

## Education, politics and opinions about climate change evidence for interaction effects

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**Abstract** U.S. public opinion regarding climate change has become increasingly polarized in recent years, as partisan think tanks and others worked to recast an originally scientific topic into a political wedge issue. Nominally “scientific” arguments against taking anthropogenic climate change seriously have been publicized to reach informed but ideologically receptive audiences. Reflecting the success of such arguments, polls have noted that concern about climate change increased with education among Democrats, but decreased with education among Republicans. These observations lead to the hypothesis that there exist interaction (non-additive) effects between education or knowledge and political orientation, net of other background factors, in predicting public concern about climate change. Two regional telephone surveys, conducted in New Hampshire ( $n = 541$ ) and Michigan ( $n = 1,008$ ) in 2008, included identical climate-change questions that provide opportunities to test this hypothesis. Multivariate analysis of both surveys finds significant interactions. These empirical results fit with theoretical interpretations and several other recent studies. They suggest that the classically identified social bases of concern about the environment in general, and climate in particular, have shifted in recent years. Narrowcast media, including the many Web sites devoted to discrediting climate-change concerns, provide ideal conduits for channeling contrarian arguments to an audience predisposed to believe and electronically spread them further. Active-response Web sites by climate scientists could prove critical to counterbalancing contrarian arguments.

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## 1 Introduction

The accumulating scientific evidence about climate change appears, at first glance, not to have moved U.S. public opinion very far. Despite recent outbursts of media coverage regarding extreme weather, Arctic ice and endangered polar bears, along with the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC 2007a, b, c, d) and the Oscar-winning film *An Inconvenient Truth*, surveys detect little rise in overall public concern (Newport 2008; Nisbet and Myers 2007). Americans rank global warming as a low priority (Pew 2007), with a majority believing it poses no threat in their lifetimes (Newport 2008). These patterns seem unusual not just for their contrast with the science and news headlines, but for their contrast with public opinion in other nations as well. The Pew Global Attitudes Project found that among people of 15 industrialized countries surveyed, only the Chinese expressed comparably low levels of concern (Pew 2006, also see Lorenzoni and Pidgeon 2006).

Apparent U.S. complacency masks two divergent trends. Public opinion has grown increasingly polarized along political or ideological lines, even while the average changed little. The percentage of Democrats agreeing that global warming has begun rose gradually over a 10-year period, from 47% in 1998 to 76% in 2008. Over the same years the percentage among Republicans declined from 46 to 41% (Dunlap and McCright 2008). By 2008, 59% of Republicans, compared with only 18% of Democrats, believed that the seriousness of global warming was generally exaggerated in the news. Other polls have found similar results (e.g., Pew 2006).

The politicization of what was originally a scientific question has not been accidental. Polarization reflects the opposition between conservative campaigns promoting the views of a small number of “skeptical” or contrarian scientists to argue against greenhouse gas reductions, on the one hand (as documented by Jacques et al. 2008; McCright and Dunlap 2000, 2003; UCS 2007), and publications of the wider scientific consensus (such as the IPCC) supported by liberal and environmental activists (such as Al Gore, with *An Inconvenient Truth*) on the other. Contrarian arguments, although couched in nominally scientific terms (for example, regarding changes in polar ice sheets), largely bypassed the science processes of peer-reviewed journals and meeting presentations. Instead, they directly addressed policymakers and the issue-aware public through books, reports and editorials, supplying people with a choice of which “experts” to believe. If more educated audiences paid closer attention to the competing scientific claims, and selectively retained information that seemed to conform with their background beliefs, that could account for the opposite correlations observed between education and the climate-change views of conservatives and liberals.

Social scientists have a substantial literature concerning “the social bases of environmental concern”—studies of demographic, ideological and other individual characteristics as predictors of concern about environmental problems. Recently, a number of authors have extended this tradition to study the social bases of concern about climate change or global warming (e.g., Dietz et al. 2005, 2007; Dunlap and McCright 2008; Finucane et al. 2000; Hamilton 2008; Hamilton and Keim 2009;

Kahan et al. 2005; Krosnick et al. 2006; Wood and Vedlitz 2007).<sup>1</sup> The first-order poll findings about education and political orientation cited above suggest that in at least one important respect, the social bases of environmental concern could be *changing*. Education no longer has a simple positive effect on concern.

