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## Introduction

A growing body of literature has demonstrated a relationship between an individual's personal experience with weather and their views on the existence of global warming. In particular recent studies have shown that temperature and precipitation departures from average in an individual's area of residence have an effect on the likelihood that the individual will indicate that there is evidence of global warming (Egan and Mullin 2012; Borick and Rabe 2014). While the relationship between weather and views on the existence of climate change appears fairly robust, it remains unclear if this relationship is the product of an individual's subjective perception of recent weather conditions or if external climatic conditions affect views on global warming in the absence of an individual's awareness of weather anomalies. Even less has been written on the determinants of subjective perceptions of seasonal variation themselves. In this study we examine the ability of individuals to accurately assess recent weather conditions in relation to historical norms, and validate the veracity of such assessments, with reference to instrumental temperature data. We then examine the relationship between individual assessments of local weather and perceptions of evidence of global warming. We find that subjective perceptions of seasonal temperatures are influenced not only by external climatic conditions but also, and more importantly, by attitudes toward the existence of global warming. The empirical bases of this study draws from surveys conducted in the United States and Canada during the fall of 2014 as part of the National Surveys on Energy and the Environment (NSEE).

## The Relationship Between Weather and Public Opinion About Climate Change

Over the last decade social science researchers have increasingly examined the relationships between weather and individual perceptions of climate change. Given the strong connections between climate and weather it may not be surprising that numerous studies have found individual views regarding the existence of climate change and global warming can be significantly affected by their experiences with and perceptions of weather.

What has been less examined is the role that views about the existence of global warming may have on individual perceptions of weather. Given a continued divide among Americans regarding both the existence and threats posed by global warming (Leiserowitz 2011; McCright and Dunlap 2011; Borick et al 2015) it is reasonable to suspect that those varied views may shape how Americans perceive the weather that they experience, especially for those individuals who have thought a lot about the issue, or who are relatively convinced that global warming is or is not happening. In this paper we explore the possibility that attitudes toward global warming influence subjective perceptions of weather independent of actual experienced temperatures.

As noted earlier there is a growing body of literature that provides evidence that individual perceptions and experiences with weather can alter an individual's views on the existence and severity of global warming. Spence et al. (2011), for instance, found that residents of the United Kingdom who had been severely affected by flooding were more confident that global warming was occurring; further, they demonstrated higher levels of concern about the impact of climate

change. In an experimental design Joierman et. al. (2010) find that outdoor temperatures are correlated with individual perceptions regarding signs of global warming.

Further, Li, Johnson and Zaval (2011) found that participants were more likely to believe that global warming was occurring when they perceived that temperatures in their area were hotter than normal at the time of their interview. Akerlof et al (2012) find that perceptions of personal experience with global warming heightens an individual's perception of the risk posed by climate change. Likewise, both Egan and Mullin (2012) and Deryugin (2012) have found that an individual's views on the existence of global warming are related to their experience with local temperature. Their studies provide evidence that outside temperatures in the period preceding an interview with a respondent are related to their responses regarding evidence of global warming. In particular, they find that warmer-than-average temperatures in the period before an interview increases the likelihood that a respondent will agree that there is evidence that the planet is warming, while cooler-than-average temperatures will have the inverse effect.

Borick and Rabe (2014) found that individuals regularly refer to weather related factors when explaining how they arrived at their conclusion that the planet is either warming or not warming, and that these explanations correspond with broad weather patterns. The study also finds that the self-reported importance of weather in shaping views of global warming is accompanied by increasing evidence that actual weather conditions shape the process by which individuals arrive at their conclusions regarding the existence of climate change. In particular snowfall

levels during the winters between 2009 and 2012 appear related to an individual's beliefs regarding global warming.

While there is now a solid body of literature that shows individual's views on global warming are shaped by their experiences with weather, there is also some evidence to suggest that views on global warming can affect an individual's perceptions of external climatic conditions. A study by Weber (1997) found that farmer's in the Midwestern United States who believed that global warming was occurring were more likely to accurately report above average local temperatures in their area over the preceding five year period than farmers who did not think global warming was occurring.

More recently Howe and Leiserowitz (2013), in the most extensive study on the subject, found that perceptions of local weather in the United States were related to individual beliefs regarding global warming. In their study Howe and Leiserowitz use a national survey in the United States to provide evidence that beliefs about global warming had significant effects on individual perceptions of past weather, particularly among survey respondents who believed that global warming is not happening. More specifically, those who think that global warming is not happening were significantly less likely to report that the last summer (2010) was warmer-than-normal, even when controlling for local climate conditions.

