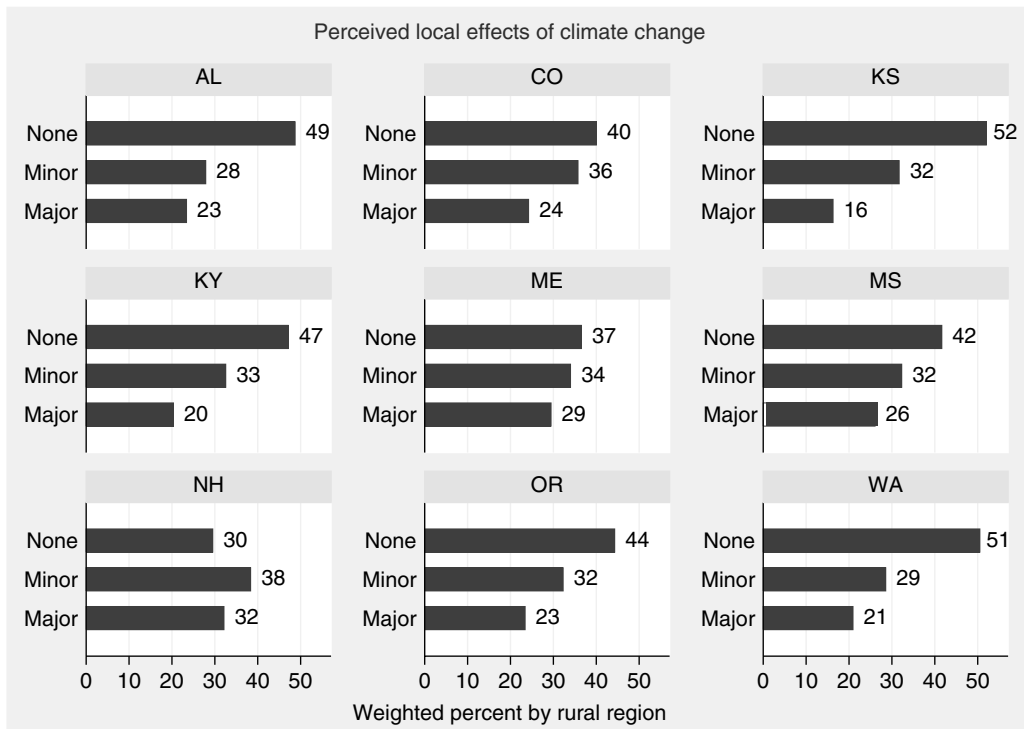


Figure 2. Perceived effects of climate change on respondent's community or family, by CERA region. This figure is available in colour online at www.interscience.wiley.com/ijoc

Looking at these results, we noticed that the three regions showing the highest levels of concern represent snow-country areas (in northern New Hampshire, western Maine and central Colorado) that recently experienced trends toward warmer and less-snowy winters, with newsworthy impacts on winter recreation, forest health

and daily life (Hamilton *et al.*, 2003, 2007; NERA, 2001; USGCRP, 2003). Does the pattern of *climate* responses in Figure 2 partly reflect a winter-warming effect, as the pattern of *sprawl* responses reflects population growth?

To explore this idea, we constructed rough indicators based on temperature records from the United States

Historical Climate Network USHCN; (Karl *et al.*, 1990, 1996). Temperature data include adjustments to correct for biases induced by invalid outliers, changes in time of observation, changes in instrumentation and random relocations of stations and urban warming. As a result, these data provide the best opportunity to capture local and regional temperature trends (e.g. Allard and Keim, 2007; Trombulak and Wolfson, 2004; Keim *et al.*, 2003). We used an updated (2007) version of this dataset, made available recently through the National Climatic Data Center. Stations near the county clusters were selected to estimate regional temperature trends (Figure 1).

Monthly, seasonal and annual temperatures were derived from average monthly minimum and maximum temperature data. Winter temperatures were used because of our observation about Figure 2, and also because they exhibit greater interannual variability, which could result in more noticeable impacts (e.g. the duration and depth of snow cover, or persistence of ice over lakes) than milder variations in warm-season temperatures. A 38-year window (1970–2007) should capture modern climate change as indicated by the upswing in global temperatures.