This paper presents tests of non-additive or *interaction* hypotheses involving education (or information) and political orientation, drawing on two regional surveys conducted in 2008. Despite substantial differences between the locations, timing, content and goals of the two surveys, both show interaction effects.

## 2 Data and methods

Data for this analysis come from two random-sample telephone surveys. The first is the Granite State Poll (GSP), a statewide survey of political and other opinions conducted quarterly by the University of New Hampshire's Survey Research Center. In January 2008, the Granite State Poll included several questions about global warming, in addition to its usual range of background and political-opinion items. The Granite State Poll achieves prominence every 4 years during New Hampshire's presidential primary season, and employs standard, well-validated techniques for obtaining representative samples of the state's adult population.

The second data source is a survey of residents from five rural counties (Alger, Chippewa, Luce, Mackinac and Schoolcraft) on Michigan's Upper Peninsula, conducted in August 2008. The Michigan survey formed part of the Community and Environment in Rural America (CERA) project, a large-scale study of selected rural U.S. regions (Hamilton et al. 2008). Like the Granite State Poll, the Michigan CERA survey sought a representative sample of the adult population in its target area. Census age–sex–race tables for these five counties affirmed that sampling had been successful. For both surveys, probability weights permit minor adjustments for design and sampling bias, and have been applied to all analyses in this paper.

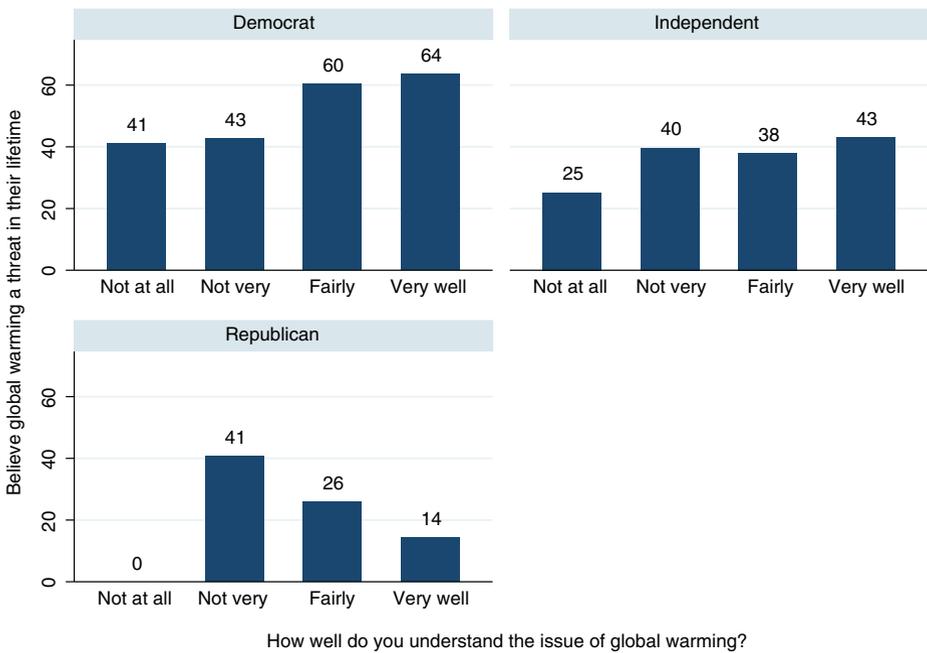
The New Hampshire and Michigan surveys had different content and goals, in addition to their geographically and socioeconomically disparate samples. The two surveys did, however, include two identical items about global warming, which had also been asked on a 2008 Gallup Poll. These items, *understand* and *threat*, appear at the top of Table 1. The table also lists definitions and responses to four background

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<sup>1</sup>Scientists often prefer to discuss “climate change” rather than “global warming,” because the former term better expresses the complexity of shifts that could include regional cooling despite average warming, as well as other changes in seasonality, variability or extreme events. In public discourse, however, the terms tend to be used interchangeably, with “global warming” more common — as on most surveys.

