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Social, Demographic, and Environmental Influences on Perceptions and Memories of Weather, Climate, and Climate Change

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SOCIAL, DEMOGRAPHIC, AND ENVIRONMENTAL INFLUENCES ON PERCEPTIONS AND MEMORIES OF WEATHER, CLIMATE, AND CLIMATE CHANGE

by

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The final copy of this thesis has been examined by the signatories, and we Find that both the content and the form meet acceptable presentation standards Of scholarly work in the above mentioned discipline.

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ABSTRACT

Malmberg, Julie Suzanne (Ph.D., Geography)

Social, Demographic, and Environmental Influences on Perceptions and Memories of Weather, Climate, and Climate Change

Thesis directed by Associate Professor Peter D. Blanken

This research seeks to understand how people in the Denver metropolitan area perceive and remember weather, climate, and climate change and how social, demographic, and environmental factors might influence these perceptions and memories. To do this, an online survey was completed in 2006 and in-person interviews were conducted in 2010 and 2011. The online survey and the in-person interviews both asked questions about recent weather, seasonal climate for specific years, beliefs about climate change and human impact on climate change, and social and demographic information. During the 2010-2011 in-person interviews, ambient meteorological conditions were recorded. For climate recollections, overall accuracy was about 20%. In general, women who were politically liberal, majored in a science field, believed in climate change, and were in a good mood were the most accurate for past climates. However, this accuracy was still only about 30%. For recent weather memories, the accuracy was about 50%. Time was the biggest indicator of accuracy, with the most recent weather being remembered the most accurately. When asked to rate the weather from positive to negative for specific events, respondents reported the weather with a negative bias for extremely negative flashbulb memory events. For perceptions about climate change, over 80% of the respondents in the Denver metropolitan area believed global warming was occurring and that humans had an impact on global warming. Over 80% of respondents believed that global warming will impact the Denver metropolitan area, however not all of these people knew how climate change would impact them personally.

"Unless someone like you cares a whole awful lot,

Nothing is going to get better. It's not."

Dr. Seuss, *The Lorax*

"In ancient times, the land lay covered in forests,

where, from ages long past, dwelt the sprits of gods.

Back then, man and beast and forest lived in harmony…"

Princess Mononoke

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CHAPTER 1

Introduction

1.1 Background

In the chapter "Assessing Adaptation Processes to Climate Change" in the *Fourth Assessment Report (AR4)* on global climate change, the Intergovernmental Panel on Climate Change (IPCC) makes a call to better understand the relationship of human cognition to the understanding of the environment and climate change (Adger et al. 2007). This same call has been made numerous times over the past five decades (e.g., Saarinen 1969, Harrison 1982, Whyte 1985, Diggs 1991, Huntington and Fox 2005, Byg and Salick 2009, Salick and Ross 2009, Leiserowitz 2010), however, there is still a lot of confusion about how cognition affects perceptions of climate, climate change, and therefore the decisions made about mitigation and adaptation to climate change.

Along with uncertainties concerning cognition and climate change, there currently are areas of the world that lack reliable instrument data, both temporally and spatially, for weather and climate histories, particularly in mountain regions, polar regions, and urban areas (Barry 1992, Changnon and Kunkel 2006). Scientists are looking to additional sources for proxy climate data (e.g., tree rings, ice cores, pollen records). In mountain regions, people have been living in these areas with sparse instrumental climate data for generations. Local knowledge may help fill the spatial and temporal gaps left by

instrument data, which is particularly important for understanding local-scale climate change. If scientists know how accurately people remember weather and climate, what may influence those memories, and if certain sects of the population have more accurate recollections as compared to instrument data, a valuable dataset could be made available.

1.2 Objectives

The purpose of this dissertation is to investigate what social, demographic, and environmental factors may influence the general population's recollections and perceptions of past weather, climate, and climate change or, in other words, to calibrate the human thermometer. The research for this study was completed in two parts: first an online survey that took place in 2006; second, in-person interviews which took place in 2010-2011. The 2010-2011 in-person interviews allowed for more in-depth analysis of some of the results of the 2006 online survey. All participants in both parts of the study lived in the Denver metropolitan area. This research addressed the following four main objectives:

1. How accurate, as compared to instrument data, does the general population remember past weather and climate? Do social or demographic factors influence the accuracy of those recollections?
2. How do current perceptions of climate change influence recollections of weather and climate?

3. How do ambient meteorological conditions at the time of interviews, such as air temperature and solar radiation, influence the accuracy of the recollections of past events and weather associated with that event?
4. How do people in the Denver metropolitan area view climate change and the human impact on climate change? Do social or demographic factors influence these perceptions? And, how do people in the Denver metropolitan area believe climate change is impacting or will impact the Colorado Front Range?

1.3 Methods

The experimental part of this research was conducted in two main sections, an online survey and personal interviews. The online survey, conducted in 2006, surveyed 441 residents of the Denver Metropolitan area (note: over 490 people opened the survey and 441 respondents answered at least one question in the survey; this is discussed below). The survey was available to anyone with Internet access with the URL at http://FreeOnlineSurveys.com/rendersurvey.asp?sid=gc72cdfqnprxju9208223 for three months (July 17, 2006 until September 15, 2006). This online survey-hosting site, Free Online Surveys, charged $10 per month for unlimited number of participants and data sorted by respondent (the free site allowed for compiled results, which was not useful for this research). The link to the online survey was sent to the following email listservs:

- University of Colorado at Boulder Department of Geography student and faculty listserv
- University of Colorado at Boulder Department of Atmospheric and Oceanic Sciences student and faculty listserv
- University of Colorado at Boulder United Governance of Graduate Students listserv administrator

- National Center for Atmospheric Research employee email list
- National Oceanic and Atmospheric Administration – Physical Sciences Division employee email list
- Western Water Association email usergroup – Denver metropolitan area members only
- The Denver-Boulder Chapter of the American Meteorological Society email list
- Adams County School District 14 employee email list
- Cooperative Institute for Research in Environmental Sciences listserv administrator
- Institute of Arctic and Alpine Research listserv administrator

The following email was sent to the listservs on July 19, 2006:

> Subject: Memories and Perceptions of Climate Research Help
>
> Hello!
>
> I am a graduate student at the University of Colorado at Boulder and am conducting a study about memories and perceptions of weather and climate in the Denver/Boulder Metro area. I am trying to get a reliable data set and was hoping that you could forward this survey on!
>
> It is located at:
> http://FreeOnlineSurveys.com/rendersurvey.asp?sid=gc72cdfqnprxju9208223
>
> Please let me know if you have any questions and thank you!
>
> -Julie Malmberg
> julie.malmberg@colorado.edu

Additionally, an email was sent to approximately 50 personal friends, acquaintances, and colleagues of the researcher in the Denver metropolitan area on July 17-19, 2006. This email included the same link sent to the listservs and a request to forward the email on to anyone in the Denver metropolitan area. This is the email sent to personal acquaintances of the researcher:

Subject: Memories and Perceptions of Climate Research Help

> Hello!
>
> As many of you know, I am a graduate student at the University of Colorado at Boulder and am conducting a study about memories and perceptions of weather and climate in the Denver/Boulder Metropolitan area. I have created an online survey for my research and

am trying to get as many responses as possible in order to have a more reliable dataset. If you have about 15-20 minutes, can you please take this survey? It is located at:

http://FreeOnlineSurveys.com/rendersurvey.asp?sid=gc72cdfqnprxju9208223

Please let me know if you have any questions or feedback! And, I would appreciate it if you could forward this on to anyone living in the Denver/Boulder Metro area.

Thank you!
Julie Malmberg
julie.malmberg@colorado.edu

491 people opened the 2006 online survey and 441 respondents answered at least one question. The peak response dates were on July 20, 2006 (n=129) and July 25, 2006 (n = 87) (see figure 1.1). On average, respondents answered 82% of the 46 questions and 77% (n =331) of the respondents answered more than 80% of the questions. 18% of the respondents (n = 79) answered all of the questions.

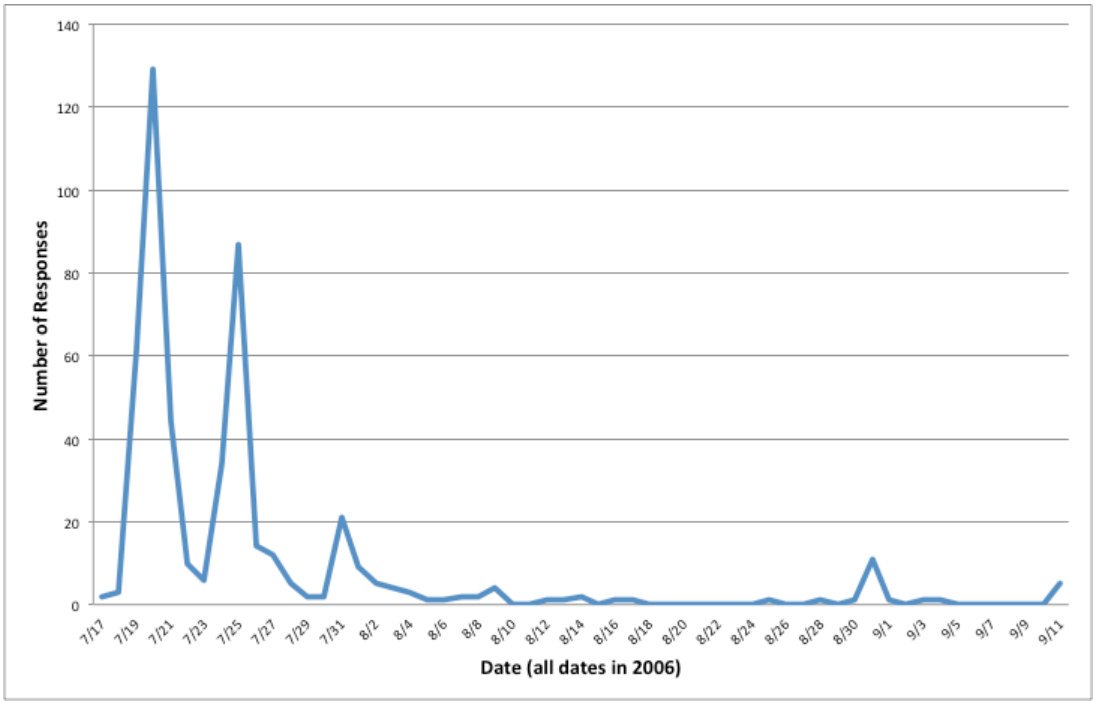

Figure 1.1. Number of responses by date for the 2006 online survey.

The 2006 online survey included questions about recent weather (one day, two days, and one week prior) and past climate (two years, 10 years, and 20 years prior) in the Denver area as well as questions about demographics, beliefs about climate change, importance of weather to job, time spent outdoors, and prior education in weather or climate (See Appendix B for the complete online survey).

Approximately 350 people answered the demographic questions on the 2006 online survey. Not answered each question, which explains the variances in *n* in the table below (table 1.1). Of those that answered, over half were female, over half had graduate-level education, 41% had a prior class in weather or climate, 33% had a weather of climate-related career, and about half spent between two and six hours outdoors each day. While these numbers don't necessarily represent an exact subset of the Denver Metropolitan area, they instead represent a sect that was interested in the survey results. With no incentive or targeted marketing, which would also cost, it was difficult to gather information from people who were not interested in the material of the survey.

Table 1.1. 2006 online survey respondent demographics.

2006 Online Survey		*n*	%
Gender	Male	147	42.2%
	Female	201	57.8%
Education Level	High School/Assoc	51	14.8%
	Bachelors	106	30.7%
	Graduate	188	54.5%
Prior Class in Weather or Climate	Yes	145	41.4%
	No	205	58.6%
Weather or Climate Career	Yes	115	33.0%
	No	233	67.0%
Time Spent Outdoors	< 2 hours	145	41.5%
	2 to 6 hours	193	55.3%
	> 6 hours	11	3.2%

The second part of the experiment was in-person interviews. The interviews consisted of a written portion followed by an oral interview (Appendix C). The interviews were conducted in an outdoor courtyard in the center of the Muenzinger Psychology Building (latitude: 40°00'39.59" N, longitude: 105°16'06.39"W, elevation: 1660 m asl) on the University of Colorado at Boulder campus from October 2010 to February 2011. Walls encompass the courtyard, so wind was not a factor (figure 1.2). Forty-four students from the "General Psychology" course Subject Pool participated in the in-person interviews. Each interview lasted for about 45 minutes and was conducted by the primary researcher. The General Psychology Subject Pool consisted of approximately 1000 undergraduate students enrolled in "Psychology 1001: General Psychology" at the University of Colorado at Boulder. Each student in the course was required to complete six hours of research credits during the semester. Department of Psychology and Neuroscience faculty and graduate students with faculty supervision

submitted research topics to the General Psychology Subject Pool. Students then signed up for available timeslots, without knowing what the study topic was before signing up.

Figure 1.2. Muenzinger Psychology on the University of Colorado at Boulder campus. The yellow thumbtack indicates the approximate location of the in-person interviews. North is indicated in the upper right-hand corner and the scale is given in the lower left-hand corner. Image from Google Earth.

For this study, 45 Introduction to Psychology students were interviewed, although one interview is not included in the final results due to the inability of the respondent to understand English. The interviews were spread out between the fall of 2010 and the winter of 2011 (figure 1.3).

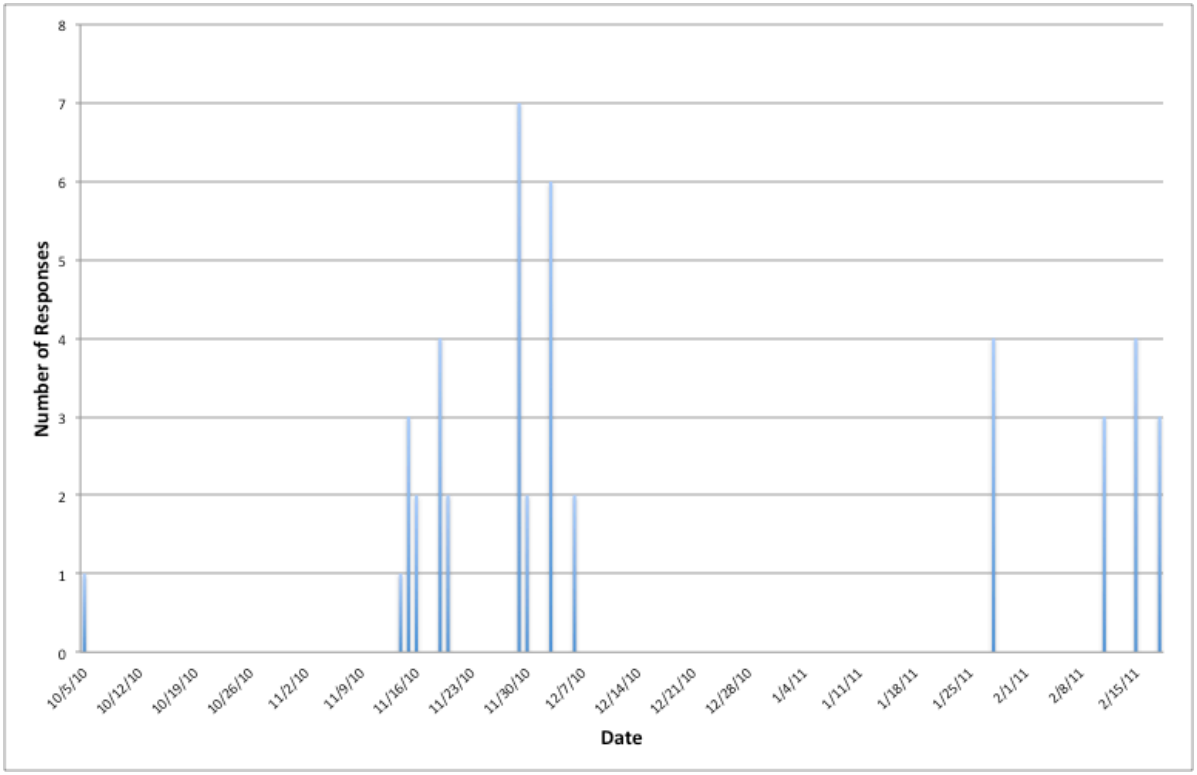

Figure 1.3. Number of responses by date for the 2010-2011 in-person interviews.