The findings from Weber (1997) and Howe and Leiserowitz (2013) provide evidence that one's position on the existence of global warming can influence their ability to accurately report their recent experiences with weather. But what explains this finding? One possibility is that individuals are partaking in a form of

motivated reasoning where beliefs on a matter influence the way in which evidence is evaluated on that subject (Nir 2011). In essence, individuals interpret new information in a way that fits pre-existing beliefs, and seek evidence to support these priors in an attempt to avoid cognitive dissonance (Kunda 1990). As views regarding global warming have become increasingly polarized among Americans (McCright and Dunlap, 2011) with conservatives and Republicans substantially less likely to believe global warming is happening than liberals and Democrats, there may be increased reasons for individuals to identify weather conditions that support their position on global warming, so as to maintain their standing in a social group (Kahan, 2013; Kahan et al., 2011). In the remainder of this study we build upon previous studies by Weber (1997) and Howe and Leiserowitz (2013) by testing the proposition that the views of Americans regarding global warming may be shaping the way they evaluate the weather that they experience.

**Methods:**

To evaluate the relationship between beliefs regarding global warming and perceptions of recent weather experiences we conducted a telephone survey of 942 adult (age 18 or older) residents of the United States between October 6 and November 6, 2014. Respondents were interviewed in English on both land lines (519) and cell phones (423). Of the 423 cell phone respondents 348 had no landlines in their household. Both the landline and cell phone samples were provided by the Marketing Systems Group (MSG), Horsham, Pennsylvania. Both landline and cell phones were chosen randomly from sampling frames of United States landline and cell numbers provided by MSG. With a randomly selected

sample of 942 respondents the margin of error for the overall sample is +/- 3.5% at a 95% level of confidence. Margins of error for questions with smaller sample sizes will be larger. In addition to sampling error, one should consider that question wording, order and other fielding issues can introduce error or bias into survey results. The sample data has been weighted by age, race, educational attainment, income and gender to reflect 2013 population parameters for these factors provided by the United States Census Bureau. The calculation of sampling error takes into account design effects due to the weighting identified above. In order to reach a representative sample of adult Americans both land lines and cell phones are called up to 10 times. The response rate for this survey as calculated using the American Association of Public Opinion Research (AAPOR) RR3 formula is 15%.

**2014 Summer Temperatures In The United States**

Before looking at the results of the survey and empirical tests of the relationship between views on global warming and perception of weather it is valuable to provide an overview of the actual weather conditions that Americans experienced during the period we are examining. Looking back at the actual temperatures in the United States during the Summer of 2014 the temperature measures from the National Oceanic and Atmospheric Administration (NOAA) point to a summer that was fairly average in terms of historical records. Using temperature records for the last 120 years NOAA ranks summer temperatures in the continental United States as the 64$^{th}$ hottest. Thus from a historical perspective the summer of 2014 was fairly usual in terms of temperature experienced in the U.S.

While the summer of 2014 was fairly normal in regards to longer-term summer temperature trends in the United States, it ranked as a much cooler summer in comparison with recent summers. As can be seen in Table One, only one summer in the last decade (2009) ranked lower in terms of summer temperatures than 2014. In terms of real temperatures over the past five summers 2014 was 1.25F colder than average for that period. Therefore, in terms of recent summers, the summer of 2014 could be considered among the coolest in recent history.

**TABLE ONE**

**United States Summer Temperature Profile**
**2005-2014**

| | Average Summer Temperature | Departure From Historical Average | Rank in terms of Warmest Summers on Record | Number of Summers Ranked |
|---|---|---|---|---|
| 2014 | 71.68F | +.028F | 69 | 120 |
| 2013 | 72.53F | +1.13F | 105 | 119 |
| 2012 | 73.70F | +2.30F | 116 | 118 |
| 2011 | 73.65F | +2.25F | 116 | 117 |
| 2010 | 73.08F | +1.68F | 113 | 116 |
| 2009 | 71.02F | -.38F | 34 | 115 |
| 2008 | 71.99F | .59F | 93 | 114 |
| 2007 | 73.07F | 1.67F | 108 | 113 |
| 2006 | 73.52F | 2.12F | 111 | 112 |
| 2005 | 72.57F | 1.17F | 102 | 111 |