**Table 1** Definitions of variables, with weighted summaries of responses to the Granite State Poll (GSP) survey of New Hampshire residents conducted in January 2008 ( $n = 541$ ), and the Community and Environment in Rural America (CERA) survey of Upper Peninsula, Michigan residents conducted in August 2008 ( $n = 1,008$ ). Responses to similar global-warming questions on a Gallup poll of U.S. adults in March 2008 are shown for comparison (from Newport 2008)

	New Hampshire (GSP)	Upper Michigan (CERA)	US (Gallup)
<i>Understand</i> —"Next, thinking about the issue of global warming, sometimes called the 'greenhouse effect,' how well do you feel you understand this issue—would you say very well, fairly well, not very well, or not at all?"			
1 DK/not at all	3%	3%	10%
2 Not very well	13%	16%	10%
3 Fairly well	51%	56%	59%
4 Very well	33%	25%	21%
<i>Threat</i> —"Do you think that global warming will pose a serious threat to you or your way of life in your lifetime, or not?"			
0 No	54%	64%	58%
1 Yes	41%	31%	40%
. DK	5%	5%	2%
<i>Gender</i>			
0 Male	48%	49%	
1 Female	52%	51%	
<i>Age</i> —"What is your current age?" (means)			
	52.2	48.1	
<i>Education</i> —"What is the highest grade in school, or level of education that you've completed and got credit for?" (CERA used a 7-category scale, combined into 4 categories for this table)			
1 High school or less	24%	32%	
2 Tech. school/some college	23%	30%	
3 College graduate	32%	24%	
4 Postgraduate work	20%	12%	
. No answer	1%	3%	
<i>Party</i> —"Generally speaking, do you usually think of yourself as a Democrat, a Republican, an Independent or what?"			
1 Strong Democrat	21%	15%	
2 Not very strong Democrat	9%	11%	
3 Independent, closer Dem.	19%	12%	
4 Independent—closer neither	18%	18%	
5 Independent, closer Rep.	11%	9%	
6 Not very strong Republican	7%	11%	
7 Strong Republican	16%	13%	
. Other, no answer	0%	11%	



**Fig. 1** Weighted percent of New Hampshire respondents reporting they think that global warming will pose a serious threat in their lifetime (*threat*), by self-assessed understanding of the issue (*understand*) and political party identification (simplified from *party*)

questions, similar enough across GSP and CERA to be used for comparison.<sup>2</sup> Confidence intervals are all less than  $\pm 5\%$ .

A majority of respondents on all three surveys said that they understood global warming “fairly well.” More confident “very well” responses occurred most often in New Hampshire (33% vs. 25% or 21%; for comparison with historical Gallup results see Nisbet and Myers 2007:448). This could reflect the state’s politically engaged (e.g., high voter turnout; see USEP 2009) and well-educated population. Fifty-two percent of the New Hampshire respondents reported having college degrees, compared with only 36% of the Upper-Peninsula Michigan respondents.

Despite high levels of self-assessed understanding among New Hampshire respondents, just 41% believed that global warming would pose a serious threat in their lifetime—similar to Gallup’s 40% national value, and well above that for Michigan (31%). Design-weighted *F* tests (not shown) found no significant relationship between *understand* and *threat* in either the New Hampshire or Michigan surveys, contrary to what climate researchers might hope.

<sup>2</sup>Other studies, including those in Table 3, often consider race among the background predictors. The New Hampshire and rural Michigan samples are relatively homogeneous in that respect, however. The simple 7-point scale for political party preference has proven useful on political opinion polls, including many connected with the 2008 presidential election. A more nuanced review of the ideological dimensions of public support for environmental protection appears in Dunlap et al. (2001).

The puzzling appearance of no relationship between *understand* and *threat* is clarified when we break it down politically, as done with the New Hampshire survey in Fig. 1. Democratic or Democrat-leaning respondents (categories 1–3 of *party*) appear at top left in this graphic, with Republicans (categories 5–7 of *party*) at bottom left. Among Democrats, the better they think they understand the issue, the more likely they are to perceive warming as a threat. A weaker version of this pattern occurs among Independents. Among Republicans, however, the better they think they understand the issue, the *less* likely they are to perceive a threat. No Republican said they did not understand it at all. Sixty-four percent of the Democrats who understand “very well” see a threat, compared with just 14% of Republicans.

Self-assessed understanding, of course, is not the same as objectively measured knowledge (Nisbet and Myers 2007). One analysis using quiz-based measures from the General Social Survey (GSS) found just simple positive effects of science knowledge on concern about climate-change impacts, unlike the more complicated effect of self-assessed understanding in Fig. 1 (Hamilton 2008).

