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Is it hot in here or is it just me? Temperature anomalies and political polarization over global warming in the American public

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Abstract Do temperature anomalies affect political polarization over global warming? Americans' attitudes about global warming are affected by whether they reside in states experiencing unseasonably warm (or cold) temperatures versus those experiencing milder temperatures. Specifically, in terms of causal attribution, political polarization over global warming is more pronounced in states experiencing temperature anomalies. Using pooled data collected during 2013–2014, this study utilizes logistic regression to explore how temperature anomalies exacerbate the political polarization among Americans over perceptions of whether global warming impacts are immediately evident as well as the attribution of global warming to human activity. Results indicate that very cold or warm temperature anomalies from a 5-year baseline predict perceptions of global warming impacts and exacerbate existing political polarization over the causal attribution of global warming. These effects are particularly noticeable among Democrats. This analysis provides a contribution to understanding how temperature anomalies from the recent past shape the sociophysical context of global warming attitudes.

> "In case we have forgotten, because we keep hearing that 2014 has been the warmest year on record, I ask the Chair, you know what this is? It's a snowball. And that's just from outside here. So it's very, very cold out. Very unseasonable."—Senator James Inhofe

1 Introduction

Politically speaking, can a snowball disprove global warming? On February 26, 2015, Senator James Inhofe of Oklahoma famously tossed a snowball across the floor of the US senate in

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order to illustrate his argument that the scientific consensus on global warming is invalid (see Fisher et al. 2015). But despite the flaws of such an argument, we can generally understand why an individual who denies the existence of global warming may feel affirmed in their beliefs during unseasonably cool periods. We can investigate whether the opposite is true as well—whether deniers of global warming may feel challenged in their beliefs during unseasonably warm periods.

As the opening quote above implies—and social scientific research confirms—American public opinion regarding global warming and other environmental problems is politically polarized (Dunlap and McCright 2008; Antonio and Brulle 2011; Hamilton 2011; McCright and Dunlap 2011a; Weber and Stern 2011; Guber 2013; Bohr 2014; McCright et al. 2014b; Hamilton and Safford 2015; Hamilton and Saito 2015). This body of research shows that across a variety of contexts, individuals with conservative political orientations are more prone to deny the existence or severity of anthropogenic global warming than are non-conservatives. This divide exists among political elites as well as the American public. For example, a recent news story in the USA regarding the record global temperatures observed in 2015 included statements from leading Democrats affirming the reality of anthropogenic climate change while Republican leaders dismissed climate change as a hoax (Mooney and Warrick 2016).

With this research, I investigate how temperature anomalies affect partisan political polarization over beliefs about anthropogenic global warming. Survey data from February 2013 to May 2014 (encompassing the infamous snowball toss) is analyzed in order to understand whether temperature anomalies—mediated by an individual's political orientation—predict the likelihood of an individual agreeing that global warming is currently happening or that human activity causes global warming.

2 Climate change denial and climate change attitudes

Why an individual may deny climate change is an important question in its own right. As climate attitudes have become politically polarized over time, researchers have turned away from the assumption that climate attitudes flow from information deficits, instead focusing on the moral and political implications of climate change (Bulkeley 2000). Across multiple studies, Norgaard (2006a, b, 2011) explored the social psychological dimensions of denying climate change. Her ethnographic work approached climate change denial not as an ideological action but as a coping mechanism responding to a perceived threat to an existing way of life.

To better understand political polarization over climate change, it is important to consider research on political orientation and social attitudes. Jost et al. (2003) comprehensively reviewed empirical research on the common tenets of ideological conservatism. These primarily included commitments to traditionalism, hostility to social innovation, and preferences for inequality. Focusing on conservatism in this way implies that climate change denial flows from increased ideological coherence. It could be that conservatives as a political subgroup have become more ideologically coherent, recognizing climate change policy as a threat to corresponding values. Given the radical breaks with the political and economic status quo implied by the mitigation of climate change, it should not be surprising that conservatives deny the scientific consensus on climate change.