A summary of demographic and social information the respondents in the 2010-2011 in-person interviews is shown in table 1.2.

Table 1.2. Summary of respondents for the 2010-2011 in-person interviews

2010-2011 In-person Interviews			
		n	**%**
Gender	Male	24	54.5%
	Female	20	45.5%
Major	Science	17	38.6%
	Non-Science	27	61.4%
Political Affiliation	Conservative	11	25.0%
	Moderate	16	36.4%
	Liberal	17	38.6%
Prior Class in Weather or Climate	Yes	19	43.2%
	No	25	56.8%

While the participants in the 2010-2011 in-person interviews were answering written questions about past weather, climate, and social and demographic information, the researcher filled out the cover page for each respondent (Appendix C). Air temperature (T_a), relative humidity (*RH*), and incident shortwave radiation data were recorded from the University of Colorado at Boulder, Department of Geography weather station located on the East Campus of the University of Colorado at Boulder (figure 1.4), approximately 1.4 km from the interview location. The weather station is on top of a six-story building at latitude: 40° 01' 33" N, longitude: 105° 25' 19" W, and elevation: 1642 m asl. Relevant to this study, the weather station records air temperature in degrees C and F (accuracy ± 0.8°C), relative humidity in percent (± 3% typical, ± 5% in natural day light), and solar radiation in W/m^2 (± 3%). Data were collected every 2 seconds (For more information about the Department of Geography, University of Colorado-Boulder Weather Station, see: http://www.colorado.edu/geography/weather_station/Geog_site/about.htm).

At the interview location, visible radiation (0.4 – 0.7 *u*m) was measured using a photometric light sensor (Li-Cor Inc., model LI-210SL, Lincoln, NE). The light sensor recorded visible radiation in millivolts, which was then converted to lux, the SI unit for illuminance. Cloud cover and if any precipitation was occurring at the time of the interview were also noted.

Figure 1.4. The Department of Geography, University of Colorado at Boulder, Weather Station (photo courtesy of Annie Pepper).

In order to compare accuracy of recollections to instrument data, weather data were collected from four weather stations around the Denver metropolitan area. The four locations were Boulder (39.992°N, 105.267°W), Northglenn (39.899°N, 105.013°W), Denver-Stapleton (39.763°N, 104.869°W), and Lakewood (39.749°N, 105.120°W) (figure 1.5). The data are available at the NOAA National Climatic Data Center (NCDC -http://www.ncdc.noaa.gov/). These locations were chosen due to availability of data, longevity of data, and locations spread across the Denver metropolitan area.

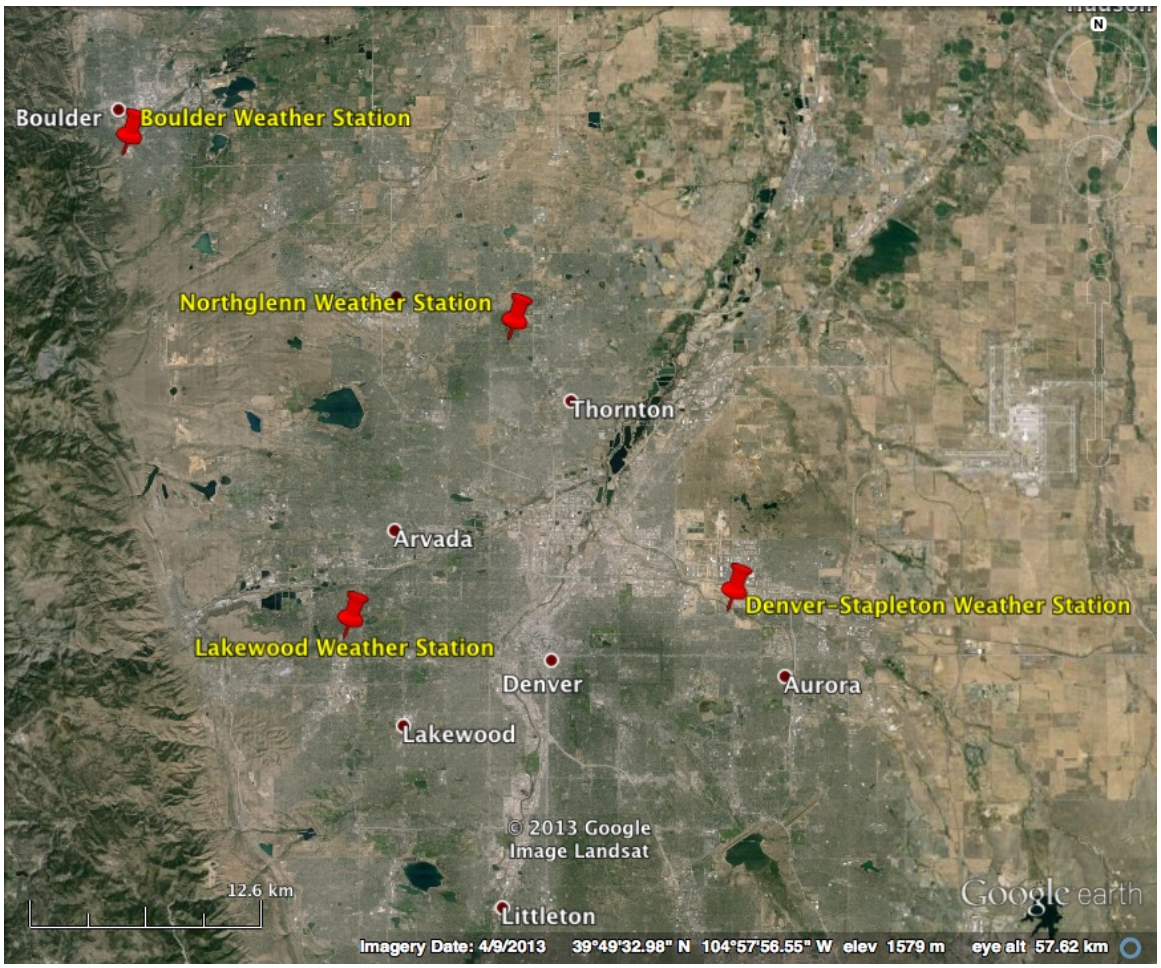

Figure 1.5. Locations of weather stations (Boulder, Denver-Stapleton, Lakewood, Northglenn) around the Denver metropolitan area are indicated by red thumbtacks. Map from Google Earth.

To compare accuracy of climate memories to the past climate instrument data, T_a and precipitation values for summer months (June, July, August) and winter months (December, January, February) for the four weather stations were analyzed. These values were then compared to recollections of past climates. A similar procedure was followed for comparing recent weather recollections to recent weather instrument data. Responses about the weather one day, two days, and one week prior for both the 2006 online survey and the 2010-2011 in-person interviews were compared to instrument data for the four

weather stations around the Denver metropolitan area. Response accuracy for both weather and past climate was then compared to social and demographic factors, including gender, political affiliation, time spent outdoors, education level, and more. Next, statistical analysis was done to see if there were any relationships between ambient meteorological conditions (T_a, RH, visible radiation, total solar radiation) and the accuracy of the responses about weather and climate. Finally, answers about beliefs about global warming, beliefs about human impact on global warming, and beliefs about local impacts of climate change were compared to the responses about weather and climate and other social and demographic factors. These results will be discussed in detail in chapters two and three.

A mixed mode methodology (online surveys and in-person interviews) has both benefits and weaknesses. Online surveys allow for many respondents very inexpensively. However, respondents may not finish the survey and may leave key questions unanswered. Additionally, there is not an opportunity for clarification. In-person interviews allow for clarification and more in-depth responses. But, in-person interviews are time consuming and there is a possibility that the respondent will bias answers to try to please the interviewer (Dillman 2007).

In the 2010-2011 in-person interviews, respondents were also asked to recall and then rate four events and the weather associated with these events. The four events included two of the respondent's choosing and two specific events; the terrorist attacks on September 11, 2001, and the Fourmile Canyon fire in September 2010. For each event, the respondent was asked to rate the event itself on a scale of one to six, with six being the best and one being the worst, and rate the weather associated with that event,

with six being the best and one being the worst. Additionally, each respondent was asked to rate his or her current mood and the current weather. These data were then analyzed to see if there were any relationships between the ambient meteorological conditions at the time of the interviews, current mood and current weather ratings, and the event rating and weather associated with the event rating.

The fourth chapter looks at how people in the Denver metropolitan area view climate change, local climate change, and human impacts on climate change. To find out beliefs, the respondents in both the 2006 online survey and the 2010-2011 in-person interviews were asked if they believe global warming is happening, whether or not humans have an impact on global warming, and if global warming is impacting the Colorado Front Range. Additionally, 2010-2011 in-person interview participants were asked to draw or describe global warming and global warming in the Colorado Front Range. These data were then compared to social, demographic, and environmental data collected during the 2006 online survey and the 2010-2011 in-person interviews.

1.4 Arrangement of the Dissertation

This dissertation is arranged into five separate chapters. Chapter one (this chapter) includes the introduction and methodology and chapter five summarizes key findings. Chapters two, three, and four are studies for the following topics:

- Chapter 2: Social, Demographic, and Environmental Influences on Memories and Perceptions of Past Climates

- Chapter 3: Social, Demographic, and Environmental Influences on Memories and Perceptions of Recent Weather
- Chapter 4: Social, Demographic, and Environmental Influences on Perceptions of Climate Change

Chapters two, three, and four include an introduction, objectives, additional methods from those described in chapter one, results, discussion, and a bibliography. A final bibliography for works cited in all chapters is after chapter five. Appendices for this dissertation include the following:

- Appendix A: Email sent to solicit respondents for the 2006 online survey
- Appendix B: Questionnaire to subjects in the 2006 online survey
- Appendix C: Questionnaire and debriefing form to subjects in the 2010-2011 in-person interviews
- Appendix D: Respondent drawings from the 2010-2011 in-person interviews

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CHAPTER 2

Social, Demographic, and Environmental Influences on Memories and Perceptions of Past Seasons

2.1 Introduction

Climate change is having local impacts on ecosystems and human activity across regions of the globe. Whether it is the melting of sea ice (Chapman and Walsh 1993), the melting of permafrost (Hinzman et al. 2005), the unprecedented high air temperatures in polar regions (Overpeck et al. 1997), increasing climate variability making it harder for indigenous tribes to predict weather (Roncoli et al. 2001), or the countless other ways climate change has been documented, climate change is affecting people. The need for better global climate models (GCMs) to forecast what may happen and the need to further understand the impacts of climate change are leading researchers to seek additional methods of studying climate change other than the traditional instrument datasets (Berkes and Jolly 2001, Sagarin and Micheli 2001, Robbins 2003, McKinsey et al. 2004, Norgaard and Baer 2005, Garcia-Herrera et al. 2006, Byg and Salick 2009, "Online Project Examines Naval Weather Logs" 2011).

One potential way of assessing climate change and its impacts is by talking to local populations. Several studies have been performed asking local populations for

recollections and memories about climate and climate change (e.g., Abele 1997, Ingold and Kurtilla 2000, Cruikshank 2001, Lorenzoni and Langford 2001, Roncoli et al. 2002, Lorenzoni and Pidgeon 2006, Salick and Ross 2009). There is a delicate balance to strive for when comparing local knowledge to instrument data; researchers are often worried about respecting local knowledge and appreciating the intricacies of this local knowledge (Huntington and Fox 2005, Woo et al. 2007). However, in order for local knowledge to help fill temporal and spatial gaps left by instrument data, particularly in mountain regions and polar regions, it is necessary to determine how accurately people remember past climates and identify the factors that influence their perceptions of weather and climate.

2.1.a Colorado Front Range Climate

The climate of Colorado is highly variable, both spatially and temporally, due to the topographic influences of the Rocky Mountain, the high elevation, the mid-latitude location, and the continentality of the state. All of these factors lead to high solar radiation, large seasonal and diurnal air temperature variability, and large variability in seasonal precipitation amounts (Doesken et al. 2003). Blizzards, thunderstorms, tornadoes, lightning, droughts, flooding, and strong wind events all impact the climate of Colorado. January is usually the coldest month and either July or August is the warmest month. The highest annual variability in air temperatures is maximum daily air temperatures in the winter; the least annual variability is minimum daily air temperatures in the summer (Ray et al. 2008). The corridor of land along the western edge of the

plains of Eastern Colorado is called the Colorado Front Range. This area has milder air temperatures in both summer and winter and lower precipitation amounts as compared to other areas in Colorado (Doesken et al. 2003). The Colorado Front Range is also the most populated section of Colorado.

Instrumental weather observations have been recorded in Colorado since the 1870s (Doesken et al 2003). In 1890, the US Weather Bureau (now the National Weather Service) was formed and more weather stations were established throughout Colorado. Now, there are about 250 weather stations in Colorado reporting to the National Weather Service (Doesken et al. 2003). The weather stations report daily minimum and maximum air temperatures, daily liquid precipitation totals, snowfall, and snow depth. Some of the stations also report cloud cover, wind data, and humidity. All of these data are stored at the National Climatic Data Center (NCDC), which also hosts the data online (http://ncdc.noaa.gov).

According to the *Climate Change in Colorado Report* (Ray et al. 2008), annual mean air temperatures in Colorado have increased by about 1.1°C in the past 30 years and will rise as much as 3.1°C by 2050 as compared to the 1950-99 baseline. By 2050, air temperatures along the Front Range are expected to be similar to air temperatures at lower elevations in eastern Colorado today. Additionally, minimum daily temperatures are expected to increase more than maximum daily temperatures. The Colorado Front Range is not predicted to have much change in overall annual precipitation amounts (including both snow and rain), however, annual snowfall and snowpack are projected to decrease by as much as 50% or more in the mountains (Christensen et al. 2007). Since snowmelt provides anywhere from 50-85% of the water for the Front Range (Changnon

et al. 1993, Barry and Seimon 2000, Stewart et al. 2004), Colorado is in an area of "high stress" for freshwater availability (Kundzewicz et al. 2007). Higher air temperatures in the spring also are leading to earlier snowmelt dates (Stewart et al. 2004, Ray et al. 2008). Some areas in the Front Range are already showing trends of snow melting as much as 15 to 20 days earlier than was the norm (Stewart et al. 2004).

Barry and Seimon (2000) found that air temperature lapse rates in American mountain regions during the day are not as steep as in the past. With a decrease in lapse rates, it will take more convectional heating to produce instability and precipitation. Decreases in snow and earlier snowmelts will also lower surface albedos (Chang and Smith 2001). With more shortwave radiation being absorbed by the surface, high evaporation of soil moisture will lead to further drying. Overall, climate change in the Front Range is projected to impact water availability, which is already an issue with the quickly growing population along the Front Range.

2.1.b General Memory

Bernsten and Thomsen (2005) found that people are able to remember the weather with extreme clarity on personally significant days. Flashbulb memories are defined as memories that can be recalled for long durations in extreme detail (Bernsten and Thomsen 2005). It is generally accepted that flashbulb memories form when an important, yet surprising, event that is personally consequential and causes extreme emotion occurs. However, some research has found that the surprise factor is not as important as the personal consequence, importance, or emotion invoked (Conway 1995).