### 3 Results

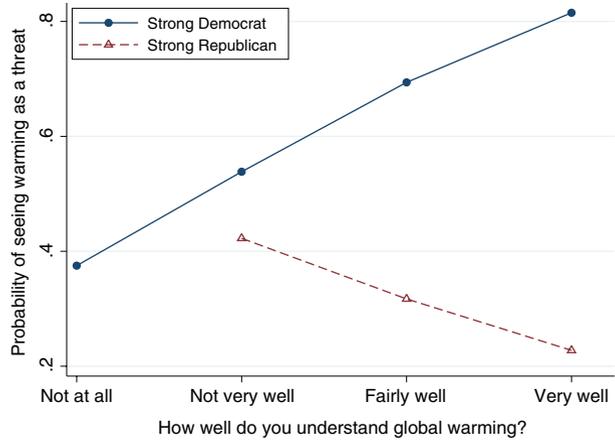
In addition to political orientation, other social-positional factors have been widely shown as predictors of environmental concern (for a recent international example that cites earlier work, see Olofsson and Öhman 2006). The most consistent findings concern age (negatively related to concern) and education (positively related). Gender often proves important, but with less consistent effects. The analyses in this section include age and gender as control variables, statistically adjusting for those previously known relationships as we examine interaction hypotheses involving education, “understanding” and political orientation.

Table 2 shows results from a weighted logit regression of *threat* (perceived threat of global warming) on the other variables listed in Table 1: *gender*, *age*, *education*, political party and self-assessed understanding of global warming. To test for interactions involving *party*, *education* and *understand*, these three variables were centered (re-expressed as mean deviations) and combined into the product terms

**Table 2** Will global warming be a serious threat in your lifetime? Weighted logit regressions of perceived *threat* on background factors, self-assessed understanding and interaction terms, with jackknife standard errors and tests. Variable definitions are shown in Table 1. For this analysis, *education*, *party* and *understand* were centered as mean deviations

Predictors	New Hampshire (GSP)			Upper Michigan (CERA)		
	Coef.	SE	<i>p</i> ( <i>z</i> )	Coef.	SE	<i>p</i> ( <i>z</i> )
<i>Gender</i> (female)	0.974	0.232	0.000	0.699	0.234	0.003
<i>Age</i> in years	−0.031	0.008	0.000	−0.023	0.008	0.003
<i>Education</i>	0.144	0.112	0.197	−0.092	0.082	0.261
<i>Party</i> (Republican)	−0.266	0.060	0.000	−0.211	0.061	0.001
<i>Education</i> × <i>party</i>	−0.035	0.056	0.529	−0.097	0.041	0.018
<i>Understand</i> GW	0.235	0.154	0.128	0.537	0.172	0.002
<i>Understand</i> × <i>party</i>	−0.203	0.081	0.012	−0.097	0.089	0.274
Constant	0.685	0.423	0.106	−0.103	0.466	0.824
	<i>n</i> = 525; <i>F</i> (7, 518) = 7.96, <i>p</i> < 0.001			<i>n</i> = 895; <i>F</i> (7, 884) = 6.93, <i>p</i> < 0.001		

**Fig. 2** Predicted probability that New Hampshire residents believe that global warming will pose a serious threat vs. self-assessed understanding of the issue, for “strong Democrats” and “strong Republicans” (calculated from the first logit model in Table 2, setting other predictors at means)



*education*  $\times$  *party* and *understand*  $\times$  *party*. The jackknife standard errors and tests shown should be more conservative and robust than classical standard errors applied to these survey data.<sup>3</sup>

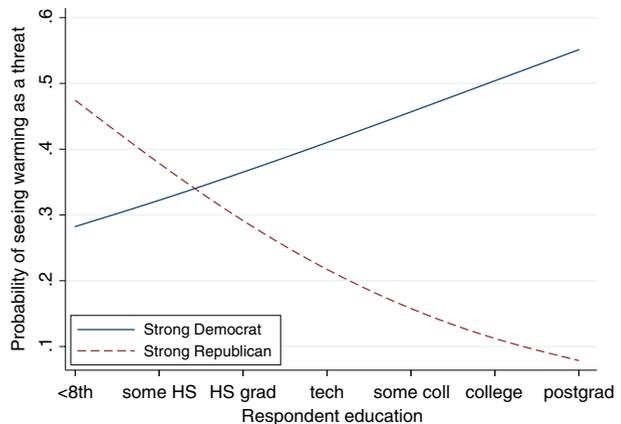
Gender has a positive, significant effect: women more often thought that global warming posed a threat in their lifetime (for good discussions of gender effects on environmental-risk perceptions, see Davidson and Freudenburg 1996; Finucane et al. 2000; Kahan et al. 2005). Older respondents were less likely to see a threat, perhaps partly because their personal horizons extend less far into the twenty-first century. Political party exerts a strong negative effect: as identification with the Republican party increases, respondents became less likely to believe that global warming posed a threat—consistent with other findings that individuals with conservative ideologies tend to discount anthropogenic climate change (Dietz et al. 2007; Dunlap and McCright 2008; Pew 2006, 2007).