Another perspective suggests individuals have remained relatively stable in their ideological orientation, but have become increasingly polarized in their political choices in response to party

polarization forcing voters to select among increasingly disparate camps (Fiorina et al. 2005). Baldassarri and Gelman (2008) analyzed US public opinion from 1972 to 2004 and found a pronounced trend of issue partisanship (an increased correlation between party identification and issue attitudes) absent a corresponding trend in issue alignment (attitudinal correlation among pairs of issues). Such research suggests that parties have become more efficient in sorting individuals along ideological lines. The party sorting perspective is supported by Brulle et al. (2012), who found that statements and votes from elected officials influenced Americans' attitudes on climate change. This is relevant to the extent that individuals seek signals from trusted sources when processing complex issues—creating "shortcuts" to attitudinal positions (Krosnick et al. 2000; Jones and Baumgartner 2005; Wood and Vedlitz 2007).

At an organizational level, conservative actors have made concerted efforts to crystallize opposition to action on global warming (McCright and Dunlap 2000, 2003, 2010; Jacques et al. 2008; Oreskes and Conway 2010; Dunlap and Jacques 2013; Brulle 2014; Bohr 2016; Boussalis and Coan 2016; Farrell 2016). Public opinion research has seen a corresponding political polarization in the USA across a variety of climate change attitudes, whether between Republicans and Democrats or conservatives and liberals (Wood and Vedlitz 2007; Dunlap and McCright 2008; McCright and Dunlap 2011b), with similar patterns found in the British public (Poortinga et al. 2011; Whitmarsh 2011). Large-scale analyses of literature produced by climate denial organizations reveal significant attention devoted to discussing temperature trends and their relation to natural patterns. Of note from these studies is that climate denial organizations have increased the amount of thematic attention to scientific topics such as temperature trends since 2012 (Boussalis and Coan 2016; Farrell 2016).

Several empirical studies have analyzed interaction effects between political orientation and various social structural and cognitive variables. For example, Hamilton et al. (2012) study of polar-region warming concern demonstrated that among ideological conservatives, greater scientific understanding predicted lower levels of concern. Hamilton (2008) found a similar interaction pattern between ideology and education regarding concern over the polar-regions. Other researchers have documented interaction effects between party identification and greater levels of self-assessed scientific understanding (Malka et al. 2009; Hamilton 2011), educational attainment (Hamilton and Keim 2009; Hamilton et al. 2010; Hamilton 2011; McCright 2011; Hamilton and Saito 2015), or income (Bohr 2014) in predicting global warming attitudes. McCright and Dunlap (2011a) found interactions for both educational attainment and self-reported understanding on global warming with ideological and partisan identification across a variety of global warming beliefs.

As the epigraph of this article implies, physical experience and the political discourse around global warming comingle, so understanding relationships between social and physical realms is an important area of study for global warming attitudes. Some research has attempted to assess this relationship through an examination of perceived or self-reported weather experiences (Spence et al. 2011; Akerlof et al. 2013). More pertinent to this study, however, is research that directly assesses connections between global warming attitudes and measured temperature or weather patterns.

Studies of aggregated public opinion show mixed results on the relationship between temperature anomalies and/or extreme weather with global warming beliefs. While Scruggs and Benegal (2012) and Donner and McDaniels (2013) both found a significant and modest relationship between increased temperature anomalies and public opinion on the reality of global warming, no such relationship was found by Brulle et al. (2012) studying the US or Shum (2012) studying European attitudes.

Other studies have more concretely assessed the relationship between measured temperature and/or weather events with individual-level global warming attitudes. Konisky et al. (2016) linked experience with extreme weather events to a modest increase in concern over climate change, while Cutler (2016) demonstrated complex socio-physical dynamics wherein severe weather events and property damage interact with party identity in predicting climate change beliefs.

Several studies have focused directly on measured temperature anomalies and global warming beliefs. Hamilton and Lemcke-Stampone (2014) found a non-linear relationship between objectively measured temperature anomalies and beliefs about Arctic warming, such that on unseasonably warm or cool days near the interview, respondents were more likely to report that Arctic warming would affect their local weather. Similarly, Capstick and Pidgeon (2014) found that severe cold weather was more often interpreted as evidence of climate change rather than a refutation against it, suggesting that severe anomalies in either direction may modify individual beliefs.

Various studies have examined global warming beliefs and risk perceptions in relation to local temperatures deviating from annual (Deryugina 2013), decadal (Shao et al. 2014), 30-year (Egan and Mullin 2012; Hamilton and Stampone 2013; Howe et al. 2012), and 38-year averages (Hamilton and Keim 2009). McCright et al. (2014a) analyzed statewide winter temperature anomalies from a 30-year average to demonstrate its influence on perceived winter warming (though it was not predictive of attribution). Marquart-Pyatt et al. (2014) merged objective measures of climatic conditions across nine regions with survey data on perceptions of global warming. Their analysis did not reveal any relationship between objective climate measurements and perceptions of global warming.