For example, Bernsten and Thomsen (2005), found that Danes accurately remembered the weather on the day of the German occupation during World War II and then again on the day of liberation. These flashbulb memories allow people to recall even minor details with incredible accuracy, although the memory might be biased by the mood of the person during that day. For example, the respondents remembered the weather as slightly worse than it actually was on the day of occupation versus remembering the weather slightly better than it actually was on the day of liberation (Bernsten and Thomsen 2005). While air temperatures and weather on individual, important days have been verified for accuracy, memories of overall weather trends, or climate, have not been checked for accuracy up to this point. Additionally, Bohn and Bernsten (2007) found similar results in a study of East and West Germans on the rise and fall of the Berlin Wall. They found that people were more likely to frequently recall the events of a positive flashbulb memory than a negative flashbulb memory. Furthermore, people were more likely to guess responses to factual questions (e.g., the day of the week of an event) if the event was positive versus a negative event. This led to factual questions about positive events garnering more responses, but the accuracy of the factual questions about negative events being higher (Bohn and Bernsten 2007).

A study by Walker et al. (2003) found that people's recollections are generally positively biased, and less pleasant memories are often forgotten faster than positive memories, which is known as the fade effect (Walker et al. 2003). Saarinen (1969) found a similar pattern in farmers recollecting drought. When asked about prior droughts, the farmers tended to remember better crop yields and fewer droughts than actually occurred. Additionally, when asked to recall specific events, Hyman and Loftus (1998) found that

people would recall details of an event with high certainty of their accuracy, but when further investigated, the details were actually associated with a different event. This is known as time-slice errors. A second type of memory error, known as the misinformation effect, is described by Frenda et al. (2011) as the distorting effects of misleading postevent information for details of a witnessed event. For example, if people see photographs of an event from a different perspective from their own, they might incorporate details from the picture into their personal memories.

2.2 *Objectives*

The purpose of this chapter is to investigate what social, demographic, and environmental factors may influence the general population's recollections and perceptions of past seasonal weather. In this dissertation, weather is defined as the conditions of the atmosphere at any particular time and place. Climate is the accumulation of weather data averaged over a 30-year period. The four main objectives of this section phrased as questions are:

1. How accurate, as compared to instrument data, does the general population remember past seasonal weather?
2. Do social or demographic factors influence the accuracy of those recollections?
3. How do current perceptions of climate change influence recollections of past seasons?

4. How do ambient meteorological conditions at the time of interviews, such as solar radiation, influence the accuracy of recollections of past seasons?

2.3. Methods

In additional to the methods described in chapter one, additional methodologies pertained only to the research in this chapter. These methods will be described below.

The 2006 online survey included questions about past seasonal weather (2 years, 10 years, and 20 years prior) in the Denver area as well as questions about demographics, beliefs about climate change, importance of weather to job, and prior education in weather or climate (See Appendix B for the complete online survey). The seasonal weather questions were as follows:

1. Did you live in the Denver metropolitan area **two years** ago?
    a. Yes
    b. No

2. During the summer **two years** ago (June to August 2004), do you think the air temperature in the Denver metropolitan area was…
    a. Higher
    b. About the same
    c. Lower
    d. Do not remember
    e. Did not live in the Denver Metropolitan Area

3. During the summer **two years** ago (June to August 2004), how did the precipitation (rain, hail) compare to now?
    a. More
    b. About the same
    c. Less
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

In order to be included in the data analysis, respondents had to be in the Denver metropolitan area for at least one of the set time periods (2 years, 10 years, or 20 years

prior) and had to have answered at least one of the social, demographic, or environmental questions (Note: if respondents answered the past season questions, they typically answered the majority of the other questions). After removing respondents for not following these guidelines, the total number of respondents was 361. All 44 of the 2010-2011 in-person interviews were included in this research.

In order to compare accuracy of recollections to instrument data, weather data were collected from four weather stations around the Denver metropolitan area. The four locations were Boulder (39.992°N, 105.267°W), Northglenn (39.899°N, 105.013°W), Denver-Stapleton (39.763°N, 104.869°W), and Lakewood (39.749°N, 105.120°W) (figure 2.1). The data are available at the NOAA National Climatic Data Center (NCDC -http://www.ncdc.noaa.gov/). These locations were chosen due to availability of data, longevity of data, and locations spread across the Denver metropolitan area.

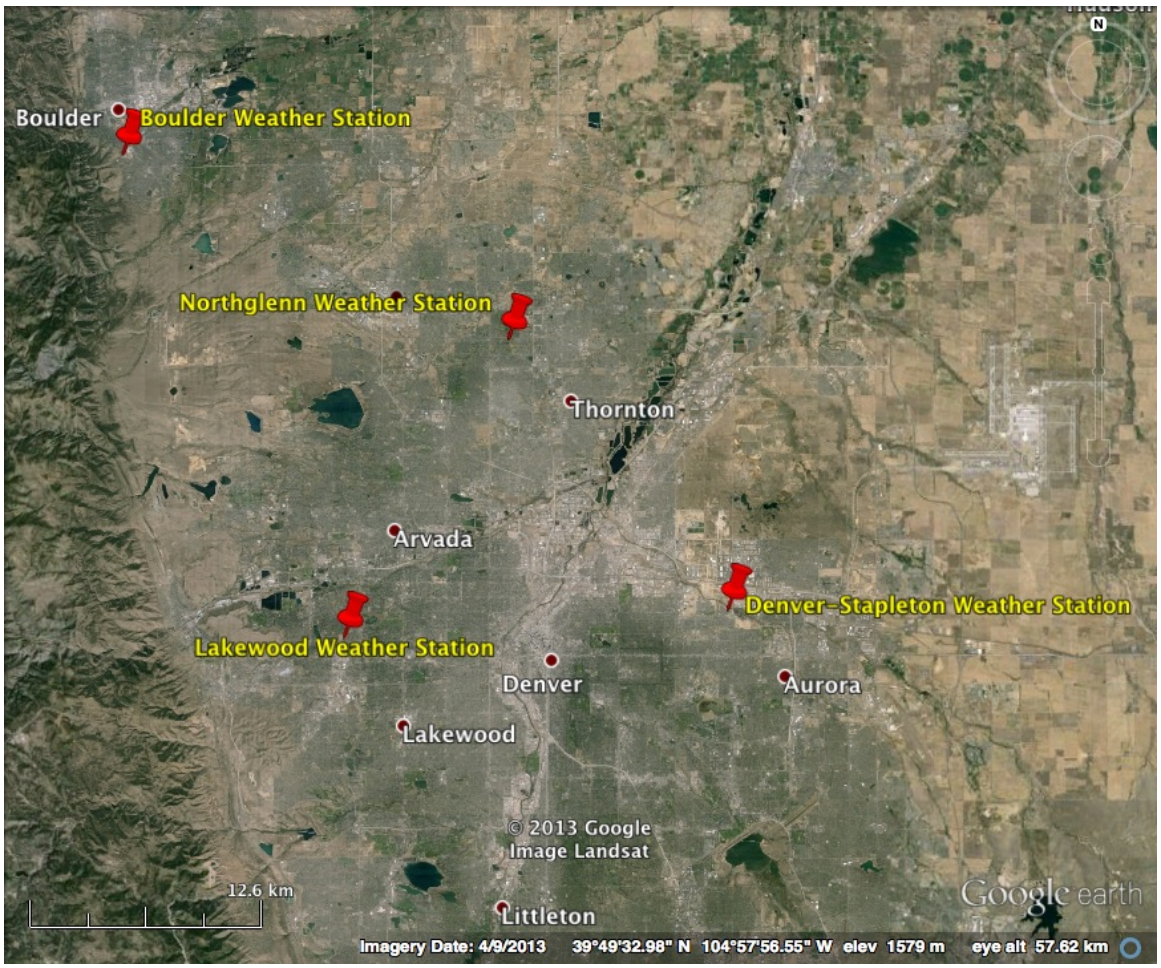


Figure 2.1. Locations of weather stations (Boulder, Denver-Stapleton, Lakewood, Northglenn) around the Denver metropolitan area are indicated by red thumbtacks. Map from Google Earth.

Air temperature and precipitation values for summer months (June, July, August) and winter months (December, January, February) were analyzed to show consistency with survey and interview questions asked for this project. Summer air temperatures showed a slight increase ($r^2 = 0.09$) (figure 2.2). Summer precipitation showed no significant trend ($r^2 = 0.001$) (figure 2.3). Winter air temperatures showed no trend ($r^2 = 0.01$) (figure 2.4). Winter precipitation showed no trend ($r^2 = 0.01$) (figure 2.5).

The next challenge was to compare qualitative answers about past seasons information (e.g., “a little more than average precipitation” or temperatures were “a little cooler than average”) to quantitative instrument data. To do this, a method of comparison was developed using the standard deviation of the four stations’ average air temperatures and precipitation amounts for the 30-year period from 1981-2010. The qualitative answer, “average” was considered to be accurate if the actual average for that particular time period (e.g., the precipitation in the summer of 1986) was within +/- 1 standard deviation away from the calculated 30-year average. Between +1 and + 2 standard deviations away from the 30-year average was considered “a little more”, and more than + 2 standard deviations away was considered “a lot more.” Between -1 and -2 standard deviations away from the 30-year average was considered “a little less” and more than -2 standard deviations away from the 30-year average was considered “a lot less.” The values for the averages for the specific periods of time as well as the 30-year averages and the standard deviations will be discussed in detail in the results section.

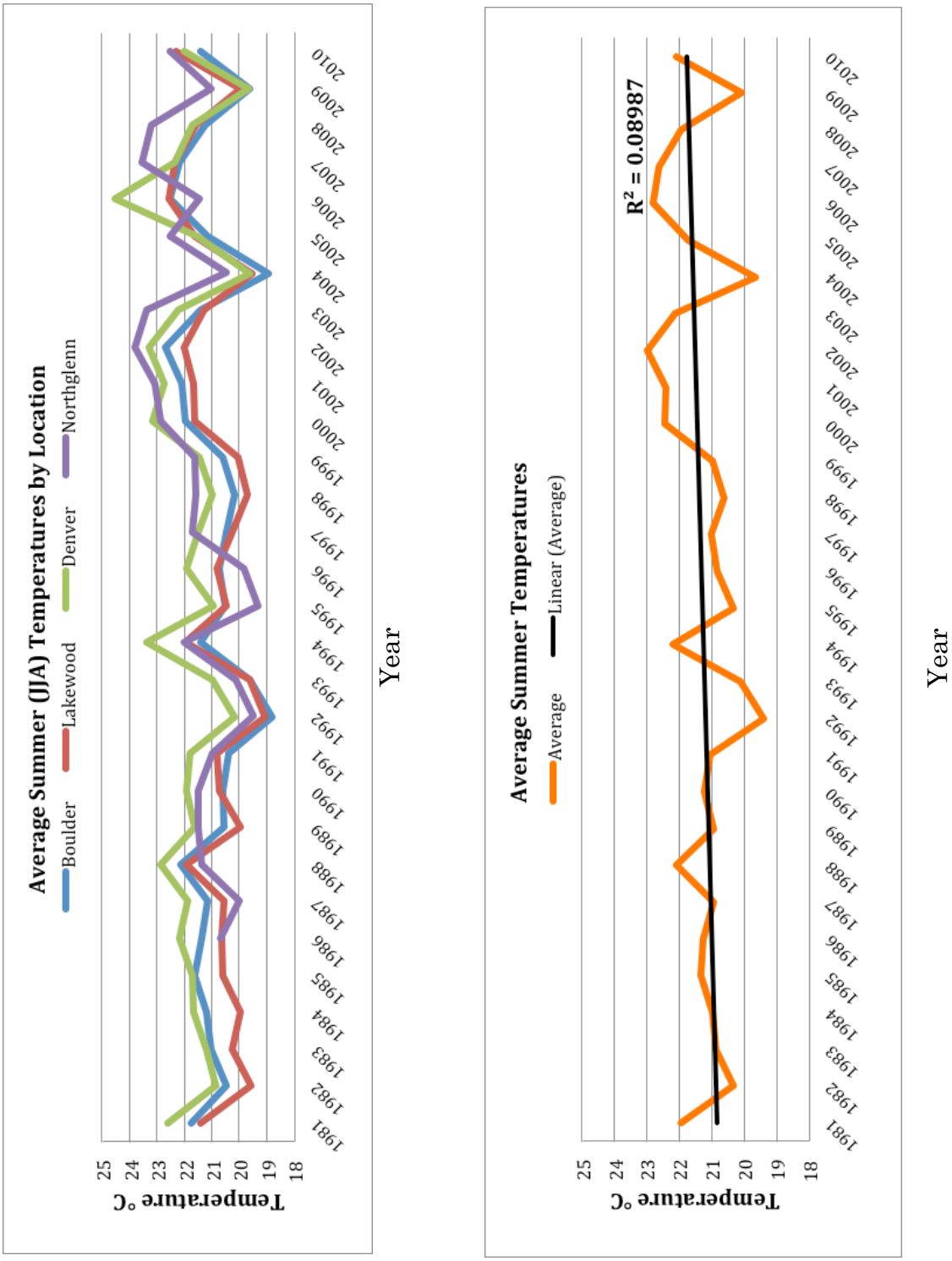


Figure 2.2 Average summer (JJA) air temperatures (°C) for the four regions (top) and the average (bottom) from 1981 to 2010.

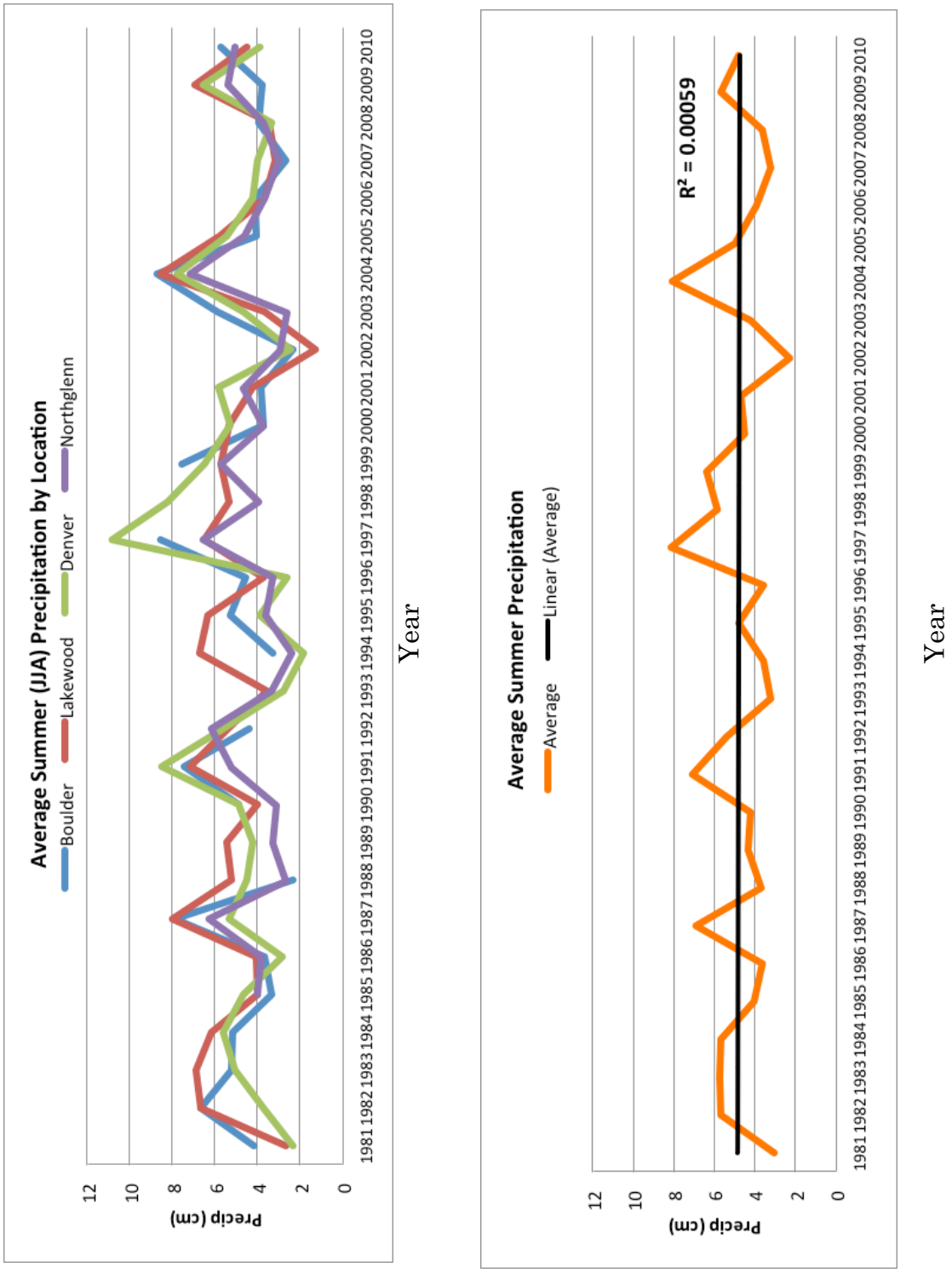


Figure 2.3 Average summer (JJA) precipitation (cm) for the four regions (top) and the average (bottom) from 1981 to 2010