*Source: The National Climate Data Center*

While national level temperature measures are important they can often mask significant regional or local variation. Such is the case with the Summer of 2014 in the United States. While much of the Western United States experienced near record warm temperatures, large areas of the Midwest, South and Mid-Atlantic experienced solidly below average temperatures (See Figure One). For example

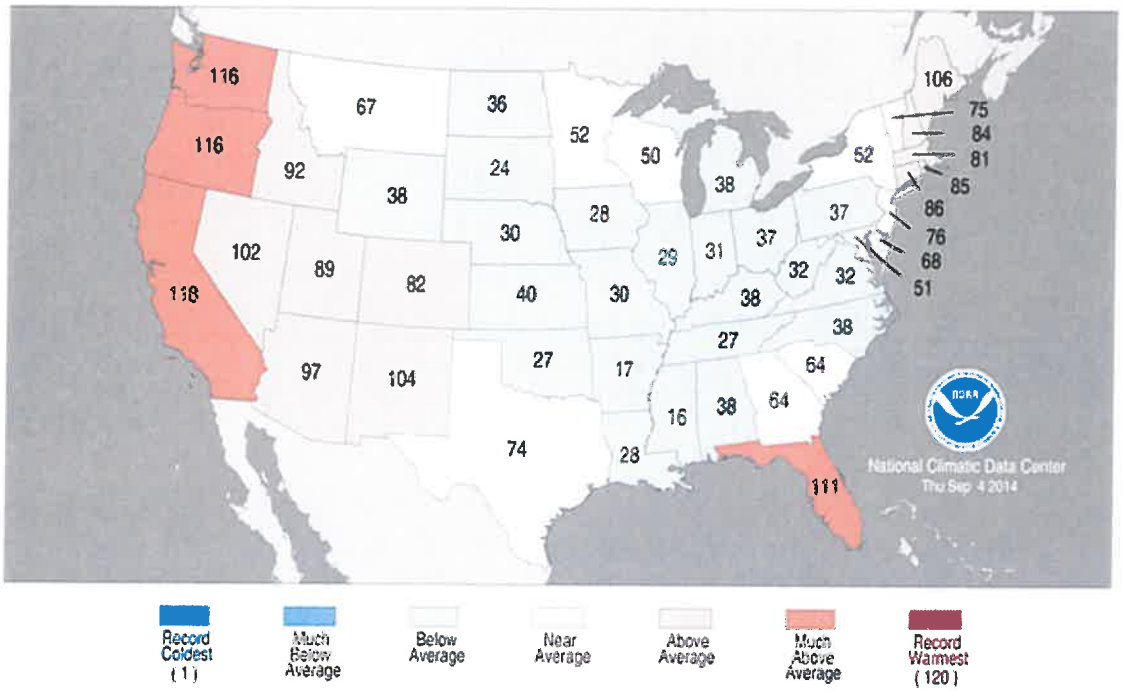
while California. Oregon and Washington experienced top 5 warm summers, states such as Arkansas and Louisiana experienced summer temperatures that ranked among the 20 coldest summers over the past 120 years.

**FIGURE ONE**

Statewide Average Temperature Ranks

June–August 2014

Period: 1895–2014




## Public Perceptions of Summer 2014 Temperatures

Such wide geographic variation in temperatures provide an opportunity to test the extent to which individuals experiencing different climatic conditions are able to make valid assessments of local temperatures. We thus asked respondents to describe the weather in their area during the past summer. Response options included A lot warmer than usual, a lot cooler than usual, and about the same as

usual. As Table Two demonstrates Americans were fairly mixed in terms of their evaluations of summer 2014 temperatures in their area.

**TABLE TWO**

**Respondent Perceptions of Summer 2014 Temperatures in Their Area**

| Response | Percent Responding |
|---|---|
| A lot warmer than usual | 24% |
| A lot cooler than usual | 37% |
| About the same as usual | 38% |
| Not Sure | 1% |

*Question: How would you describe the weather in your area this past summer? On average would you say it was:*

Given the fairly disparate temperature conditions across areas of the United States during the Summer of 2014 as displayed in Figure 1, the varied evaluations of local temperature conditions may have been reasonably expected. Of course an individual's perception of temperature anomalies in their area should be related to actual departures from normal observed in their area during the timeframe being examined.