Extant research has established the influence of political orientation as well as the socio-physical context of measured temperature and weather patterns in shaping global warming beliefs. Underexplored is the possible interaction between political orientation and measured temperature anomalies. This study addresses this by specifically focusing on the interaction between party identification and quadratic temperature anomaly as a means of predicting beliefs about global warming. We should expect to find increased political polarization over global warming beliefs during unseasonable temperature anomalies, as these are precisely the locations and moments when partisan differences over the role of human activity in global warming may be most consequential.

3 Data and methods

This study utilizes data from two sources. The main source of data concerning global warming belief and social characteristics is pooled from four nationally representative CBS/*New York Times* surveys of American adults collected during February 2013, March 2013, February 2014, and May 2014.[1] These data were merged with state-specific monthly temperature averages collected by the NOAA's National Centers for Environmental Information.[2] Given limitations in the specificity of geo-referencing in the survey data, merging more localized

[1] These data were downloaded through the Inter-university Consortium for Political and Social Research (ICPSR), study numbers 34993, 34998, 36195, and 36198.

[2] These data were downloaded at www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp (accessed November 2016).

temperature records was not a possibility (though statewide measures have been used in prior research and may be conceptually relevant to media consumption discussed later).

The timing of the surveys provide a strong test for how political orientation interacts with temperature to predict global warming attitudes for two reasons. First, this period immediately precedes and follows Senator Inhofe's famous snowball toss, a period in which climate contrarians are making explicit observations on whether unseasonable weather indicates evidence for or against anthropogenic global warming. Second, as indicated by the quote from Senator Inhofe, February 2014 *was* an unseasonably cool month, at least for much of the USA. All 4 months included in this study represent moments when different regions in the USA experienced temperatures both 5 °F above or below their 1981–2010 baseline (PRISM 2004). According to NOAA (2016) data tracking "very cold" and "very warm" months in the contiguous USA (defined as the percentage of climate division measures ranking in the bottom or top 10th percentiles since 1895), each month included in this study reported the following: 0.00% very cold and 0.83% very warm (February 2013); 10.44% very cold and 16.21% very warm (March 2013); 14.06% very cold and 11.61% very warm (February 2014); 0.25% very cold and 5.18% very warm (May 2014). Thus, this pooled dataset reflects a diversity of temperature anomalies from standard climate periods experienced throughout the contiguous USA.

One challenge of combining temperature records with survey data is the possibility that temperature anomalies may correlate with geographic patterns that may in turn correlate with global warming attitudes. Although there are certainly geographic clusters in the data utilized, they remained varied enough that anomalies (whether hot or cold) were never exclusively concentrated across predominately Democrat- or Republican-leaning states, nor states economically dependent on fossil energy extraction.

The dependent variables in this study concern attitudes about the timing of global warming impacts and attributions of its cause. First, respondents were asked, "Do you think global warming is an environmental problem that is causing a serious impact now, or do you think the impact of global warming won't happen until sometime in the future, or do you think global warming won't have a serious impact at all?" This question was not included in the February 2014 sample. Those responding that global warming impacts were happening now were coded = 1, with all others coded = 0. Respondents were also asked, "Which statement comes closest to your view about global warming? 1. Global warming is caused mostly by human activity such as burning fossil fuels, 2. Global warming is caused mostly by natural patterns in the earth's environment or 3. Global warming does not exist." This question was included in all samples referenced above. Respondents selecting the first option—attributing human causes to global warming, in line with the scientific consensus—were coded = 1, while respondents attributing global warming to natural patterns or denying its existence were coded = 0.

The key focus of this study concerns whether temperature anomalies affect attitudes about anthropogenic global warming, specifically whether temperature interacts with party identification. To measure temperature anomalies, a variable was generated as the difference between temperatures for the month of the survey with the preceding 5-year average of corresponding monthly temperatures for each of the 48 contiguous US states. Although there is no established standard for measuring temperature anomaly, several studies of global warming attitudes have followed meteorological and climate science practices of normalizing climate by 30-year periods. In selecting a relatively short-term baseline to measure temperature anomaly, I am paying close attention to the possible social construction (as opposed to statistical construction)

of climate communication and expectations discussed by Hulme et al. (2009), relevant given the conceptual importance of the socio-physical context of climate communication as opposed to objective climate conditions (some climatological perspectives argue that 30-year baselines may not be optimal in predicting successive seasonal averages compared with shorter period normals, such as Lamb and Changnon 1981 or Livezey et al. 2007).