Both surveys thus agree on the signs and significance of *gender*, *age* and *party* effects, and also on the nonsignificance of main effects for *education*. We see divergent patterns with regard to the *education*  $\times$  *party* and *understand*  $\times$  *party* interactions. Among New Hampshire respondents, *understand*  $\times$  *party* has a significant effect. Among Michigan respondents, *education*  $\times$  *party* has a significant effect. It is worth noting that whether significant or not, both interactions in both surveys exhibit the expected negative signs. Moreover, *F* tests (not shown) for each survey’s pair of interaction effects (*education*  $\times$  *party* and *understand*  $\times$  *party* both) reject the null hypothesis.

The New Hampshire results serve to illustrate interpretation of such effects. The main effect of *understand* is .235. Because *education*, *party* and *understand* all were centered before generating the interaction terms, we can interpret this as the positive

<sup>3</sup>Jackknife estimation involves resampling the data *n* times, each time leaving out one observation (or in complex surveys, one primary sampling unit). This procedure yields alternative design-based standard errors for hypothesis tests and confidence intervals, with less reliance on theoretical assumptions (StataCorp 2007; also see Hamilton 2009). For both models in Table 2, jackknife estimation produced slightly larger, more conservative standard errors (hence, lower *t* or *F* statistics and higher *p* values) than those calculated from theory.

**Fig. 3** Predicted probability that Upper-Peninsula Michigan residents believe that global warming will pose a serious threat vs. respondent education, for “strong Democrats” and “strong Republicans” (calculated from the second logit model in Table 2, setting other predictors at means)



effect (increased log odds of seeing warming as a threat) of a one-unit increase in understanding, for respondents of average political party identification. Along with reduced multicollinearity, straightforward interpretation of main effects is the chief benefit of centering in this context.<sup>4</sup>

The coefficient on *understand* × *party* is  $-0.203$ . Thus, for respondents who identify themselves as strong Democrats ( $party = 1$ , or as a mean deviation  $1-3.7 = -2.7$ ), the log odds that global warming is perceived as a threat increase by  $.783$  with each one-unit increase in self-reported understanding:

$$.235 + (-2.7 \times -.203) = .783$$

On the other hand, for respondents who identify themselves as strong Republicans ( $party = 7$ , or as a mean deviation  $7-3.7 = 3.3$ ), the log odds that warming is perceived as a threat decrease by  $.435$  with each additional unit of self-reported understanding:

$$.235 + (3.3 \times -.203) = -.435$$

In other words, Democrats who believe they understand global warming better also are more likely to believe that it poses a threat in their lifetimes. Conversely, Republicans who believe they understand global warming better are *less* likely to believe that it poses a threat. Ideology thus affects perceptions of the science behind climate change. The conditional effects plot in Fig. 2 re-expresses logit coefficients in the more intuitive metric of probabilities. It graphs the effect of *understand* on *threat* for extreme values of *party*, with other variables set at their means.

In the Michigan survey an *understand* × *party* interaction was not a significant predictor, but *education* × *party* was. This interaction has a similar flavor, as seen in Fig. 3. The probability of perceiving global warming as a threat increases with education among Democrats, but decreases with education among Republicans. Only two respondents out of a thousand described themselves as “strong Democrats”

<sup>4</sup>OLS variance inflation factors (VIF) were calculated as a check for possible multicollinearity problems involving the predictors in Table 2. The highest VIFs were 1.08 (New Hampshire data) or 1.16 (Michigan data). Values above 10 would be cause for concern; see Chatterjee et al. (2000).

or “strong Republicans” with less than an 8th grade education, so the crossover at far left in Fig. 3 should not be over-interpreted. Setting aside this extreme, threat perceptions are roughly similar among Republicans and Democrats with lower education. They are most divergent among those with higher educations.