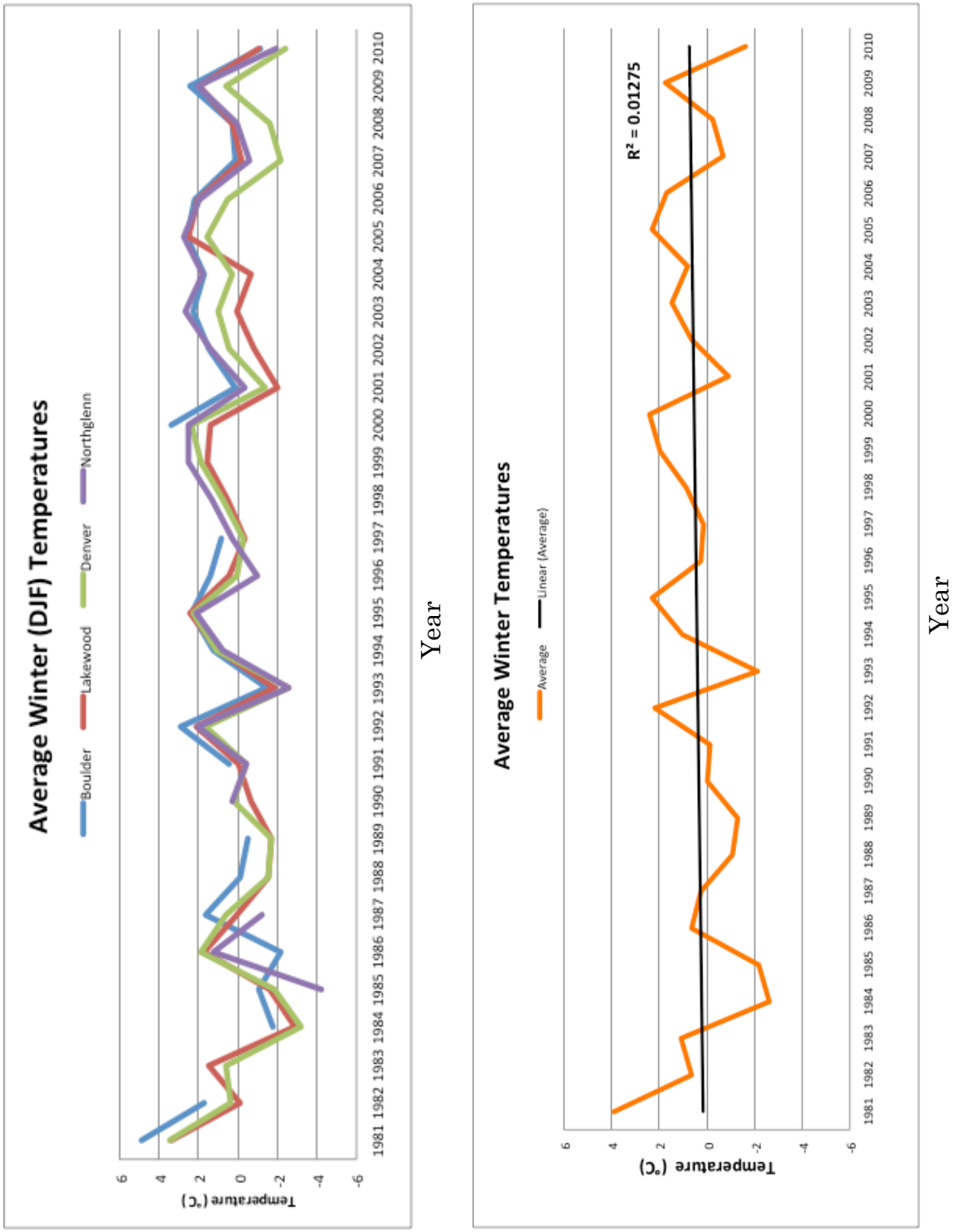


Figure 2.8 Average winter (DJF) air temperatures (°C) for the four regions (top) and the average (bottom) from 1981 to 2010.

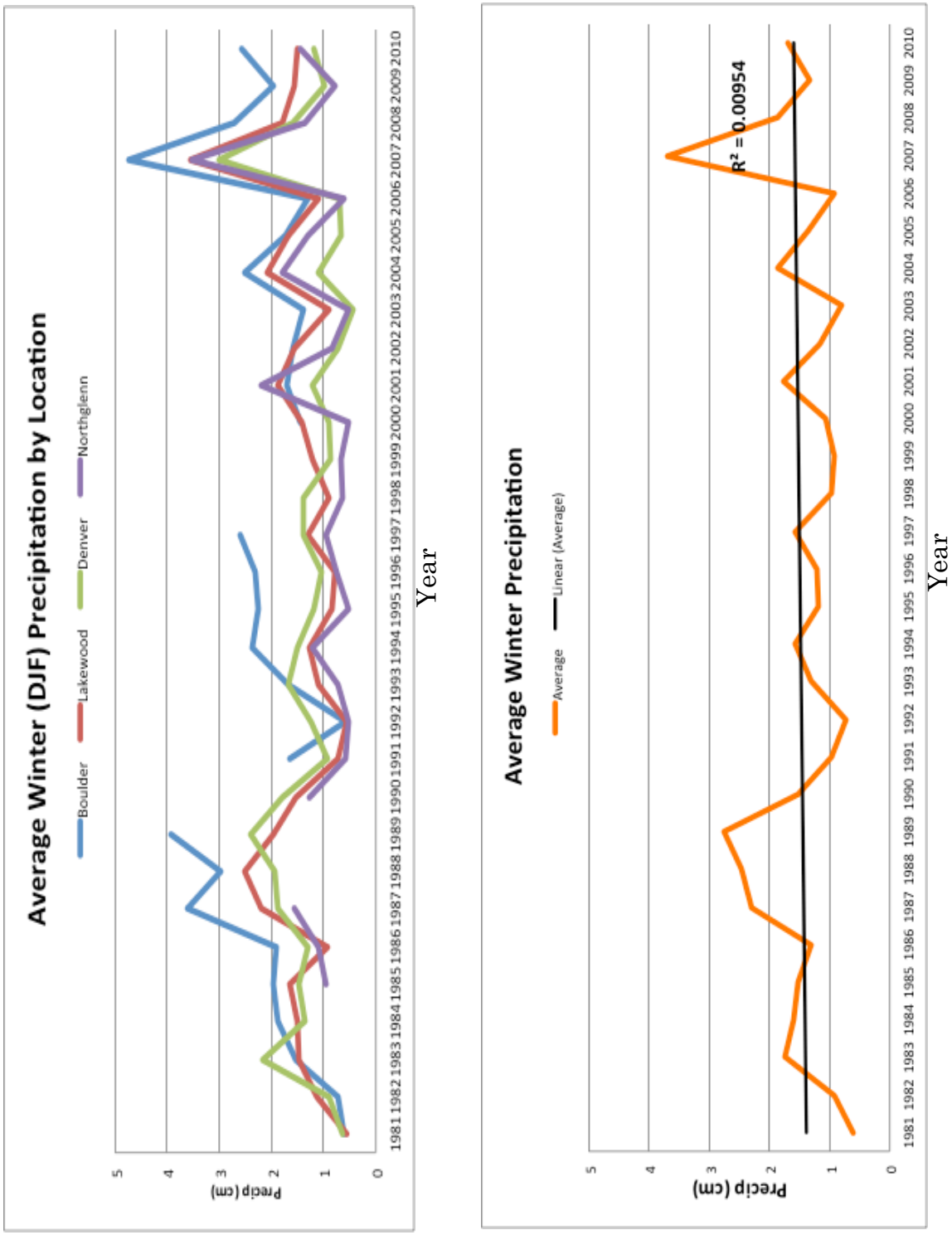


Figure 2.9 Average winter (DJF) precipitation (cm) for the four regions (top) and the average (bottom) from 1981 to 2010

2.4 Results

The results will be discussed for each of the four objectives.

2.4.a. Objective 1

Objective 1: How accurate as compared to instrument data does the general population remember past seasonal weather?

In order to compare to instrument data, air temperature and precipitation data were analyzed from the four Denver Metropolitan locations (Boulder, Denver Weather Forecast Office, Lakewood, and Northglenn). The 30-year averages for summer (June, July, August) and winter (December, January, February) were calculated from the NCDC dataset. Then, summer and winter averages for each location were calculated for the specific years respondents were asked to recollect. In order to determine if the season was a lot less, a little less, average, a little more, or a lot more than average, the standard deviation was calculated. If the seasonal average temperature was within one standard deviation of the 30-year average, the season was considered average. If the seasonal average was between one and two standard deviations away from average, it was considered a little less or a little more than average. If the seasonal average was more than two standard deviations away from the 30-year average, it was considered a lot less or a lot more than average (table 2.1).

Table 2.1. 30-year averages ($\bar{A}$) for air temperature and precipitation. Summer is June, July, August; Winter is December, January, February. Standard deviation (σ) was calculated from the averages for the four weather stations around the Denver metropolitan area. The remaining columns show the ranges for the answer categories. For example, the average air temperature for the summer of 1996 was 20.77°C, therefore an accurate answer would be "a little less than average."

		30-year average ($\bar{A}$)	Standard Deviation (σ)	"A lot less than average" range	"A little less than average" range	"Average" range	"A little more than average" range	"A lot more than average" range
				$< \bar{A} - 2\sigma$	$\bar{A} - 2\sigma$ to $\bar{A} - 1\sigma$	$\bar{A} - 1\sigma$ to $\bar{A} + 1\sigma$	$\bar{A} + 1\sigma$ to $\bar{A} + 2\sigma$	$> \bar{A} + 2\sigma$
Air Temperature (°C)	Summer	21.7	0.57	< 20.56	20.56 - 21.13	21.13 - 22.27	22.27 - 22.84	> 22.84
	Winter	0.79	0.8	< -0.88	-0.88 - -0.08	-0.08 - 1.52	1.52 - 2.32	> 2.32
Precipitation (cm)	Summer	4.83	0.38	< 4.07	4.07 - 4.45	4.45 - 5.21	5.21 - 5.59	> 5.59
	Winter	1.49	0.45	< 0.59	0.59 - 1.04	1.04 - 1.94	1.94 - 2.39	> 2.39

For the 2006 online interviews, respondents were asked if values were average, less than average, or more than average. If the actual air temperature or precipitation values were more than one standard deviation away from the instrument data average, it was considered less or more than average (depending on the value).

For the 2006 online survey, respondents were accurate, or within one standard deviation of the average, 20.48% (+/- 3.64%) of the time (n = 361). When broken down, respondents were 24.88% accurate about air temperature, 16.07% accurate about precipitation, 21.42% accurate about summer climate (both air temperature and precipitation), and 19.53% accurate about winter climate. When looking temporally, accuracy decreased as time increased. For questions about 2003-2004 (two years prior), accuracy was 31.09%; accuracy was 16.41% accurate for 1995-1996 (ten years prior); and 13.92% for 1985-1986 (20 years prior). (See figure descriptions for figures 2.6 – 2.9 for accurate answers.)

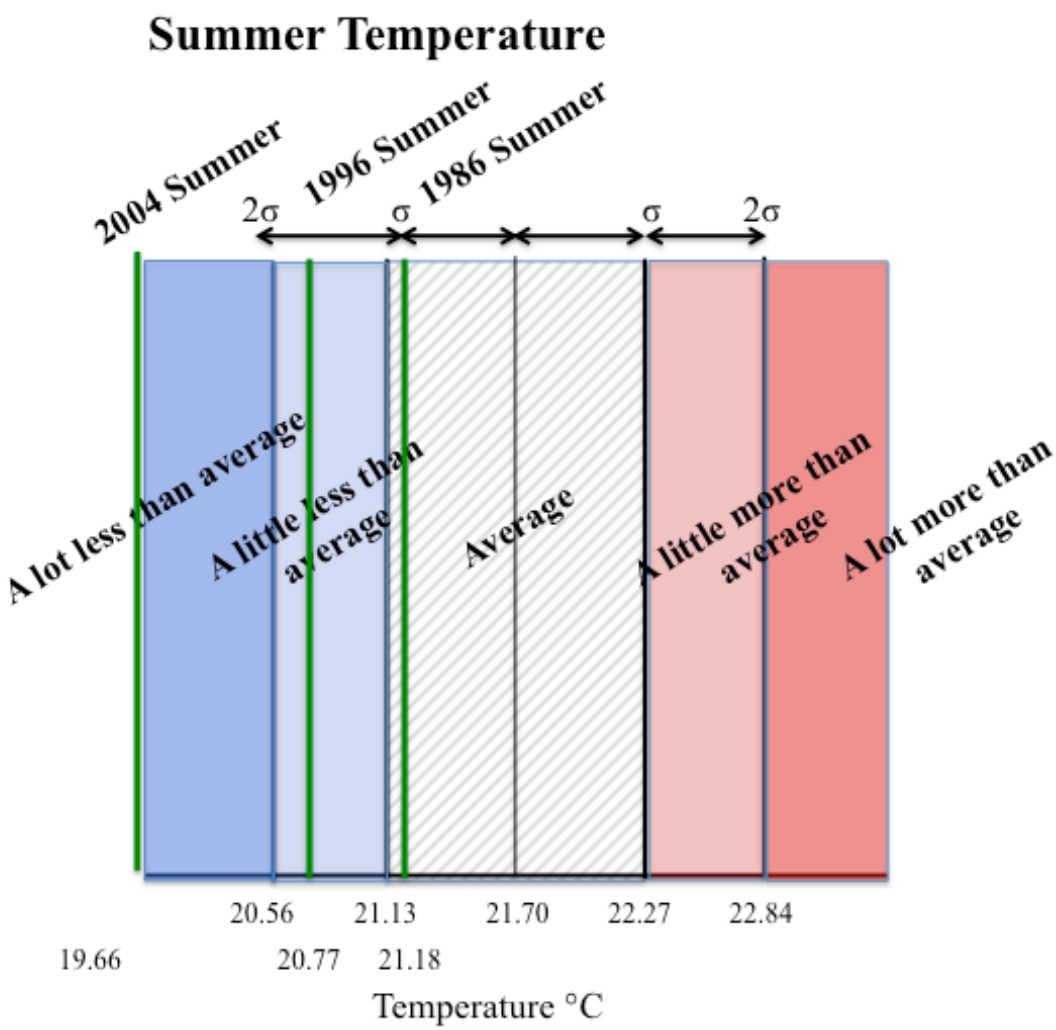


Figure 2.6 This figure shows comparisons of summer (June, July, August) air temperatures for specific years (1986, 1996, and 2004) as compared to the 30-year average for the Denver Metropolitan area. The green lines represent the average values for the specific years: 1986 = 21.18°C, 1996 = 20.77°C, 2004 =19.66°C. The 30-year average for the Denver Metropolitan area was 21.70°C. The standard deviation (σ) = 0.57°C. In order to be considered accurate for summer 1986, respondents had to answer "average"; for summer 1996, "a little less than average"; and for 2004, "a lot less than average".