To estimate trends we fit a mixed-effects model of the form

$$temp_{ij} = \beta_0 + \beta_1 year_{ij} + \zeta_{0j} + \zeta_{1j} year_{ij} + \epsilon_{ij} \quad (1)$$

where $temp_{ij}$ is average winter (DJF) temperature for year i in rural region j . $Year$ simply denotes calendar year (1970, 1971, ... 2007). The β parameters represent fixed effects – intercept (β_0) and slope (β_1) of temperature trends for all places considered together. ζ_j parameters represent random intercepts (ζ_{0j}) and slopes (ζ_{1j}) unique to each region. ϵ_{ij} are random disturbances, representing everything else (besides linear trends) causing year-to-year variation in temperatures. Rabe-Hesketh and Skrondal (2008) provide a detailed account of mixed-effects modeling (also see StataCorp 2007; Hamilton 2009). Trends for the j th region were estimated by adding the fixed slope (β_1) to the best linear unbiased prediction of that region's random slope (ζ_{1j}).

Figure 3 integrates survey and climate data by graphing responses to the *climate* question (Figure 2) against winter temperature slopes ($\beta_1 + \zeta_{1j}$ from (1)). Consistent with our hypothesis, perceptions of climate-change effects tend to be higher in regions that experienced the most winter warming. New Hampshire was highest on both counts, with the greatest proportion of respondents perceiving climate-change effects, and also the steepest winter temperature increase. Maine and Colorado respondents were not far behind. We performed similar analyses using annual and other-season temperature trends, but found the most consistent effects for winter.

Two regions, in the Mississippi delta and Kansas farm country, depart noticeably from the pattern of perceived impacts rising with observed winter temperature trends. In post-Katrina Mississippi, some respondents, no doubt, had hurricanes or flooding in mind as an 'effect of climate change.' Furthermore, in the years just prior to the

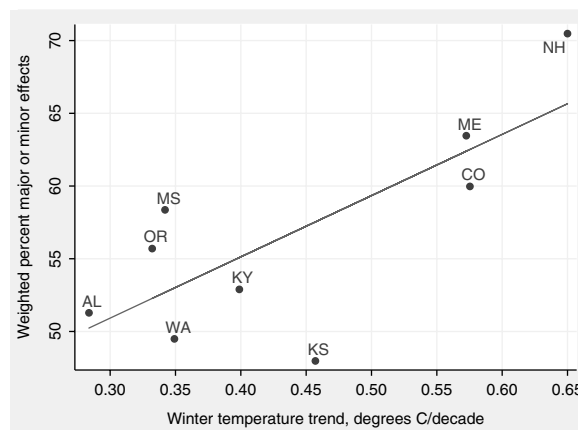


Figure 3. Weighted percent perceiving climate change effects *versus* winter temperature trends by region. Robust regression line shown is resistant to outliers and does not assume normality ($p = .026$; see Hamilton, 2009). This figure is available in colour online at www.interscience.wiley.com/ijoc

survey, the US Drought Monitor depicts frequent drought conditions in this agricultural region. The Mississippi anomaly highlights limitations of our one-dimensional climate indicator and scope for improvement in future research, which should include weather and climate extremes.

The Kansas anomaly, on the other hand, likely reflects social rather than climatic complexity. People in the rural Kansas region surveyed are politically conservative, more so than any others in this study (Hamilton, 2007b). US public opinion surveys consistently find that political orientation shapes views about climate change.

3. Individual and Regional Effects

Figure 3 encourages speculation that climate might influence perceptions. At the same time, scatter around the line emphasizes that other things also influence perceptions. Previous studies have identified a number of ideological, socioeconomic and demographic factors related to opinions about climate change (Dietz *et al.*, 2007; Dunlap, 2008; Finucane *et al.*, 2000; Kahan *et al.*, 2005; Krosnick *et al.*, 2006; Hamilton, 2008; Wood and Vedlitz, 2007), and have also noted regional variation (Shwom *et al.*, 2008).

Our next step involves testing whether temperature trends have a detectable effect net of individual characteristics, and also net of regional variations unrelated to temperature. Modelling by mixed-effects ordered logit regression (Rabe-Hesketh and Skrondal, 2008; also see Hosmer and Lemeshow, 2000; Long, 1997) suits the ordinal *climate* variable, and allows for geographical variations or clustering that would bias estimation in a one-level model.

Table 1 displays results from the regression of *climate* on individual characteristics and regional temperature trends, with random intercepts. Individual-level predictors include eight demographic, socioeconomic or ideological indicators suggested by previous research. In

Table I. Mixed-effects ordered logit regression of perceived local effects from climate change (Figure 2) on characteristics of individual respondents and winter temperature trends (Figure 3).