According to this measurement of temperature anomaly, approximately 36% of respondents lived in states experiencing temperatures at least 3 °F below the recent 5-year monthly average while about 13% of respondents live in states experiencing temperatures at least 3 °F above the recent 5-year monthly average. A quadratic term for temperature anomaly was included in order to account for non-linear effects shown by Hamilton and Lemcke-Stampone (2014) and suggested by Capstick and Pidgeon (2014), to explore whether unseasonably warm *or cool* temperatures affect attitudes about anthropogenic global warming. In order to test the robustness of this measurement, baselines were also generated to test year-on-year differences as well as anomalies from a decadal temperature baseline. Interaction terms between temperature difference and Republican or Independent identity were created, with Democrats as the reference category. In light of Hamilton and Saito (2015), an alternative coding of party identification was also created, separating Tea Party supporting Republicans from non-Tea Party supporting Republicans. The sample was split fairly evenly between Tea Party supporting Republicans (12.1% for model 7 and 12.5% for model 8) and non-Tea Party supporting Republicans (15.4% for model 7 and 14.4% for model 8). For all models, dummy variables measuring conservative or moderate ideological identification were also created, with liberal as the reference category.

Several control variables are also included. Age is controlled through two dummy variables, representing individuals under 30 as well as 55 or older. Likewise, dummy variables are included representing males and those with family incomes greater than $50,000. Educational degree attainment ranged from −1 = high school or less to 2 = post graduate work or degree, centered on 0 = some college (including trade or business). Given the well-established interaction effects between levels of education and political orientation in predicting global warming attitudes, terms were created representing interactions between educational degree attainment with Republican and Independent identification.

Since the outcome variable is binary, this study uses logistic regression to understand the relationship between party identification and temperature anomalies with beliefs about global warming. Missing data was handled using listwise deletion in all models. While unstandardized coefficients are reported in the results' table, odds ratios are reported in text.

4 Results

Table 1 supplies a description of the data used in this analysis. Results from logistic regressions predicting attitudes about anthropogenic global warming are presented in Table 2. In the baseline models estimating agreement with the idea that global warming impacts are happening now (model 1) and attributing global warming to human activity (model 4), almost all predictors are statistically significant and generally in line with prior research on global warming attitudes. There are clear and broad differences across age groups in the assessment of global warming across Table 2. Exponentiating the coefficients to odds ratios, we see that relative to respondents aged 30–54, those under 30 had about half the odds of believing the impact of global warming is happening now, but had about 40% greater odds of attributing

Table 1 Descriptive statistics of variables used in analysis

Study	Global warming impact ($N = 2655$)			Global warming attribution ($N = 3478$)		
Variable	Mean (S.D.)	Min	Max	Mean (S.D.)	Min	Max
Global warming impact	0.50 (0.50)	0	1			
Global warming attribution				0.50 (0.50)	0	1
Under 30	0.21 (0.41)	0	1	0.21 (0.40)	0	1
55 or older	0.35 (0.48)	0	1	0.37 (0.48)	0	1
Male	0.50 (0.50)	0	1	0.49 (0.50)	0	1
Income >$50 k	0.53 (0.50)	0	1	0.53 (0.50)	0	1
Education	0.01 (1.02)	−1	2	0.01 (1.02)	−1	2
Ideology (reference group = Liberal)						
Moderate	0.36 (0.48)	0	1	0.37 (0.48)	0	1
Conservative	0.37 (0.48)	0	1	0.37 (0.48)	0	1
Party (reference group = Democrat)						
Independent	0.37 (0.48)	0	1	0.38 (0.49)	0	1
GOP	0.27 (0.44)	0	1	0.27 (0.44)	0	1
ΔTemperature (5-year baseline)	−1.17 (2.92)	−10.4	5.16	−1.80 (4.01)	−13.1	5.92

Data is weighted using weights supplied by the survey

global warming to human activity. By contrast, those over the age of 55 had approximately 30% lower odds of both believing the impact of global warming is happening now or attributing global warming to human activity.