Instrumental temperature records provide a way of validating individual perceptions of local weather. To match actual temperature conditions in a respondent's area with their expressed perceptions of temperatures we: (1) identified the closest reporting weather station to a respondent's area of residence; (2) collected 2014 summer temperature data in relation to normal temperatures for the varied locations of respondents; and (3) paired the actual temperature departures from normal with the individual evaluations of temperature departures. Respondents in the survey were asked to provide the zip code for their primary area

of residence with **** of the 942 survey respondents providing existing zip codes. Those zip codes were then used to search for the nearest National Weather Service (NWS) station through the NWS station locater interface. We then used the National Climatic Data Center's Local Climatological Monthly reports to access summer temperature anomalies for all NWS stations matched to respondent zip codes.

Our first approach to measuring the relationship between perceptions and actual summer temperatures was to categorize the summer temperatures in relation to the 30 year average (1981-2010) for each respondent's NWS weather station and then cross tabulate those weather conditions with the individual's perception of summer temperatures in their area. As can be seen in Table Three, there appears to be a relationship between experienced weather and perceptions of weather in which Americans are more likely than not to evaluate temperature anomalies correctly. When actual temperatures were colder than normal in a respondent's area they were more than twice as likely to state that temperatures were a lot colder than normal than a lot warmer than normal. When summer temperatures were much warmer than normal (1 degree F or greater) in a respondent's area they were almost twice as likely (39% to 20%) to say their summer was a lot warmer in comparison to a lot cooler than normal. However when temperatures were only moderately warmer than normal (.01 to .99) more respondents stated that their summer temperatures were a lot cooler than normal

**TABLE THREE**

**ACTUAL SUMMER TEMPERATURES IN RELATION TO PERCEPTIONS OF SUMMER TEMPERATURES**

| Average Summer Temp Departure | A lot warmer than usual (n =202 ) | A lot cooler than normal (n =326) | About the same as usual (n =332) | Not sure (n =4) |
|---|---|---|---|---|
| -1 degree F or lower (n = 129) | 24% | 56% | 19% | 1% |
| -.01 to -.99 degree F(n = 318) | 18% | 40% | 42% | <1% |
| Average Temp (n = 40) | 18% | 48% | 35% | 0% |
| .01 to .99 degree F (n = 208) | 21% | 36% | 43% | 1% |
| 1 degree F or higher(n = 169) | 39% | 20% | 41% | 1% |

Chi Square Value 65.652 DF = 12, Significant at .99 level

While Americans who indicated that there were temperature anomalies in their area during the summer of 2014 were more likely than not to accurately identify the direction of the anomaly (i.e. warmer vs colder), a significant portion of respondents inaccurately claimed anomalies that were opposite of what actually occurred. We thus began to probe the dynamics of accurate versus inaccurate subjective interpretations of weather experience and attempt to identify the determinants of such evaluations. In particular we seek to determine what role individual views on the existence of global warming might have in individual evaluations of local weather.

As noted earlier there is a growing body of literature that has examined the role of motivated reasoning related to the issue of global warming. Studies from scholars such as Howe and Lieserowitz (2013) and Weber (1997) have found that preexisting beliefs regarding global warming can influence an individual's evaluations and descriptions of their experienced weather. Our results contribute to this literature by subjecting the motivated reasoning hypothesis to new empirical

tests. The data used in these tests focus on perceptions of weather during the summer of 2014 in the United States.

Our first step in identifying possible motivated reasoning in evaluations of summer temperatures is to look at a simple bivariate relationship between an individual's views on the existence of global warming and their perceptions of 2014 summer temperatures. The results presented in Table Four indicate significant differences in evaluations of local summer temperatures in relation to individual views on evidence of global warming. While Americans who believe there is solid evidence of global warming are fairly divided regarding temperature anomalies in their area during the summer of 2014 with 36% saying summer was a lot cooler compared to 32% who said it was a lot warmer, global warming skeptics were much more likely to report that their summer temperatures were a lot colder (46%) than a lot warmer (8%).