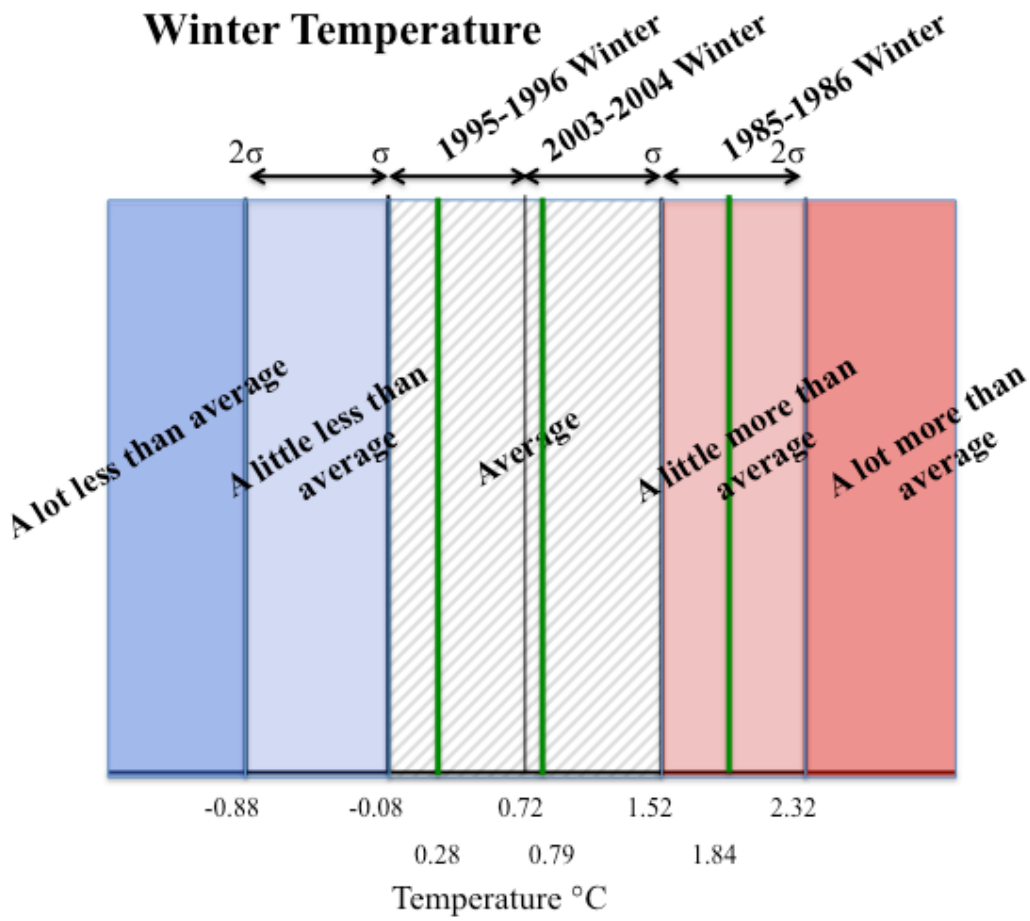


Figure 2.7 Same as figure 2.10, except winter (December, January, February) air temperatures. The average values for 1985-1986 = 1.84°C, 1995-1996 = 0.28°C, 2003-2004 = 0.79°C. The 30-year average was 0.79°C. The standard deviation was 0.80°C. In order to be considered accurate for winter 1985-1986, respondents had to answer "a little more than average"; for winter 1995-1996, "average"; and for 2003-2004, "average".

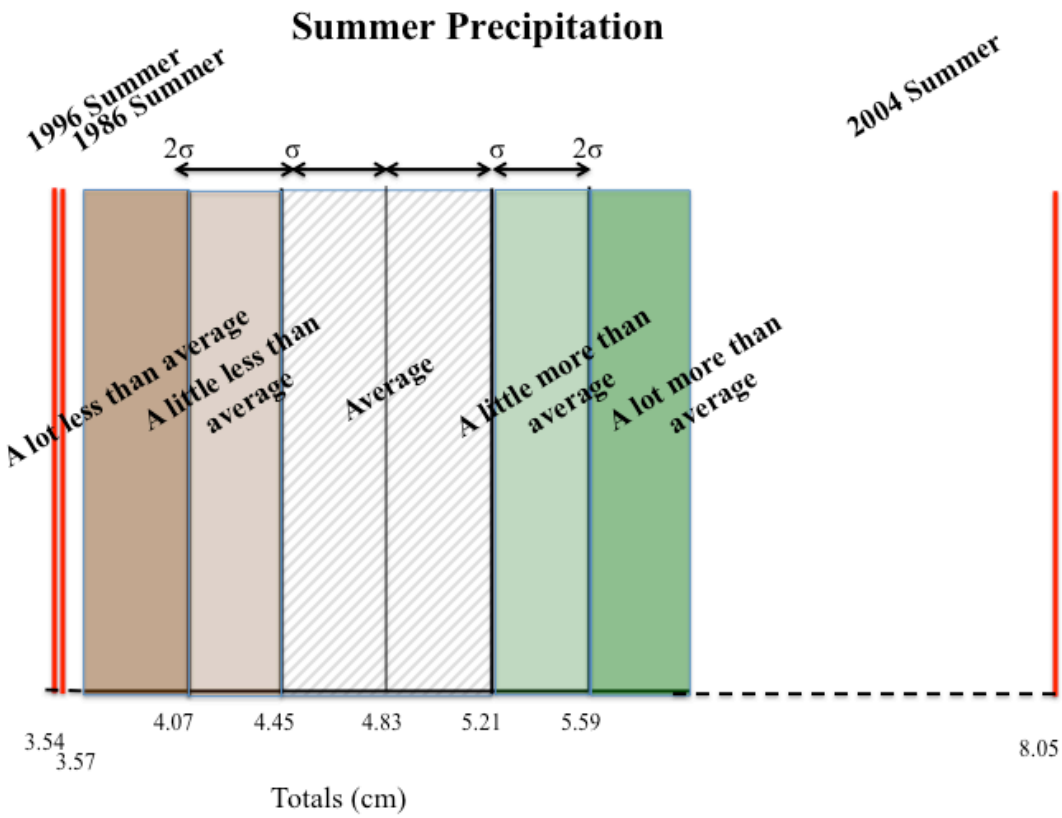


Figure 2.8 Same as figure 2.10, but now for summer precipitation. The red lines represent the average values for the specific years: 1986 = 3.57cm, 1996 = 3.54cm, 2004 = 8.05 cm. The 30-year average for the Denver Metropolitan area was 4.83cm. The standard deviation (σ) = 0.38. In order to be considered accurate for summer 1986, respondents had to answer "a lot less than average"; for summer 1996, "a lot less than average"; and for 2004, "a lot more than average."

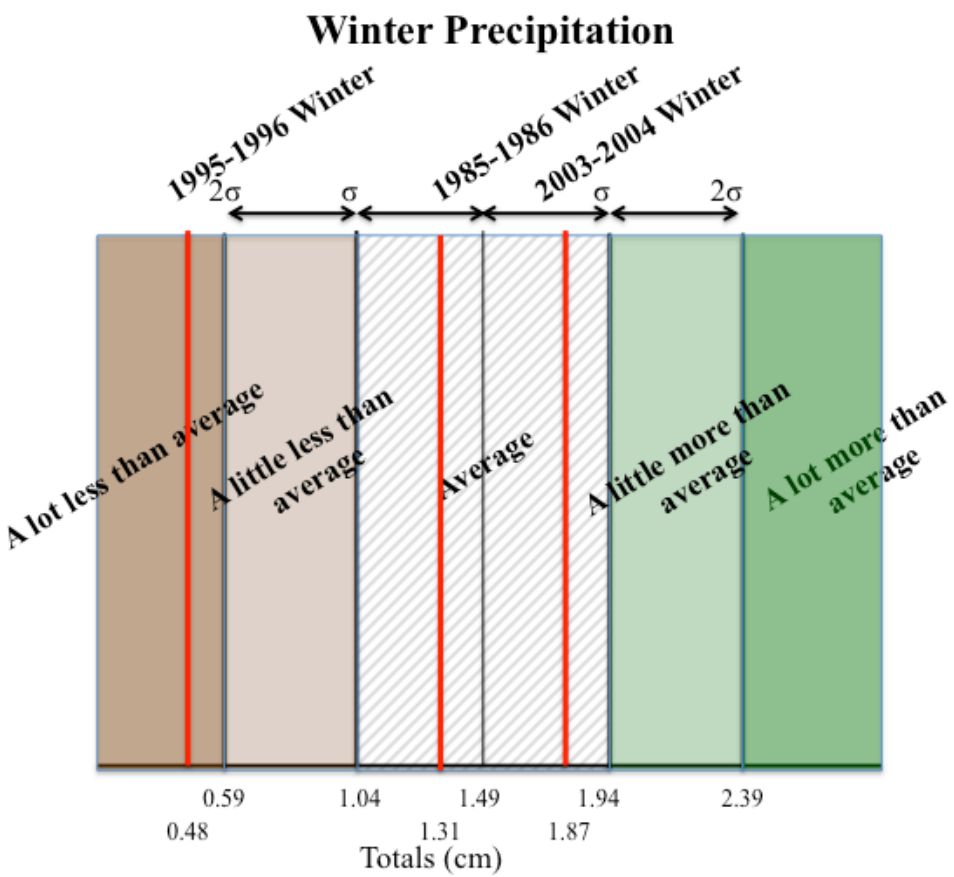
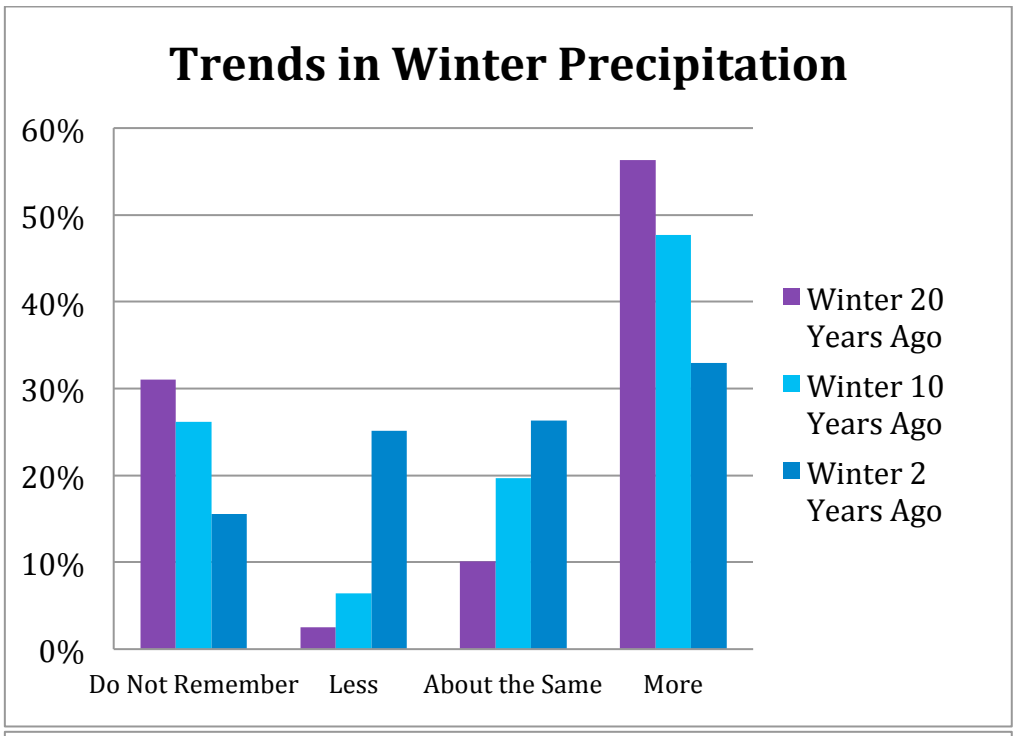


Figure 2.9: Same as figure 2.10, but now for winter precipitation. The red lines represent the average values for the specific years: 1985-1986 = 1.31 cm, 1995-1996 = 0.48 cm, 2003-2004 = 1.87 cm. The 30-year average for the Denver Metropolitan area was 1.49 cm. The standard deviation (σ) = 0.45 cm. In order to be considered accurate for winter 1985-1986, respondents had to answer "average"; for winter 1995-1996, "a lot less than average"; and for 2003-2004, "average."

When asked about past seasons, people generally responded that the past was cooler and received more precipitation. When looking at answers to how precipitation trends compared to now, respondents were significantly more likely to respond that precipitation 20 years ago was more than now as compared to precipitation two years ago being more than now ($\chi 2 = 10.453$, $p = 0.0013$). However, for two years prior to the survey, people were split evenly on whether the Denver metropolitan area had more or less precipitation than now (figure 2.10).



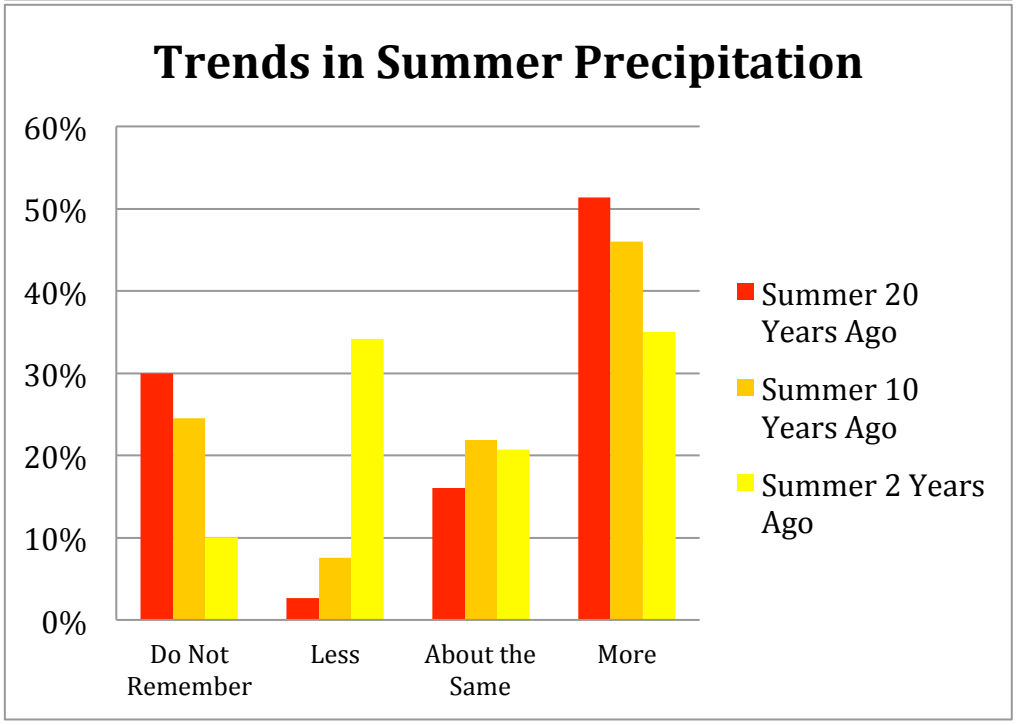


Figure 2.10 Responses to questions about trends in precipitation for winter (top) and summer (bottom). Respondents were asked how precipitation amounts compared to now (at the time of the survey).