Political orientation also displayed an influence on global warming attitudes across both base models (1 and 4), both in terms of ideology and party identification. Relative to ideological liberals, both moderates and conservatives were less likely to believe that the impact of global warming is happening now or to attribute global warming to human activity. Republicans were less likely than Democrats to believe that global warming is happening now or to attribute it to human activity, while Independents were only less likely than Democrats to attribute global warming to human activity (though there was no statistically significant difference in believing that global warming is happening now). In line with Hamilton and Lemcke-Stampone (2014) and Capstick and Pidgeon (2014), there is a statistically significant non-linear relationship between temperature anomaly and belief that global warming impacts are happening now. Inspecting marginal differences while holding all other variables at their means (Fig. 1), respondents were significantly more likely than the sample average to believe global warming impacts are happening now in states experiencing monthly temperature averages 3 °F above the 5-year baseline. However, temperature anomaly has no statistically significant direct impact on respondents' attribution of global warming to human activity (model 4).

Models 2 and 3 include interaction terms for party identification with temperature anomaly and education, predicting belief that global warming is happening now. Independents were significantly different from Republicans and Democrats for much of the temperature anomaly range, and both Independents and Republicans were less likely to state that global warming impacts are happening now as their educational attainment increased. However, Wald tests indicate that model 2 fails to provide significant improvement over model 1. Thus, when predicting whether Americans believe that the impacts of global warming are immediately evident, there is weak evidence that a robust interaction exists between party identification and temperature anomalies that improves our understanding over a simpler model.

Table 2 Unstandardized coefficients (and standard errors) from logistic regression predicting agreement that global warming impact is happening now (models 1–3) and the attribution of global warming to human activity (models 4–6)

Model	Global warming impact			Global warming attribution		
	(1)	(2)	(3)	(4)	(5)	(6)
Under 30	−0.595**	−0.604***	−0.615***	0.334*	0.342*	0.340*
	(0.183)	(0.182)	(0.182)	(0.153)	(0.153)	(0.152)
55 or older	−0.311*	−0.324**	−0.328**	−0.438***	−0.439***	−0.437***
	(0.124)	(0.125)	(0.127)	(0.104)	(0.104)	(0.105)
Male	−0.285*	−0.284*	−0.283*	−0.109	−0.122	−0.117
	(0.121)	(0.122)	(0.122)	(0.100)	(0.100)	(0.101)
Income >$50 k	−0.198	−0.202	−0.209	−0.332**	−0.336**	−0.353***
	(0.129)	(0.129)	(0.129)	(0.106)	(0.107)	(0.107)
Education	0.201***	0.203***	0.460	0.186***	0.185***	0.386
	(0.057)	(0.057)	(0.144)	(0.048)	(0.048)	(0.084)
Ideology						
Moderate	−0.623***	−0.623***	−0.568***	−0.636***	−0.632***	−0.594***
	(0.158)	(0.159)	(0.161)	(0.129)	(0.129)	(0.131)
Conservative	−1.171***	−1.173***	−1.105***	−1.214***	−1.225***	−1.172***
	(0.177)	(0.178)	(0.181)	(0.143)	(0.143)	(0.145)
Party						
Independent	−0.251	−0.214	−0.247	−0.693***	−0.671***	−0.690***
	(0.145)	(0.159)	(0.159)	(0.119)	(0.138)	(0.138)
GOP	−0.971***	−1.007***	−1.033***	−1.373***	−1.363***	−1.386***
	(0.169)	(0.184)	(0.185)	(0.142)	(0.160)	(0.159)
ΔTemperature	0.079*	0.181	0.182	0.020	0.117	0.116
	(0.032)	(0.056)	(0.059)	(0.019)	(0.036)	(0.037)
ΔTemperature2	0.013**	0.026***	0.026***	0.002	0.012*	0.012*
	(0.004)	(0.008)	(0.008)	(0.002)	(0.006)	(0.006)
Ind.*ΔTemperature		−0.176*	−0.177*		−0.122**	−0.121*
		(0.075)	(0.076)		(0.046)	(0.047)
Ind.*ΔTemperature2		−0.027**	−0.027**		−0.013*	−0.013*
		(0.010)	(0.010)		(0.007)	(0.007)
GOP*ΔTemperature		−0.088	−0.083		−0.164**	−0.160**
		(0.082)	(0.083)		(0.056)	(0.056)
GOP*ΔTemperature2		−0.009	−0.010		−0.017*	−0.017*
		(0.011)	(0.012)		(0.007)	(0.007)
Ind.*Education			−0.344**			−0.261*
			(0.129)			(0.106)
GOP*Education			−0.466**			−0.352**
			(0.144)			(0.125)
Intercept	1.453***	1.468***	1.458***	1.647***	1.652***	1.641***
	(0.176)	(0.182)	(0.184)	(0.148)	(0.153)	(0.155)
N	2,075	2,075	2,075	3,478	3,478	3,478