Predictors	coef.	SE	p (z)
Individual-level fixed effects			
<i>sex</i> (0=male, 1=female)	.238	.054	.000
<i>race</i> (0=white non-Hispanic, 1=other)	.062	.089	.483
<i>age</i> (18 to 96 years)	-.003	.002	.067
<i>income class</i> (1 to 6 scale for household quintiles & top 5%)	-.056	.020	.005
<i>education</i> (1=8th grade or less, 7=postgraduate; centered)	-.017	.017	.313
<i>party</i> (1=strong Democrat, 7=strong Republican; centered)	-.149	.012	.000
<i>education</i> × <i>party</i> (interaction term)	-.024	.007	.001
<i>religious</i> (0=never attend services, 4=twice or more/week)	-.060	.020	.002
<i>newcomer</i> (0=lived here >5 years, 1=lived here ≤ 5 years)	-.008	.073	.917
cut1	.280	.232	
cut2	1.770	.234	
Region-level fixed effects			
<i>winter temperature trend</i> (°C/decade)	1.923	.409	.000
Region-level random intercept			
Standard deviation	.127	.105	.008

addition to *education* and political *party*, we include the interaction term *education* × *party*.

Table 1 shows that, other things being equal, local climate-change effects are less often perceived by respondents who are male or high-income – findings consistent with studies of risk perception (Finucane *et al.*, 2000; Kahan *et al.*, 2005). Race, age and newcomer status have no significant effects.

Republican party identification and more frequent religious-service attendance reduce the probability of perceiving climate-change effects. Other researchers have noted that ideological predispositions can filter how people process information (Krosnick *et al.*, 2006; Shwom *et al.*, 2008; Wood and Vedlitz, 2007). Individuals with conservative ideologies tend to discount anthropogenic climate change (Dietz *et al.*, 2007; Dunlap, 2008; Dunlap and McCright, 2008; Pew Research Center, 2006, 2007).

One recent poll found a proportion believing that global warming is real increased with education among Democrats, and decreased with education among Republicans (Pew Research Center, 2007). This interaction reflects efforts to reframe climate change from a nonpartisan science question to a political wedge issue through arguments aimed at educated voters (Freudenburg, 2000; Jacques *et al.*, 2008; McCright and Dunlap, 2000, 2003, 2008; UCS, 2007). Multivariate analyses of other data

have detected similar effects (Hamilton, 2008, 2009). We therefore hypothesized that the *education* × *party* interaction effect should be negative; Table 1 confirms this. Among Democrats, increasing education is associated with higher probability of perceived effects. Among Republicans, the opposite is true.

Winter warming increases the probability of perceiving local climate change – even after adjusting for individual demographic, socioeconomic or ideological predictors, and for unexplained regional differences. In fact, temperature trends appear second only to political party as the strongest single predictor. Table 1 thus supports the hypothesis that a real climate signal, distinguishable from social and regional effects, underlies these survey responses – despite the broad indicators used.

A likelihood-ratio test confirms that the model with random intercepts fits better ($p = .008$) than a similar model with fixed effects only. In other words, there exists significant regional variation not explained by other variables in the model. More elaborate models including random slopes do not bring further improvement.

4. Discussion

Our perceptions and climate-change indicators are very simple, but nevertheless exhibit statistically significant relationships with the expected sign, both in aggregate-level bivariate analysis and in individual-level multivariate analysis controlling for background characteristics and regional variation.

Figure 3 suggests that our findings partly reflect warming winters in snow country, which have had important and much-discussed impacts (Huntington *et al.*, 2004). This intuitively appealing idea parallels earlier CERA findings of relationships between perceived impacts of urban sprawl and actual population growth, and between opinions favouring conservation over jobs and local unemployment. In each case, CERA questions referred to local impacts, which could boost their connection to objective local conditions.

The relatively strong impacts perceived by respondents in the Mississippi Delta, where floods, droughts or hurricanes are more salient than warming winters, underlines the desirability of using multiple indicators in future research. We suspect that specific, multidimensional climate indicators, matched with similarly specific survey questions, could uncover stronger perception–climate relationships than those observed using very general one-dimensional indicators in our study. Developing multidimensional climate indicators for integration with survey research would itself be a substantial project, needing more geographical diversity (or degrees of freedom) than the nine regions described here.

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