From the 2010-2011 in-person interviews, the overall accuracy was 18.18% (+/- 4.44%, $n = 44$). Accuracy was 19.32% for temperatures, 17.05% for precipitation, 25.57% for summers, and 10.80% for winters. For specific time periods, accuracy was 24.43% for 2009-2010 (the previous year) and 11.93% for 2005-2006 (five years prior).

Responses to prior climates are illustrated in the figures below (figures 2.11 and 2.12). The respondents were asked how overall seasonal temperatures and precipitation during the previous year (Summer 2010 and Winter 2009-2010) and five years ago (Summer 2005 and Winter 2005-2006) amounts compare to average temperature and precipitation. Overall, the majority of the respondents thought that air temperatures were about average or above average both five years prior and the previous summer (figure 2.11).

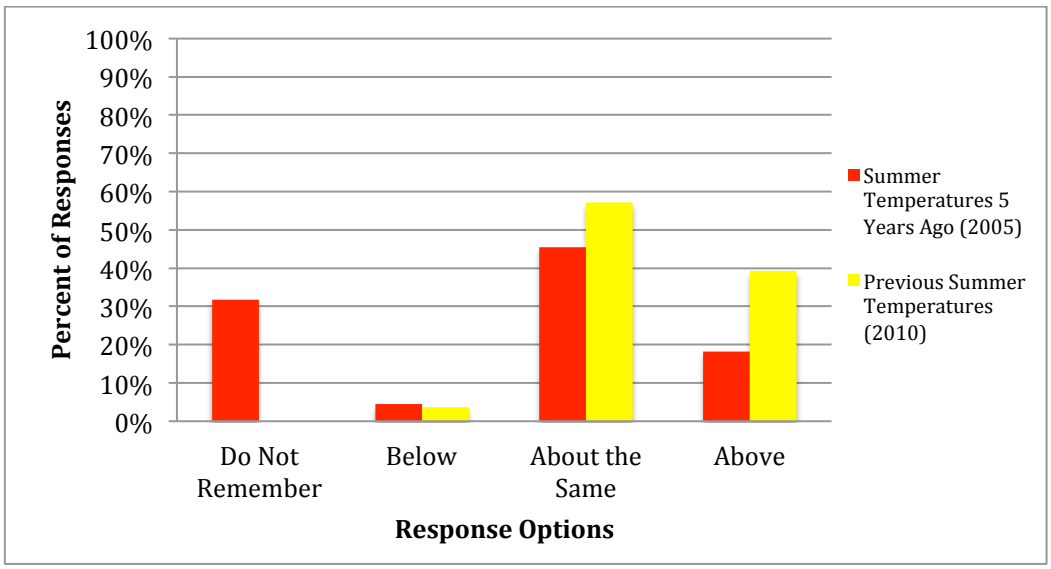


Figure 2.11 Responses to memories about trends in summer air temperatures in the Denver metropolitan area. The chart shows how summer temperatures compared to average temperatures. Respondents could say that they did not remember, that the temperatures were below average, about the same as average, or above average. Total respondents were n=28 for previous summer and n=22 for summer five years prior.

The majority of respondents thought the temperature was about the same as average five years prior (52%) and below average for the previous winter (40.6%) (figure 2.12). However, the differences in trend for the previous winter for below, about the same, and above average are not significantly different ($\chi 2 = 0.823$, $p = 0.671$). For five years prior, respondents were significantly more likely to answer "About the same" than the other two responses ($\chi 2 = 14.281$, $p = 0.001$).

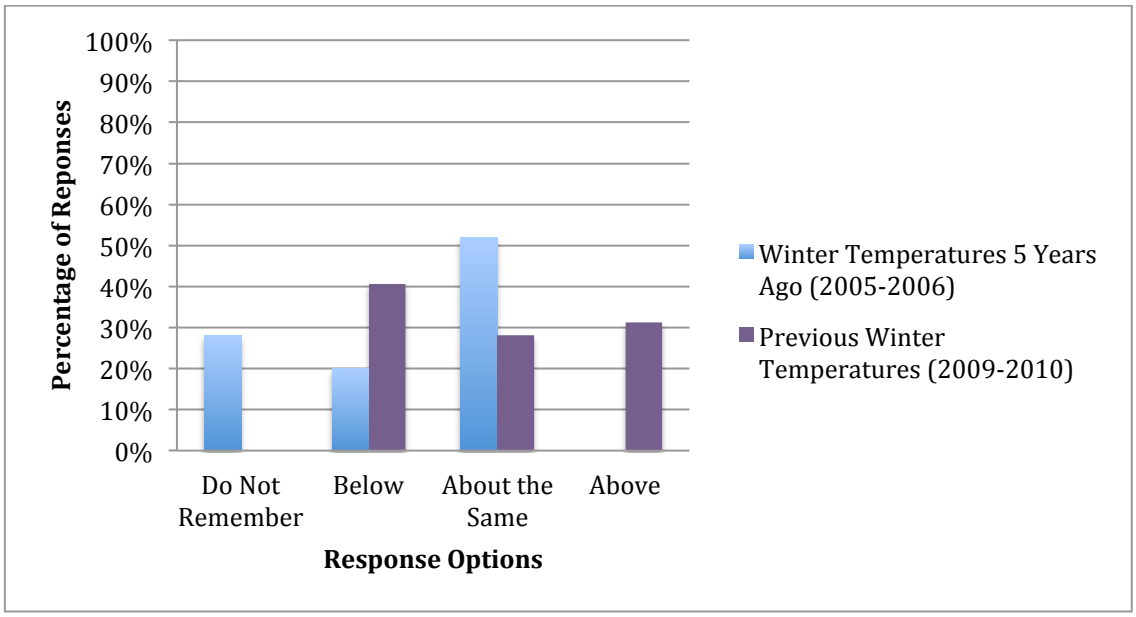


Figure 2.12 Same as Figure 2.15 except for winter. Total respondents were *n*=32 for previous winter and *n*=25 for winter five years prior.

For summer air temperature, the 30-year average (1981-2010) was calculated as 21.70°C. The standard deviation was 0.57°C. The average 2005 summer air temperature was calculated to be 21.70°C, which was exactly average. Therefore, a correct response was "average." For the 2010 summer air temperature, the average was calculated to be 22.03°C, which was less than one standard deviation from the

30-year average. The 2010 summer air temperature correct response was also "average" (figure 2.13).

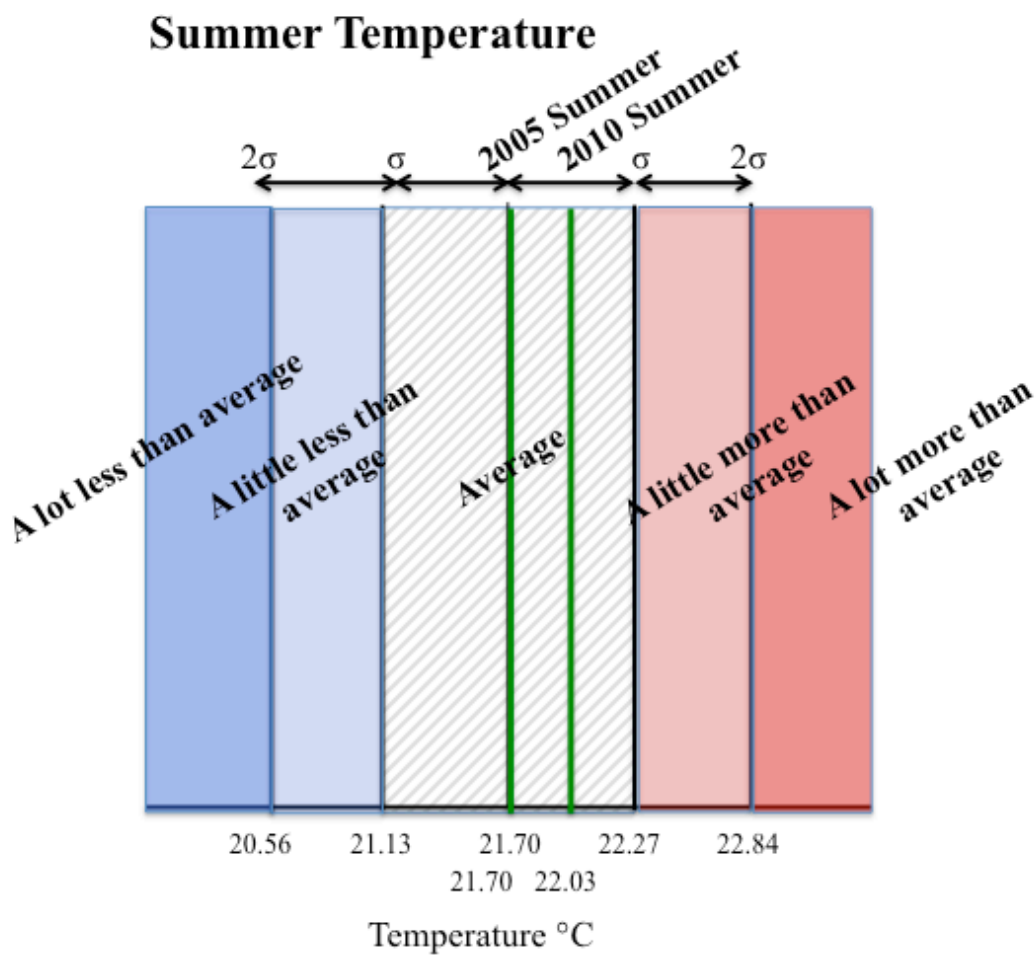


Figure 2.13. Comparison of specific summer air temperature averages to the 30-year (1981-2010) average. σ = 0.57°C

The same methodology was used to calculate accuracy for winter air temperature. The 30-year average was calculated to be 0.72°C and the standard deviation was 0.80°C. The 2005-2006 average winter air temperature was 1.75°C, which was between one and two standard deviations from the 30-year average. Therefore, this was considered to be "a little more than average." The average winter air temperature for 2009-2010 was -2.56°C. This was more than two standard

deviations from the 30-year average, so the correct response was “a lot less than average” (figure 2.14).

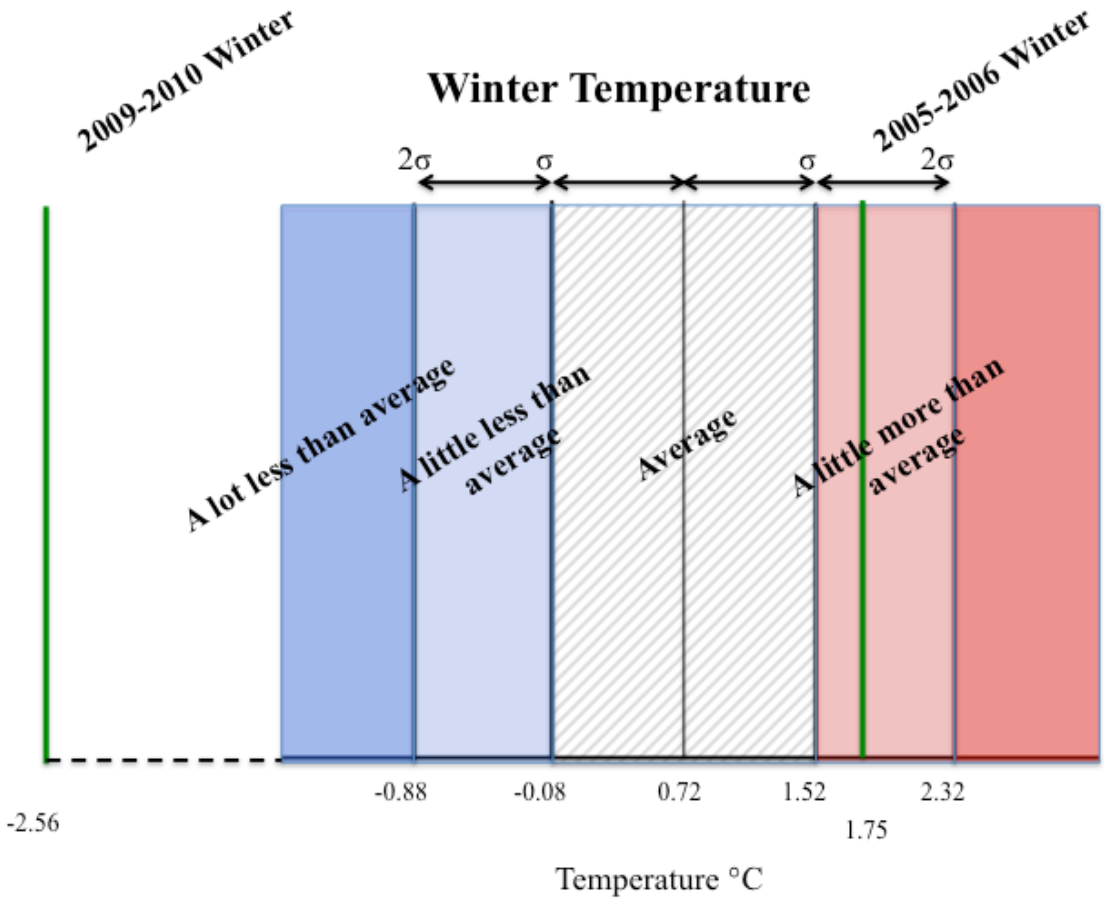


Figure 2.14. Comparison of specific winter air temperature averages to the 30-year (1981-2010) average. σ = 0.80°C.

The same type of procedure was used for precipitation. For summer precipitation, the 30-year (1981-2010) average was 4.83 cm and the standard deviation was 0.38 cm. The 2005 and 2010 average monthly precipitation totals both fell within one standard deviation from the 30-year average, therefore “average” was the correct answer for both (figure 2.15).

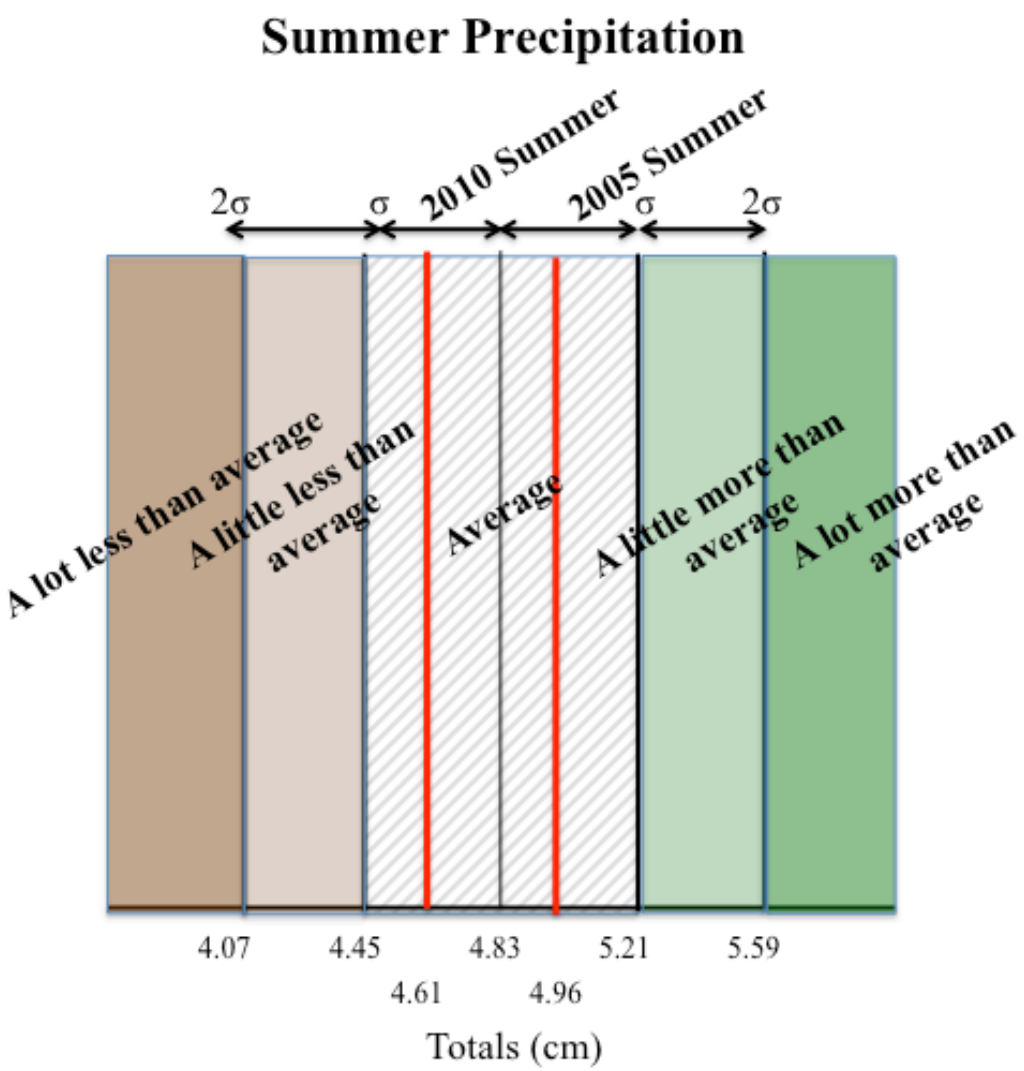


Figure 2.15 Comparison of specific summer precipitation averages to the 30-year (1981-2010) average. σ = 0.38 cm.