Data is weighted. Wald tests indicate that inclusion of the interaction terms do not significantly improve model fit over the previous model for model 2 ($p = 0.105$) or model 3 ($p = 0.114$), but do provide significant improvement over the previous model for model 5 ($p = 0.033$) and model 6 ($p = 0.009$)

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Model 5 includes party*temperature anomaly interactions. All predictors from the base model remain relatively unchanged, while there is a statistically significant interaction between both Independent and Republican identity with temperature anomaly. These interactions significantly improve model fit and make up the primary contribution of this analysis. The party*temperature anomaly interactions remain statistically significant when including

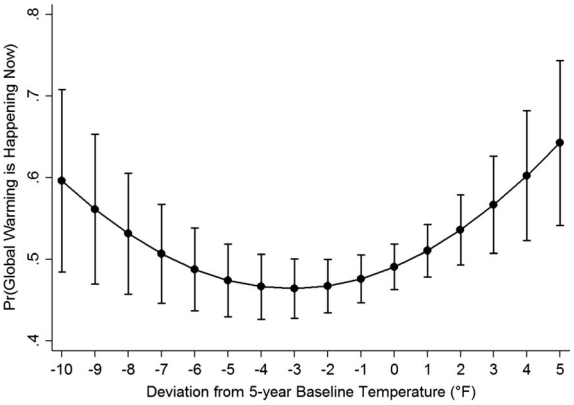

Fig. 1 Predicted probabilities (with 95% confidence intervals) of agreeing that global warming impact is happening now by temperature deviation from 5-year baseline. Note: Marginal effects were calculated holding all other predictors in model 1 from Table 2 at their means

party*education interactions in model 6. The education interactions are also statistically significant for both Independents and Republicans, consistent with well-established findings from prior research. Inspection of the marginal effects reveals that while both Democrats and Independents become increasingly likely to attribute global warming to human causes with higher levels of educational attainment, Republicans are virtually uniform in their attitudes when broken down by education (.26 predicted probably among those with high school degrees or less versus .28 predicted probability among those with post graduate education; among Democrats, these predicted probabilities are .62 and .83, respectively). Of note is that model 6 provides a significantly improved fit over model 5, suggesting that party*education interactions should be included in research on the socio-physical context of climate attitudes.

Figure 2 displays the predicted probabilities of attributing global warming to human activity from model 6, according to party identification and temperature anomaly. While Democrats, Independents, and Republicans are all significantly different from one another, political polarization is most pronounced at much colder (more than 5 °F deviation) and warmer temperature anomalies from a 5-year baseline. The impact of temperature anomaly appears strongest for Democrats, nonexistent for Independents, and weaker (though reversed) for Republicans. The predicted probabilities of attributing global warming to human activity

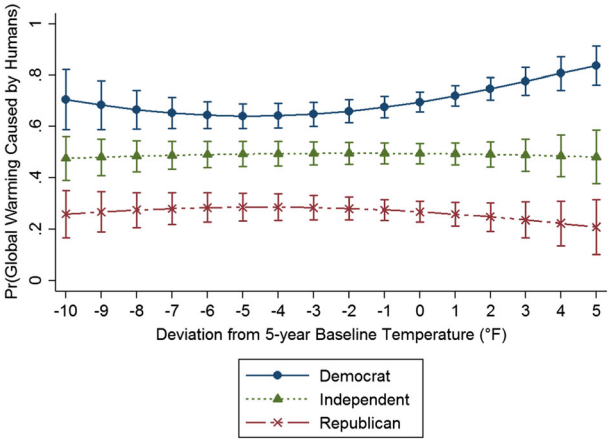

Fig. 2 Predicted probabilities (with 95% confidence intervals) of attributing global warming to human activity by three-party identification and temperature deviation from 5-year baseline. Note: Marginal effects were calculated holding all other predictors in model 6 from Table 2 at their means

among Democrats range from .71 (−10 °F below average) to .64 (−5 °F below average) to .84 (5 °F above average), while predicted probabilities among Republicans ranges from .26 (−10 °F below average) to .29 (−5 °F below average) to .21 (5 °F above average). Independents remain relatively constant throughout the range of temperature anomalies.