**TABLE FOUR**

**VIEWS ON THE EXISTENCE OF GLOBAL WARMING BY PERCEPTIONS OF SUMMER TEMPERATURES**

| | A lot warmer than usual (n = 230) | A lot cooler than normal (n = 346) | About the same as usual (n= 359) | Not sure (n =6) |
|---|---|---|---|---|
| There is Evidence of GW (n = 565) | 32% | 36% | 32% | 1% |
| There is Not Evidence of GW (n = 220) | 8% | 46% | 45% | 1% |
| Not Sure (n = 156) | 21% | 26% | 53% | 0% |

Probing the relationship between global warming beliefs and perceptions of local weather, we generated a series of control tables to better explore the bi-variate relations for the three categories of beliefs regarding global warming: (1) those that

think there is solid evidence of global warming; (2) those that think there is not solid evidence of global warming; and (3) those that are not sure if there is solid evidence of global warming.

First we look at Americans who think there is solid evidence of global warming and the relationship between their perceptions of the weather they experienced during the summer of 2014 and the actual weather in their area during that summer. Overall, Table Five shows that responses are fairly accurate. For instance, when the summer weather in the area of an American who thinks that global warming is happening was colder than normal, a plurality of this group stated that their local weather was indeed colder than normal. Similarly, when the weather was substantially (more than 1 degree F) warmer than normal, those who believe global warming was happening were much more likely to say the weather was a lot warmer than usual (50%) compared to a lot cooler than usual (17%). Notably, when temperatures were either normal or slightly above normal Americans who accept the existence of global warming were actually more likely to say their summer temperatures were colder rather than warmer.

**TABLE FIVE**

**ACTUAL SUMMER TEMPERATURES IN RELATION TO PERCEPTIONS OF SUMMER TEMPERATURES (ONLY THOSE THAT THINK THERE IS EVIDENCE OF GW)**

| Average Summer Temp Departure | A lot warmer than usual (N = 156) | A lot cooler thanusual (n = 196) | About the same as usual (n = 164) | Not sure (n =3) |
|---|---|---|---|---|
| -1 degree F or lower (n = 68) | 32% | 59% | 9% | 0% |
| -.01 to -.99 degree F (n = 192) | 20% | 44% | 35% | 1% |
| Average Temp (n = 26) | 23% | 42% | 35% | 0% |
| .01 to .99 degree F (n = 119) | 27% | 35% | 38% | 1% |
| 1 degree F or higher (n = 114) | 50% | 17% | 33% | 1% |

Chi Square Value 60.401 DF = 12, Significant at .99 level

Among Americans who do not think there is evidence of global warming a more consistent pattern appeared. Overall, these respondents tended to offer less accurate subjective evaluations than those with different global warming beliefs. As with those who accept global warming's existence, skeptics were much more likely to say their summer was colder than usual when it was actually colder (see Table Six). However, unlike their counterparts who think global warming is happening, Americans who think global warming is not incurring were twice as likely (35% to14%) to claim their weather was colder rather than hotter when in reality it was substantially warmer (1 degree F above average) than usual. In other words, those with more skeptical views on climate change were more likely to over report cold temperatures, and more likely to under report warmer temperatures, when it was actually warmer.

**TABLE SIX**

**ACTUAL SUMMER TEMPERATURES IN RELATION TO PERCEPTIONS OF SUMMER TEMPERATURE (ONLY THOSE THAT THINK THERE IS NOT EVIDENCE OF GW)**

| Average Summer Temp Departure | A lot warmer than usual (n = 15) | A lot cooler than usual (n = 91) | About the same as usual (n = 90) | Not sure (n=1) |
|---|---|---|---|---|
| -1 degree F or lower (n = 36) | 3% | 61% | 33% | 3% |
| -.01 to -.99 degree F (n =65) | 8% | 43% | 50% | 0% |
| Average Temp (n = 5) | 0% | 92% | 8% | 0% |
| .01 to .99 degree F (n = 54) | 7% | 43% | 50% | 0% |
| 1 degree F or higher (n = 37) | 14% | 35% | 51% | 0% |

Chi Square Value 17.935 DF = 12, Significant at .88 level

Finally, among Americans unsure about the existence of global warming there are more respondents who said their weather was about the same as usual in comparison with both those who accept or reject the existence of global warming. At least half of those unsure about the existence of global warming said their summer temperatures were about the same as usual for all but one category of summer temperatures. Only when temperatures were 1 degree F or lower than average in the area of individuals unsure about climate change did a plurality of that group believe temperatures were a lot different than usual (40% indicating temperatures were a lot colder than usual).