For winter precipitation totals (the liquid water equivalent if the precipitation fell as rain), the 30-year (1981-2010) average was 1.49 cm and the standard deviation was 0.45 cm. The 2005-2006 average winter precipitation was "a little less than average", with an average of 0.93 cm. The 2009-2010 average winter precipitation was "average", with a value of 1.72 cm (figure 2.16).

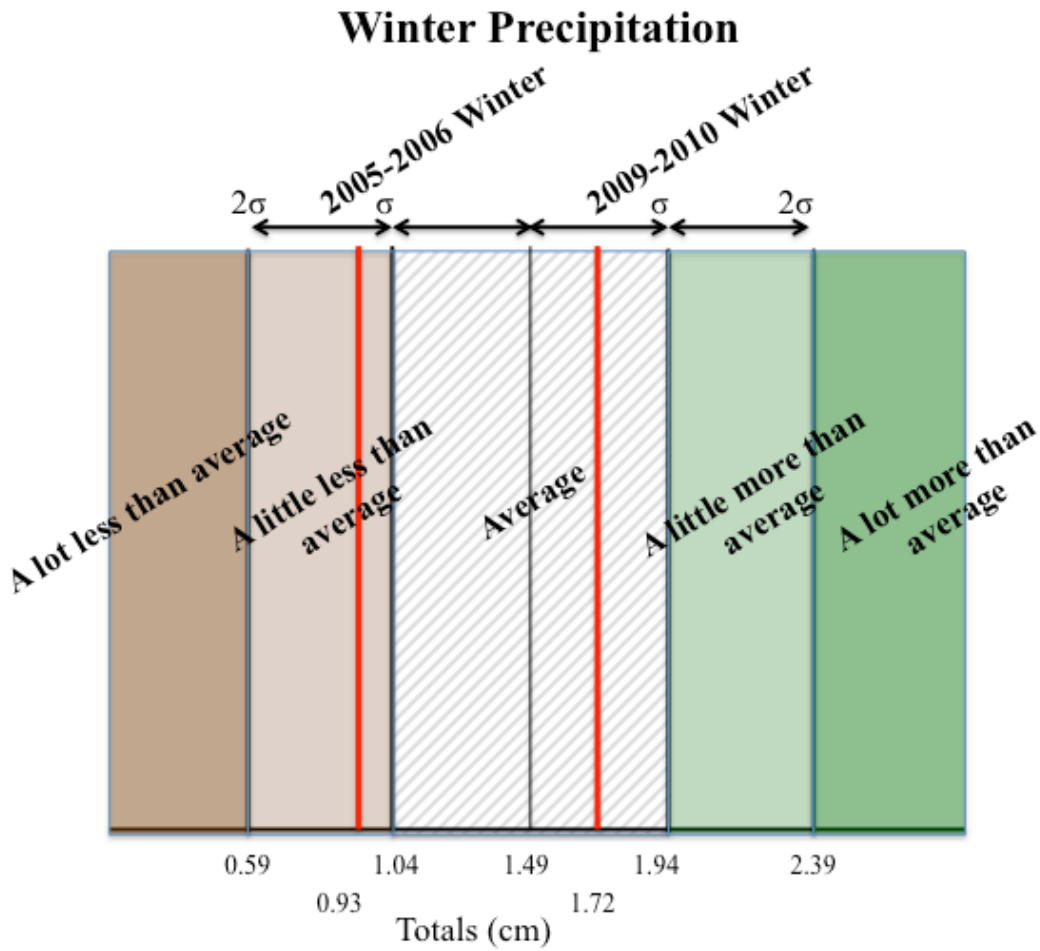


Figure 2.20 Comparison of specific winter precipitation averages to the 30-year (1981-2010) average. σ = 0.40 cm.

Overall results for the 2006 online survey and the 2010-2011 in-person interviews can be seen in the tables below (table 2.2 and table 2.2).

Table 2.2 2006 online survey response accuracy by season (June-July-August for summer or December-January-February for winter), time period, and meteorological variable (T_a and precipitation). For each, correct category and percent of accurate responses is shown. Refer to table 2.1 for climatological averages.

2006 online survey responses

Summer			J-J-A Ave	Category	% Accurate
	1986 (20 years prior)	**Air Temp**	21.18°C	Average	20.50%
		Precipitation	3.57 cm	A lot less than average	1.11%
	1996 (10 years prior)	**Air Temp**	20.77°C	A little less than average	31.58%
		Precipitation	3.54 cm	A lot less than average	4.71%
	2004 (2 years prior)	**Air Temp**	19.66°C	A lot less than average	38.50%
		Precipitation	8.05 cm	A lot more than average	32.13%

Winter			D-J-F Ave	Category	% Accurate
	1985-1986 (20 years prior)	**Air Temp**	1.84°C	Average	9.41%
		Precipitation	1.31 cm	Average	24.65%
	1995-1996 (10 years prior)	**Air Temp**	0.28°C	Average	25.48%
		Precipitation	0.48 cm	A lot less than average	3.88%
	2003-2004 (2 years prior)	**Air Temp**	1.84°C	A little more than average	23.82%
		Precipitation	1.87 cm	Average	29.92%

Table 2.3 Same as table 2.2, but for the 2010-2011 in-person interviews.

2010-2011 in-person interview responses

Summer			J-J-A Ave	Category	% Accurate
	2005 (5 years prior)	**Air Temp**	21.70°C	Average	22.73%
		Precipitation	4.96 cm	Average	22.73%
	2010 (previous summer)	**Air Temp**	22.03°C	Average	38.64%
		Precipitation	4.61 cm	Average	18.18%

Winter			D-J-F Ave	Category	% Accurate
	2005-2006 (5 years prior)	**Air Temp**	1.75°C	A little more than average	0.00%
		Precipitation	0.93 cm	A little less than average	2.72%
	2009-2010 (previous winter)	**Air Temp**	-2.56°C	A lot less than average	15.91%
		Precipitation	1.72 cm	Average	25.00%

2.4.b Objective 2

Objective 2: Do social or demographic factors influence the accuracy of climate recollections?

In order to see the influence of social and demographic factors on the accuracy of recollections, a chi-square test was performed. For the 2006 online survey, no social or demographic factors were found to be statistically significant ($\alpha = 0.05$), however, possible relationships were found between several of the social and demographic values and recollections about past seasons. Values were calculated for gender, education level, time spent outside, whether or not weather or climate was important to the respondent's career, and whether or not the respondent was currently taking or had previously taken a course about weather or climate. The only factor close to being statistically significant was outside activity, for which people reporting to spend more than six hours per day outside were more like to respond accurately than those reporting to spend less time outside ($p = 0.116$) (see table 2.4). Females may have been more accurate than males, although the relationship was not statistically significant ($p = 0.272$). Finally, respondents who had taken a class about weather or climate were slightly more accurate than those who had not. Interestingly enough, respondents who reported a weather or climate related profession were not more accurate than those not in a weather or climate related profession.

Table 2.4: Chi-squared, degrees of freedom, and *p*-values of various social and demographic factors for the 2006 survey listed in order of increasing *p*-values.

Category	**Accuracy**	**χ^2 value**	**df**	***p*-value**
Time Spent Outside	<2 hours (n=145): 19.94%, +/- 3.90% 2 to 6 hours (n=193): 21.07%, +/- 3.53% >6 hours (n=11):28.03%, +/- 5.53%	4.315	2	0.116
Gender	Female (n=201): 21.43%, +/- 3.93% Male (n=147): 20.07%, +/- 3.42%	1.208	1	0.272
Weather/Climate Class	Yes (n=145): 21.21%, +/- 3.91% No (n=205): 20.61%, +/- 3.60%	0.473	1	0.482
Education Level	High School/Assoc (n=51): 22.22%, +/-4.10% Bachelors (n=106): 20.52%, +/- 3.52% Graduate (n=188): 20.48%, +/- 3.74%	0.906	2	0.636
Weather/Climate Related Profession	Yes (n=115): 20.58%, +/- 3.70% No (n=233): 20.78%, +/- 3.78%	0.130	1	0.718

Responses were also broken down into more specific questions. When looking at gender, females were more accurate in every subcategory (air temperatures, precipitation, summers, winters, 2003-2004, 1995-1996, and 1985-1986). While not statistically significant, there are possible relationships between female accuracy and recollections of summers in general, air temperatures, and the 1985-1986 time period (table 2.5). Each category was analyzed for relationships between answer and specific climate responses (as described for gender), however, none were as strong as the gender responses.

Table 2.5 Chi-squared, degrees of freedom, and *p*-values for subcategories in gender for the 2006 on-line survey. For all categories, $n = 201$ for females, and $n = 147$ for males.

Category	Accuracy	χ^2 value	df	*p*-value
Overall	Females: 21.43% Males: 20.07%	1.208	1	0.272
Temperature	Females: 26.29% Males: 24.04%	1.210	1	0.271
Precipitation	Females: 16.58% Males: 16.10%	0.199	1	0.656
Summer	Females: 22.89% Males: 20.29%	1.731	1	0.188
Winter	Females: 19.98% Males: 19.84%	0.171	1	0.679
2003-2004	Females: 32.09% Males: 30.44%	0.507	1	0.476
1995-1996	Females: 17.29% Males: 16.16%	0.602	1	0.438
1985-1986	Females: 14.93% Males: 13.61%	0.938	1	0.333

For the 2010-2011 in-person interviews, information about gender, political affiliation, prior weather or climate class, major (science or non-science), and current mood were collected (table 2.6). For these, political affiliation was statistically significant to the accuracy of recollections. Respondents identifying as liberal were significantly more likely to answer accurately than those identifying as moderate or conservative ($\chi^2 = 6.212$, $p = 0.045$). Science majors were more accurate than non-science majors and those in a good mood were more accurate than those in a bad to neutral mood. Additionally, females were slightly more accurate than males.

Table 2.6 Chi-squared, degrees of freedom, and *p*-values for various social and demographic factors from the 2010-2011 interviews listed in order of significance.

Category	Accuracy	χ^2 value	df	*p*-value
Political Affiliation	Conservative (n=11): 12.64%, +/- 4.86% Moderate (n=16): 14.84%, +/- 4.25% Liberal (n=17): 24.26%, +/- 6.52%	6.212	2	0.045
Major	Science (n=17): 22.06%, +/- 5.42% Non-Science (n=27): 15.74%, +/- 4.30%	1.832	1	0.176
Current Mood	Bad to Neutral (n=21): 16.07%, +/- 5.32% Good (n=23): 20.11%, +/- 4.64%	0.787	1	0.375
Gender	Female (n=20): 20.00%, +/- 4.82% Male (n=24): 16.67%, +/- 4.38%	0.533	1	0.465
Weather/Climate Class	Yes (n=19): 16.45%, +/- 4.82% No (n=25): 19.00%, +/- 4.46%	0.443	1	0.506

2.4.c. Objective 3

Objective 3: How do perceptions of climate change influence recollections of past seasons?

To understand current perceptions of climate change, respondents in both the 2006 online survey and the 2010-2011 in-person interviews were asked about beliefs in climate change and beliefs about human impact on climate change. In the 2006 online survey, respondents were asked if human impact on climate change was minor, moderate, significant, or if there was no impact. In the 2010-2011 in-person interviews, respondents were asked a "yes/no" question about humans impacting climate change. In the 2006 online survey, respondents were also asked if the global air temperature is changing (responses could range from it is now "a lot colder" to "a lot warmer" than it used to be) and if the start of winter

is changing (responses could range from "a lot earlier" to "a lot later" than it used to start).

From the 2006 online survey, beliefs about climate change with the exception of human impact on climate change, were significant or close to being significant (table 2.7). Whether or not human impact has a role in climate change was also close to being significant. For whether or not climate change is happening, respondents saying "Yes" were more likely to be accurate. For whether or not there is a human impact on climate change, respondents saying "moderate" and "significant" were more likely to be accurate than those saying "no impact" or "minor impact". For change in air temperature, those saying it is now a lot warmer than it used to be were significantly more likely to be accurate than those saying a little cooler, the same, or a little warmer. And, those saying that the start of winter is starting a little or a lot later were significantly more likely to be accurate than those answering a little earlier or the same.

Table 2.7: Chi-squared, degrees of freedom, and *p*-values for perceptions about climate change and impact on accuracy from the 2006 online survey

Category	**Accuracy**	**χ^2 value**	**df**	***p*-value**
Climate Change	Yes (n=309): 21.28%, +/- 3.71% No (n=40): 17.29%, +/- 3.85%	3.544	1	0.060
Human Impact	None (n=21): 17.86%, +/- 2.94% Minor (n=35): 17.38%, +/- 3.97% Moderate (n=68): 22.55%, +/- 3.78% Signficant (n=222): 21.21%, +/- 3.91	5.216	3	0.156
Temperature Change	Little Cooler (n=1): 8.33%, +/- 8.33% Same (n=61): 10.11%, +/- 3.11% Little Warmer (n=236): 21.05%, +/- 3.66% Lot Warmer (n=53): 32.55%, +/-6.10%	85.992	3	0.000
Start of Winter	Little Earlier (n=10): 13.33%, +/-2.25% Same (n=176): 17.33%, +/- 3.38% Little Later (n=139): 24.7%, +/- 4.19% Lot Later (n=19): 32.89%, +/-6.25%	44.878	3	0.000

In the 2010-2011 in-person interviews, those answering, "yes" that climate change is happening and "yes" that humans have an impact on climate change were more accurate for both precipitation and air temperature. However, this was not statistically significant (table 2.8). An important note: those answering "no" about climate change were not the same as those answering "no" about human impact.

Table 2.8 Chi-squared, degrees of freedom, and *p*-values for perceptions about climate change and impact on accuracy from the 2010-2011 personal interviews.

Category	Accuracy	χ^2 value	df	*p*-value
Climate Change	Yes (n=36): 19.44%, +/- 4.81% No (n=8): 12.50%, +/- 4.09%	1.389	1	0.239
Human Impact	Yes (n=36): 18.75%, +/- 4.69% No (n=8): 15.63%, +/- 5.67%	0.281	1	0.596

2.4.d Objective 4

Objective 4: How do ambient meteorological conditions at the time of the interviews influence the accuracy of recollections of past seasons?