All models presented in Table 2 were also run with alternative measurements of temperature anomaly, measured as a year-on-year difference as well as a deviation from a 10-year baseline. For both outcomes, models utilizing a year-on-year temperature anomaly produced nearly identical results as those presented with the 5-year baseline. The significance of the interaction between Independents and temperature anomaly was not robust when utilizing a 10-year baseline with respect to the global warming impact outcome, although this measure of a party*temperature anomaly interaction was still significant in predicting attitudes about the attribution of global warming. However, political polarization took on a slightly different shape with reference to a 10-year baseline temperature average, with Republican denial of global warming caused by human activity more pronounced with colder temperature anomalies and less pronounced with warmer anomalies relative to the results reported in model 6 (while Democrats displayed very similar results).

Models 7 and 8 include an alternate coding for Republican identity between those who do and do not report supporting the Tea Party movement. These alternative party*temperature anomaly interactions are reported in Table 3. While the interaction with Independent party identification was statistically significant in predicting belief that global warming impacts are happening now, including the party interactions did not improve fit over the base model plus party*education interactions. However, these interactions with temperature anomaly are statistically significant among Independents, Non-Tea Party Republicans and Tea Party Republicans in predicting attitudes about the attribution of global warming. Predicted probabilities of attributing global warming to human activity for each party identification are plotted in Fig. 3.

Table 3 Unstandardized coefficients (and standard errors) of temperature interaction terms using a four-party identification coding from logistic regression predicting agreement that global warming impact is happening now (model 7) and the attribution of global warming to human activity (model 8)

Model	7	8
Ind.*ΔTemperature	−0.171*	−0.144**
	(0.029)	(0.050)
Ind.*ΔTemperature2	−0.029**	−0.022***
	(0.011)	(0.007)
Non-tea party GOP*ΔTemperature	0.009	−0.169*
	(0.099)	(0.071)
Non-tea party GOP*ΔTemperature2	−0.009	−0.028**
	(0.014)	(0.008)
Tea party GOP*ΔTemperature	−0.154	−0.174*
	(0.132)	(0.082)
Tea party GOP*ΔTemperature2	−0.014	−0.024*
	(0.018)	(0.009)
Intercept	1.352***	1.473***
	(0.177)	(0.153)
N	1,912	3,193

Data is weighted. These models included predictors reported in models 3 and 6 from Table 2, but not shown here. Wald tests indicate that inclusion of the interaction terms are insignificant for model 7 ($p = 0.116$) but significant for model 8 ($p = 0.018$) versus base models

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

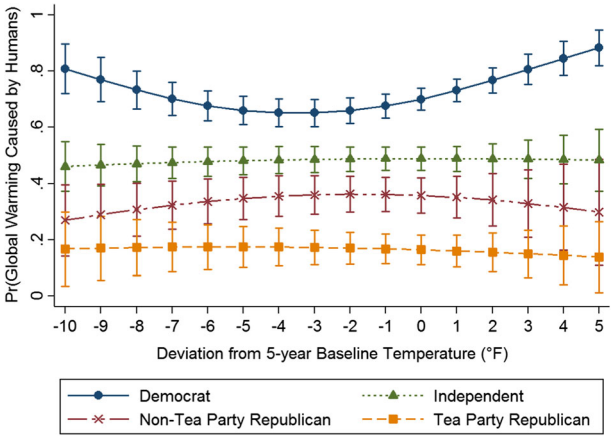

Fig. 3 Predicted probabilities (with 95% confidence intervals) of attributing global warming to human activity by four-party identification and temperature deviation from 5-year baseline. Note: Marginal effects were calculated holding all other predictors in model 8 from Table 3 at their means

Again, we see a similar trend wherein the effects of temperature anomaly are strongest for Democrats. Beliefs about the attribution of global warming do not vary much with temperature anomalies among Tea Party Republicans, ranging from a predicted probability of .17 (10 °F below average) to .14 (5 °F above average). This suggests that party identification trumps temperature anomaly for this subset. However, the range among non-Tea Party Republicans is nonlinear, and significantly different from Tea Party Republicans for temperature anomalies ranging between −6 °F below average to 2 °F above average. While non-Tea Party Republicans are more aligned with Independents during milder temperature anomalies, they are more similar to Tea Party Republicans around very cold and very warm temperature anomalies.