#### 4 Discussion

Our data are regional, but these findings have broad implications. First, they are supported by other results. The *education*  $\times$  *party* interaction found among Michigan respondents agrees with findings from several national polls (Dunlap and McCright 2008; Pew 2006). Similar interaction effects have been reported with respect to concern about polar aspects of climate change, using the 2006 General Social Survey (Hamilton 2008). Analysis of the 2007 CERA survey in rural areas of nine U.S. states likewise found an interaction affecting perceived local effects of climate change (Hamilton and Keim 2009). Other CERA questions on local-environment (but not climate related) topics showed interaction effects as well (Hamilton et al. 2010). Table 3 summarizes replications involving four different surveys and nine dependent variables. Those nine variables are the main ones analyzed in each paper (or four of six analyzed in Hamilton 2008). That is, they were not selected because of interaction patterns.

Secondly, the *education*  $\times$  *party* and similar interactions are both socially and climatically important. Earlier researchers found education (along with age) to be the most consistent predictor of citizen concern about the environment, and about climate in particular. Tables 2 and 3 indicate that this has changed. Although age effects remain evident, education now shows inconsistent effects depending on political orientation (Fig. 3). The inconsistency marks a social shift away from patterns seen in older research. It reflects the efficacy of media campaigns that provide scientific-sounding arguments against taking climate change

**Table 3** Significant *education*  $\times$  *party* (or similar) interaction effects have been reported for global warming and other environmental questions on four recent surveys

Interaction	Dependent variables	Survey	Reference
Education $\times$ conservative	1. Sea level rise 2. Melting icecaps 3. Polar bears extinct 4. Arctic seals threatened	2006 national GSS	Hamilton (2008)
Education $\times$ political party	5. Local effects GW	2007 9-state CERA	Hamilton and Keim (2009)
Education $\times$ political party	6. Urban sprawl impacts 7. Conserve resources 8. Environmental rules good	2007 9-state CERA	Hamilton et al. (2010)
Education $\times$ political party	9. Threat of GW	2008 MI CERA	This paper
Understand GW $\times$ political party	9. Threat of GW	2008 NH GSP	This paper

seriously, which disproportionately reach educated but ideologically receptive audiences (Freudenburg 2000; Jacques et al. 2008; McCright and Dunlap 2000, 2003; UCS 2007). Among many educated, conservative citizens, it appears that that such arguments have overshadowed the scientific consensus presented by the IPCC reports and other core science sources.

Ideological predispositions can affect how people process information (Shwom et al. 2008; Wood and Vedlitz 2007). The Internet and cable television news make it easier for us not only to process information selectively ourselves, but to selectively acquire information that has been processed already, when we only tune in to ideologically compatible Web sites, cable news shows and so forth (Iyengar and Hahn 2007; Pew 2004). The bias or selectivity of our sources can be higher than the newspapers, magazines or broadcast news that formerly supplied most current-events information. Narrowcast media, including many Web sites devoted to discrediting climate-change concerns, provide ideal conduits for channeling politically inspired but scientific sounding arguments to an audience predisposed to retain and repeat them. The power to repeat favored arguments has been vastly expanded as well, through forwarding emails or posting links and content online, in a process that can become “viral” as it motivates new readers to do the same. The pace of normal scientific communication is glacial by comparison.

The effective dissemination of contrarian arguments means that many people who have no contact with climate scientists or the primary research literature can nevertheless learn that a scientist says temperatures have risen on Mars (politically spun as evidence that global warming has solar or cosmic origins), or another scientist says it is cooling in East Antarctica (spun as evidence that our planet is not warming after all). They might consider themselves well informed about climate science even while not understanding its basic ideas—as evident in Figs. 1 and 2. Lack of knowledge concerning the scientific context of Mars and Antarctica reports, or lack of consistency between the lessons political commentators might draw from them, need not be an obstacle to accepting and repeating those lessons when they fit with pre-existing beliefs.

If non-specialists want to find out what scientists really know about temperature trends of Mars and East Antarctica, or other arguments aired in today’s news or last night’s party, they are best served by a relatively small number of active-response Web sites written by climate scientists, such as Realclimate.org. Unlike journal articles, science meetings or reports, Web sites and blogs have the capability to react quickly (albeit less rigorously), reach broader audiences, and seriously confront arguments that have no scientific merit. Moreover, their online science posts can be passed on from reader to reader, which is difficult to do with journal articles or technical reports. The hard work that climate scientists invest in these sites could thus play a critical role in disseminating solid information about climate to educated and ideologically receptive audiences, counterbalancing those reached so successfully by the “climate change is a hoax” campaigns.

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