**TABLE SEVEN**

**ACTUAL SUMMER TEMPERATURES IN RELATION TO PERCEPTIONS OF SUMMER TEMPERATURE (ONLY THOSE THAT ARE UNSURE IF THERE IS EVIDENCE OF GW)**

| Average Summer Temp Departure | A lot warmer than usual (n = 32) | A lot cooler than normal (n = 40) | About the same as usual (n =77) | Not sure |
|---|---|---|---|---|
| -1 degree F or lower (n = 25) | 32% | 40% | 28% | 0% |
| -.01 to -.99 degree F (n = 61) | 20% | 25% | 56% | 0% |
| Average Temp (n=0) | 13% | 38% | 50% | 0% |
| .01 to .99 degree F (n = 35) | 20% | 29% | 51% | 0% |
| 1 degree F or higher (n = 20) | 20% | 10% | 70% | 0% |

Chi Square Value 10.167 DF = 8, Significant at .74.6 level

The evidence presented thus far presents some evidence of motivated reasoning, particularly among Americans who are more skeptical of climate change. However, the control tables are limited in that they do not account for other factors that may plausibly influence perceptions of seasonal weather. For instance, whether an individual perceives a departure from "normal" may depend on the naturally occurring level of climate variability in a given region (c.f. Egan and Mullin, 2012). We might thus have reason to want to control for region of residence, to account for, if only partially, for such contextual effects. In addition, there are good reasons to want to control for such other variables as partisanship, which have consistently emerged as significant predictors of climate-related beliefs. In sum, though results in Tables Five to Seven provide some evidence of motivated reasoning related to the evaluation of summer temperatures, the differences may be more the product of other factors, which should be accounted for.

## Empirical models

In order to control for the effects of other factors, we ran a multinomial logistic model with perception of summer temperature as the dependent variable. To facilitate interpretation, we ran the model with "A lot warmer" as the reference category, comparing the probability of this response to either "A lot colder" and "About the same." In addition to global warming beliefs, we included average temperature departures for the summer of 2014, which is a continuous variable that is the average monthly temperature deviation for a specific weather station, averaged over the three summer months of June, July and August 2014. We also include a measure of the maximum daily temperature recorded for a respondent's weather station on the day of the interview. We then added controls for partisanship, gender, age categories, education and region. Results are presented in Table Eight.

**Table EIGHT: Multinomial logit model**

| | A lot colder | About the same |
|---|---|---|
| *Beliefs* | | |
| No evidence | 3.42 (1.11)*** | 4.43 (1.39)*** |
| Not sure | 0.95 (0.30) | 1.76 (0.50)* |
| Temp. Departure | 0.67 (0.08)** | 0.87 (0.10) |
| High Temp (day of interview) | 0.95 (0.01)*** | 0.99 (0.01) |
| *Region* | | |
| South | 0.32 (0.11)** | 0.46 (0.16)* |
| Midwest | 0.49 (0.18)* | 0.45 (0.17)* |
| West | 0.31 (0.13)** | 0.45 (0.18) |
| *Partisanship* | | |
| Democrat | 0.78 (0.20) | 0.69 (0.17) |
| Republican | 1.18 (0.35) | 1.18 (0.33) |
| Other | 0.31 (0.35) | 0.54 (0.24) |
| Female | 0.66 (0.14) | 0.59 (0.12)* |
| *Age* | | |
| 30-44 | 1.98 (0.77) | 1.16 (0.44) |
| 45-64 | 1.94 (0.67) | 1.39 (0.45) |
| 65+ | 1.81 (0.63) | 1.60 (0.53) |
| *Education* | | |
| High school graduate | 1.90 (1.05) | 3.97 (2.25)* |
| Some college | 1.94 (1.05) | 2.91 (1.64) |
| College graduate | 2.04 (1.11) | 3.11 (1.75)* |
| Graduate or professional | 2.06 (1.17) | 3.37 (1.97)* |
| Intercept | 35.36 (34.23) | 2.62 (0.31) |
| N | | |

Total N = 798

Notes: Reference category in the equation is A lot warmer
Standard errors in parentheses.
*p .05 **p.01 ***p.001 (two-tailed tests).

Results from the model show some fairly large and substantive effects. Being a climate skeptic (as opposed to a believer) increases the odds of reporting much colder temperatures (as opposed to warmer ones) last summer by a factor of about 3.5, controlling for actual temperature departures and maximum daily high, region

of residence, partisanship, and other socio-demographics. The odds of reporting no substantial change in temperature relative to perceiving warming temperatures is even larger. Overall, the effect of global warming belief on perceptions of local temperature anomalies is larger than for any other variable included in the model, and suggests that individuals with more skeptical views of global warming are more likely to perceive something other than warmer local temperatures in the summer of 2014.