5 Discussion

Prior research on the social bases of climate attitudes has established the significance of political orientation, particularly as it interacts with factors such as educational attainment. This analysis affirms prior work that identifies political polarization as the overriding factor predicting global warming beliefs while accounting for measured temperature (Marquart-Pyatt et al. 2014; McCright et al. 2014a), while offering an extension that temperature anomalies from 5-year baselines moderately exacerbate U.S. political polarization over global warming attitudes. Specifically, Republicans are less likely to conform to the scientific consensus on global warming during very cold or very warm periods while Democrats display the opposite trend.

When breaking down Republican identity between those who do and do not support the Tea Party movement, we see that both kinds of Republicans converge in their global warming beliefs during extreme temperature anomalies but diverge during more seasonable temperature conditions. This would be consistent with the elite cues hypothesis, in that we would expect political leaders who deny anthropogenic global warming to claim victory during unseasonably cold periods or amplify their denial during unseasonably warm periods that invite challenge to their worldview (essentially what was on display with Senator Inhofe's snowball speech).

Level of temperature measurement could be conceptually related to another important aspect of climate attitudes—media consumption as shaped by political orientation (McCright 2011). Mass media play an important role in interpreting the links between climate science and climate policy, and climate denial perspectives receive disproportionate media coverage relative to their standing

in scientific fields, possibly causing confusion among lay publics (Boykoff 2013). The political leanings of a media outlet may shape the type coverage dedicated to global warming. Painter and Ashe's (2012) study of left- and right-leaning print media indicated that more conservative media tended to let climate skeptic claims go unchallenged compared with more liberal media, although this was primarily restricted to editorial comment rather than news reporting. This connection between political leaning and global warming coverage was reinforced in a study of US cable television news by Feldman et al. (2012), demonstrating that while holding party identification constant, viewers of conservative Fox News were more likely to dismiss global warming claims relative to viewers of the more politically moderate CNN and liberal MSNBC.

We can also consider how temperature anomalies affect media environments. Donner and McDaniels (2013) showed a relationship between temperature anomaly and the proportion of newspaper editorial and opinion content aligned with the expert consensus on climate change. We should expect that conservative- and liberal-oriented media pay attention to temperature anomalies through framing processes that discount or affirm temperature anomaly as an indication of global warming, respectively. Thus, during periods of extreme temperature anomaly, politically attuned individuals may consume additional media coverage dedicated to global warming through their media consumption. This could plausibly explain why disagreement between Democrats and Republicans widens during periods of greater temperature anomaly, as Democrats are likely exposed to greater amounts of opinion within the scientific mainstream while Republicans are likely exposed to disproportionate amounts of climate contrarian messages.

The process by which individuals align their media consumption with their political values, and how this interacts with external climate conditions, is a crucial but underexplored aspect of socio-physical approaches to climate attitudes. Unfortunately, the data analyzed here did not include measurements of media consumption (either by volume or medium). Gathering data on information exposure to climate change (whether by media consumption, personal conversation, or something else) should become a greater priority for future research. Whether the political discourse around temperature trends manifests in the form of interpersonal conversations, local media (letters to the editor, e.g.,), increased activism by political organizations, state policy debates, or national media (and whether changes in the frequency or intensity of such discourse are associated with changes in weather patterns) remains an open question. Certainly, an opportunity exists for future researchers to further explore the socio-physical context of climate attitudes by inquiring whether physical changes in climate precede increased political discourse regarding climate change.

Lastly, there could also be connections between various aspects of global warming beliefs with findings from climate change denial content analysis (McCright and Dunlap 2000; Dunlap and Jacques 2013; Medimorec and Pennycook 2015; Bohr 2016; Boussalis and Coan 2016; Farrell 2016). In particular, since recent analyses of a large textual corpora of climate change denial literature demonstrate that the period of the present study (February 2013–May 2014) coincides with an uptick in attention dedicated to temperature trends—particularly among those organizations receiving corporate funding (Farrell 2016; also see Boussalis and Coan 2016)—there is an implied relationship between organized climate change denial activity and its impact on public opinion. Whether this relationship conforms to the general pattern described in this study—that is, whether climate change denial arguments are consumed and/or resonate more among Republicans and/or ideological conservatives experiencing temperature anomalies—cannot be known with certainty absent some sort of measurement of media consumption and/or elite cues.

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