As expected, there are some regional differences, which reflect regional variation in experienced temperatures as well as, potentially, broader characteristics in regional temperature variability. We also found that education is associated with a higher likelihood of perceiving normal temperatures (as opposed to warmer ones) while greater (warmer) temperature departures are associated with a lower likelihood of perceiving colder, as opposed to warmer, seasonal temperatures.[1]

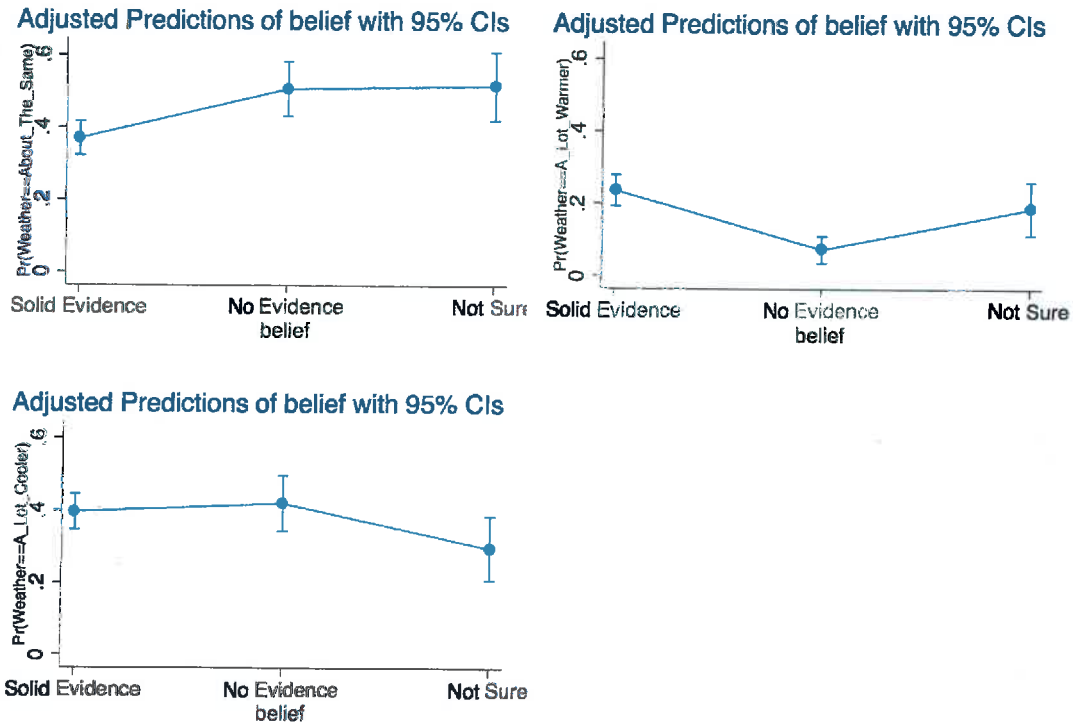
Overall, the model summarized in Table Eight provides additional evidence of a motivated reasoning process whereby individuals that do not see solid evidence of global warming are more likely to perceive colder (as opposed to warmer) summers, even when controlling for actual weather in their area. Similarly, global warming skeptics are more likely to perceive last summer as being "normal" even in cases where local temperatures were on average significantly warmer. This

[1] Other models were estimated with average temperature departures for each of the three summer months – June, July and August. Results are consistent, though they suggest August temperatures are a stronger predictor of retrospective seasonal temperature assessments. This makes sense, since August temperatures would have been more recent at the time the survey was asked. In the same vein, temperatures recorded on the day of the interview appear to be better predictors of recalled seasonal temperatures.

tendency to discount evidence that does not fit one's prior views is suggestive of motivated reasoning.

In order to say something more general about probabilities, we simulated discrete marginal effects for global warming belief after running the fully specified model. Results are summarized in Figure Two.

**Figure Two: Discrete marginal effect plots**




As shown in the top left panel, the effect of global warming beliefs on the probability of perceiving last summer as being "About the same" is significantly lower among those believing there is solid evidence of global warming, relative to those with more skeptical views. More precisely, the odds of perceiving "normal temperatures

last summer is on average about 14 percentage points higher (i.e. a difference in the predictive margin of about 0.487- 0.344) for skeptics than for believers with the same values on the other independent variables included in the model (including partisan id, living in the same area, similar experience with temperatures last summer and day of interview, etc).

The case for some motivated reasoning dynamic among skeptics is even stronger when looking at the marginal effect of global warming beliefs on the probability of perceiving last summer's temperatures as being "A lot warmer" than usual (top right panel). As shown, the effect of more skeptical beliefs is negative. Specifically, the probability of perceiving a warmer summer is on average about 16 percentage points lower for skeptics than for believers living in the same area under similar climatic conditions and with equivalent socio-demographic characteristics. However, the marginal effect of global warming belief on the probability of perceiving much colder temperatures is negligible. This is because, as shown in the cross-tabulations, believers are just as likely to report colder temperatures as much warmer ones (Table Four). Overall, those with more skeptical views of global warming are also those more likely to engage in a form of motivated reasoning that enhances the likelihood of recalling things and events that confirm, while discounting the weight of evidence that challenges, one's global warming views.

**Discussion, Conclusion and Extensions**

Several studies on the relationship between global warming beliefs and experienced weather have found that experienced precipitation and temperature deviations have an effect on beliefs about the existence of global warming. If perceptions of

weather are important determinants of attitudes toward global warming, as this literature suggests, then it is important to better understand the factors that may bias perceptions of prevailing weather patterns. By matching public opinion data measuring perceptions of weather to instrumental temperature data, we are able to validate the accuracy with which individuals are able to perceive departures from normal weather, and test for factors that may bias such perceptions.

In this study, we examine the relationship between perceptions of seasonal variation in temperature and attitudes toward the existence of global warming. We find some evidence of motivated reasoning, particularly among global warming skeptics, who are much less likely to perceive temperatures in their area in the summer of 2014 as being a lot warmer than usual, even when controlling for other factors including locally recorded temperatures. We also find some evidence that local temperatures, especially more recent ones, can affect perceptions of seasonal temperature deviations, though the effect of such external climatic conditions is less robust than individual perceptions of them. Overall, this suggests that perceptions of climatic conditions are prone to bias from views about the existence of global warming.

Though other studies have examined perceptions of weather as the dependent variable, the distinctive contribution of this study lies in its design. Past studies (e.g. Howe and Leiserowitz, 2013) have relied on respondent's to recall seasonal temperatures up to 8 months prior to the administration of the survey. In contrast, the survey data used here were collected in the month of October, just a few weeks following the official end of summer in 2014. This study thus reduces the

temporal lag between respondent's perceptions of the previous summers weather, and their actual experience of it. The present study also includes a variable measuring maximum recorded temperature on the day of the survey, to further control for the effects of more recent experience with temperatures. In contrast to Howe and Leiserowitz, whose study employs a categorical variable that segments different types of global warming belief based on answers to 36 climate change related items, here we use a simplified categorization of belief based on whether respondents see or fail to see evidence of global warming, which is also the first question asked in the survey. This more simple categorization may actually be a more direct measure of the beliefs most likely to bias perceptions of experienced weather. Finally, though time constraints prevented inclusion of results in this paper, we have comparable data for Canada collected using the same instrument at the same time, which will be used to further explore the relationships examined here but in a different national and climatic context.

While the evidence found is fairly robust, there are important limits to the present study. The cross-sectional design, for instance, does not allow for a conclusive answer to the question of whether beliefs related to the existence of global warming influence perceptions of weather, or vice versa. Although the direction of causality is a thorny one, one study employing a panel design has found that attitudes toward global warming shape perceptions of weather, particularly in cases where an individual has thought a lot about the issue of global warming (Myers et al. 2012).

Overall, we find evidence suggesting that beliefs about global warming may influence subjective experience with, and ability to accurately assess past experience with weather. In the future, we plan to further test this motivated reasoning hypothesis by looking more closely at individuals who are more confident in their views about the existence, or non-existence of climate change. Preliminary results suggest that the probability of perceptions of temperatures being influenced by beliefs about global warming is higher for individuals that are more convinced that global warming is not occurring. Future work will also exploit the comparable Canadian data. Replicating these tests in Canada's distinctive climatic context may provide new insight into the relationships between external climatic conditions, subjective experiences with weather, and public perceptions of climate change.

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