Meteorological conditions were only collected during the 2010-2011 interviews, which took place from October 5, 2010 until February 18, 2011. Questions about current weather were asked during the 2006 online survey, but respondents wrote in the comments that they were not sure if this meant air temperature of their office or location they were taking the survey or air temperature outside. Enough respondents commented on this that the question was excluded from

the analysis. The 2010-2011 in-person interviews were conducted outdoors, so there was no question about what the current meteorological conditions referred to, which were recorded at the time of the interviews. The meteorological variables recorded were air temperature, relative humidity, visible radiation, and total short-wave radiation (table 2.9).

Table 2.9 Meteorological variables collected during the interviews. Variables were air temperature, relative humidity, visible radiation, and total radiation. Table displays the minimum and maximum values recorded as well as the mean and the median.

Variable	Minimum	Maximum	Mean	Median
Air Temperature	-1.89°C	22.72°C	7.69°C	6.89°C
Relative Humidity	17.90%	88.30%	38.03%	35%
Visible Radiation	0.3 klux	109.8 klux	28.1 klux	12.4 klux
Total Radiation	0 W/m2	669.9 W/m2	204.8 W/m2	149.6 W/m2

The highest correlation between meteorological conditions and accuracy about past climates was air temperature. It should also be noted that relative humidity and total radiation may have had some relationship with accuracy about past climate data, but the relationship was not as strong as air temperature and recollections about past climates (See table 2.10).

Table 2.10 Regression values for comparing meteorological conditions to accuracy of climate recollections

	***p*-value**	***r*^2**
Temp	0.212	0.877
RH	0.483	0.319
Vis Rad	0.843	0.011
Total Rad	0.541	0.009

The meteorological conditions were also divided into above and below the mean to see if any correlations could be found. As can be seen from table 2.11, there were no relationships found. Regardless of below or above the mean for that variable, there were no significant relationships found.

Table 2.11 Regression values for meteorological variables above and below the mean for that variable as compared to the accuracy for recollections about past climates.

	Below the Mean		Above the Mean	
	P-value	r2	P-value	r2
Air Temperature	0.913	0.0182	0.766	0.129
Relative Humidity	0.971	0.00205209	0.785	0.109561
Visible Radiation	0.867	0.042849	0.986	0.00051984
Total Radiation	0.9855	0.051984	0.999	0.00000361

Overall, air temperature was the only meteorological variable with a possible relationship to recollections of past climate.

2.5 Discussion

Do social, demographic, or environmental conditions have an impact on recollections of climate? From this research, the answer is both yes and no. Overall, respondents did not remember past climate very accurately, with overall responses of 20.48% accurate for the 2006 online survey and 18.18% accurate for the 2010-2011 in-person interviews. They did recollect summer (21.42% in 2006, 25.57% in 2010-2011) better than winter (19.52% in 2006, 10.80% in 2010-2011) and air temperature (24.89% in 2006, 19.32% in 2010-2011) better than precipitation (16.07% in 2006, 17.05% in 2010-2011). And, they remembered more recent climate with more

accuracy than further in the past (ranging from 11.93% to 31.09%). However, the highest value for any of these was still only 31.09% (recollection of the 2003-2004 summer and winter precipitation and air temperatures). Since precipitation and minimum temperatures are important in understanding climate change, the lower accuracy of these responses indicates that humans as proxy data would not be as useful for these measurements.

Demographic and social conditions might have an impact, however, more research is needed. From the 2006 online surveys, gender and time spent outdoors were both close to being significant. From the 2010-2011 in-person interviews, political affiliation was significantly related to accuracy, and undergraduates majoring in science courses and ratings of current mood were close to being significant.

The significant factors, besides political affiliation, were all in current perceptions of climate change. These, however, could also be used as a proxy for political affiliation, since liberals are more like to believe in climate change than moderates and even more so than conservatives (Leiserowitz et al. 2011). In the 2006 on-line survey, beliefs about climate change and the human impact on climate change were significant or close to significant, respectively. Responses about how air temperature, as well as the start of winter, have changed over time were statistically significant in regards to the accuracy of climate responses. In the 2010-2011 interviews, those answering that "yes", climate change is happening were more likely to answer accurately about past climates, however, not significantly so. Unfortunately for this research, the number of respondents answering, "no" to

questions about climate change were much smaller than answering "yes" ("no" n = 40, "yes" n = 309 for 2006 and "no" n = 8, "yes" n = 36 for 2010-2011).

The Denver metropolitan area has voted more politically liberal in the past few elections, so it would be interesting to continue this research in more politically conservative areas. It would also be interesting to further investigate the connection between gender, working outside, and scientist versus non-scientist for both major and career. Finally, it would be interesting to explore responses about past climates when air temperatures are at more extreme values for the Denver Metropolitan area. Additionally, it would be interesting to see if answers change if the air temperatures were much lower or much higher than the -1.89°C to 22.72°C range observed for this study.

From this research, we are now better informed to answer the question "Who would be the best person to ask for recollections about past climates?" as a proxy data source in locations lacking instrumental climate data. *Overall, this person would be a politically liberal female who majored in a science field and spends a lot of time outdoors. She would be in a good mood and would also report that winters are starting later than they have in the past and overall air temperatures are warmer than they were in the past. Her career wouldn't matter, or her education level or if she has taken a class about weather or climate. But, even with all of these variables working in her favor, she would still only be accurate for about 20-30% of her responses about past climates.*

When looking at the 2006 online interviews, only 11 people responded correctly as compared to instrument data over 50% of the time. Of those 11, four

were male, seven were female; all of them answered that global warming is happening with a moderate or significant impact by humans; and five had a class in weather or climate at some point. For the 2010-2011 in-person interviews, four people were 50% or more accurate for climate responses. Of these four people, three were female, they all answered that global warming is happening with a human impact, three were politically liberal, one was politically moderate, and only one had a prior class in weather or climate.

Various articles that interviewed populations about climate change in their local communities were examined in order to see how their target populations were compared to this "ideal" person based on this study. It is important to keep in mind that most of the populations in the literature are indigenous tribes in remote areas, which is vastly different from the urban areas of Denver. However, regardless of this fact, of the articles examined, only three mentioned anything about the demographic and social factors of their populations and none mentioned anything about the environmental factors or the mood of the respondents at the time of the interviews or discussions. Of these three, two mentioned elders in the communities (Roncoli et al. 2002, Huntington and Fox 2005) and one mentioned a wide range of ages, from high school students to community members to elders (Woo et al. 2007). Roncoli et al. (2002) noted that they interviewed mainly elder farmers from a range of socioeconomic statuses, but they did mention that females might remember different things than males.

From the research discussed in this chapter, some social, demographic, and environmental factors do relate to accuracy and recollections about past seasons as

compared to instrument data. So, regardless of the populations being asked, this information should be included in the research. Should researchers use recollections of climate from people in the Denver metropolitan area to fill in spatial or temporal gaps? With an accuracy percentage of 30% or less, other sources for proxy data may be more useful. However, populations in other areas, particularly areas with a long oral history, may have higher accuracy. This would be a topic for future research.

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CHAPTER 3

Social, Demographic, and Environmental Influences on Memories and Perceptions of Recent Weather

3.1 Introduction

How well do people remember recent weather? And, what influences these memories? Daily weather patterns have been found to influence mood and memory (Keller et al. 2005, Forgas et al. 2009), but how does mood influence memory of weather? Pleasant weather relates to a better mood and better short-term memory (Keller et al. 2005), although the opposite was found for remembering mundane events. Forgas et al. (2009) found that "bad" weather (defined in the study as cloudy or rainy) led to a better retention of everyday events.

The types of memories addressed in this chapter are two types of autobiographical memories; episodic memories and flashbulb memories. Autobiographical memories are memories of something that one has personally experienced (Williams et al. 2008, Pillemer 2009), such as recalling the first day of school or graduation or an exciting vacation; really any part of one's own life. Episodic memories are autobiographical memories that consist of recollections of events or experiences (Tulving 2002). These can be mundane events (like recalling the weather from last Saturday) or more exciting events (like getting married or winning the lottery). Flashbulb memories are also a type

of autobiographical memory, but these memories are defined as "memories for the circumstances in which one first learned of a very surprising and consequential (or emotionally arousing) event" (Brown and Kulik 1977). Flashbulb memories must be surprising, personally important, have consequence, and cause an emotional response (Conway 1995) (figure 3.1). In order to have a flashbulb memory, a person does not have to be an active participant in the event, i.e., "hearing the news" and "being there" can both lead to flashbulb memories (Pillemer 2009). Common examples of events that could lead to flashbulb memories include the assassination of John F. Kennedy, the explosion of the space shuttle *Challenger*, the flooding in Colorado in September 2013, and events related to wars (e.g., the attacks on Pearl Harbor, the terrorist attacks on September 11, 2001).

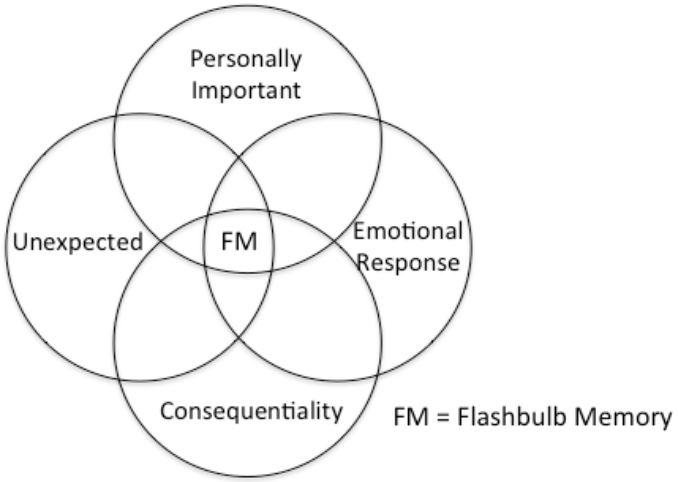

Figure 3.1 The four needed elements for the development of a flashbulb memory. Adapted from Conway 1995.

When asking about memories of weather, these memories could be episodic or part of a flashbulb memory, depending on how the event originally occurred. For this research questions about both episodic events (what was the weather like one day, two

days, and one week prior) and potential flashbulb events (the Fourmile Canyon Fire of 2010 and the terrorist attacks on September 11, 2001) were asked.

There are other important factors to consider when dealing with memories about weather too. Walker et al. (2003) describe a "fading affect bias" in their work, which is defined as the affect associated with unpleasant events fading faster than the affects associated with pleasant events. In other words, negative memories will not be recalled as being as unpleasant as initially described. The accuracy of all weather memories decrease exponentially with time after the event (Healy and McNamara 1996, Schmolck et al. 2000). However, Walker et al. (2003) hypothesized that the unpleasantness of a memory fades because the suppression of negative memories is a coping mechanism; the fading affect bias allows people to deal with tragedies and look forward to tomorrow. However, this idea that "good is stronger than bad" memories is in opposition to the general idea that "bad is stronger than good" for other areas of psychology research (e.g., Öhman et al. 2001). Similar theories have been discussed in other research as well (e.g., Lindsay and Read 2006). Negative stimuli often invoke a more powerful reaction than positive stimuli (Öhman et al. 2001). So, the question is, how will this carry over into weather recollections? Will people remember the weather as being better than it actually was, i.e., will the memories of bad weather fade? Or, will the negative weather events create a more powerful reaction, which will then lead to better recollection of the bad weather?

Joslyn and Schooler (2006) found that current beliefs or interpretations can distort memories from the past to make them more consistent with current beliefs. Lindsay and Read (2006) found similar results when asking adults about memories of the past; their

recollections were influenced by the rememberers' beliefs and desires. Will this be found for recent weather recollections also? Will a person's belief about global warming influence how he or she remembers the recent weather?

An additional idea to consider is whether or not positive (or negative) events cause a bias for weather recollections. A study by Bernsten and Thomsen (2005) studied flashbulb memories of Danes in relation to World War II. The researchers asked people living in Denmark during both the occupation and the liberation by the Germans about their memories for those days. The study participants were asked many details of the occupation and liberations days, including questions about the weather. It was found that recollections from both days resulted in extremely accurate recollections of weather. However, the negative day (occupation) was correlated with slightly more negative responses about the weather. And, the positive day (liberation) was correlated with slightly more positive response about the weather. Positively biased weather descriptors included more sun, fewer clouds, less wind, less rain, higher than the actual air temperature, and/or descriptions of the weather in an idealistic tone. Negatively biased weather descriptors were the reverse of the positive descriptors (Bernsten and Thomsen 2005). This study will seek to find out if the same is true for flashbulb memories associated with the terrorist attacks on September 11, 2001, and the Fourmile Canyon Fire of 2010.

Finally, a study by Hamilton and Stampone (2013) found that weather influences public beliefs about climate change. They found that air temperature anomalies led to changes in beliefs about climate change, particularly in people identifying as politically

independent. This study will see how political affiliation impacts recollections of recent weather.

3.2 Objectives

The purpose of this chapter is to investigate how accurately people in the Denver metropolitan area remember recent weather as compared to instrument data and to see what social or demographic factors might influence those memories. Additionally, this chapter looks at how people remember the weather (positive or negative) as compared to past events. The four main objectives of this section phrased as questions are:

1. How accurate as compared to instrument data does the general population remember recent weather?
2. Do social, demographic, or environmental factors influence the accuracy of those recollections?
3. How do current perceptions of climate change influence memories of recent weather?
4. How do people remember the weather for specific events?

3.3 Methods

Methods for this research are described in chapter one. Additional methods specific to this chapter are described below.

The 2006 online survey included questions about recent weather (one day, two days, and one week prior) in the Denver area as well as questions about demographics, beliefs about climate change, importance of weather to job, and prior education in weather or climate (See Appendix B for the complete online survey). Questions about recent weather were as follows for one day, two days, and one week prior to the survey:

What was the weather in the Denver metropolitan area like yesterday?

2. Select the option that most closely describes how warm (high temperature) it was during the day.
    a. Below 50F (10C)
    b. 50 to 59F (10 to 15C)
    c. 60 to 69F (15.1 to 21C)
    d. 70 to 79F (21.1 to 26C)
    e. 80 to 89F (26.1 to 31.7C)
    f. 90 to 99F (31.8 to 37.2C)
    g. Above 99F (37.2C)
    h. Do not remember

3. Select the option that most closely describes how cold (low temperature) it was at night.
    a. Below 30F (-1.1C)
    b. 30 to 39F (-1.1 to 3.9C)
    c. 40 to 49F (4 to 9.4C)
    d. 50 to 59F (10 to 15C)
    e. 60 to 69F (15.1 to 21C)
    f. 70 to 79F (21.1 to 26C)
    g. Above 79F (26.1C)
    h. Do not remember

And as follows for the 2010-2011 interviews:

20. What was the weather like yesterday? (Guided to include temperature and precipitation.)

21. What was the weather like two days ago?

22. What was the weather like seven days ago?

In order to be included in the data analysis, respondents had to be in the Denver Metropolitan area for at least one of the set time periods (one day, two days, or one week prior) and had to of answered at least one of the social, demographic, or environmental

questions (Note: if respondents answered the recent weather questions, they typically answered the majority of the other questions).

3.4 Results

The results will be discussed for each of the five objectives.

3.4.a Objective 1

Objective 1: How accurate as compared to instrument data does the general population remember recent weather?

In order to compare how accurate memories about recent weather were to instrument data, two dates were picked from the 2006 online survey. While the survey received 491 responses from July 17 to September 11, 2006, the majority of responses were on Thursday, July 20, 2006 and Tuesday, July 25, 2006. On July 20th, 129 people (27%) opened the survey and answered at least one question and on July 25th, 87 people (18%) opened the survey and answered at least one question. It is speculated that on July 25th, the survey was forwarded to a new listserv. While not all of these results were included in the analysis, these two days were the peak days for the 2006 survey (figure 3.2).

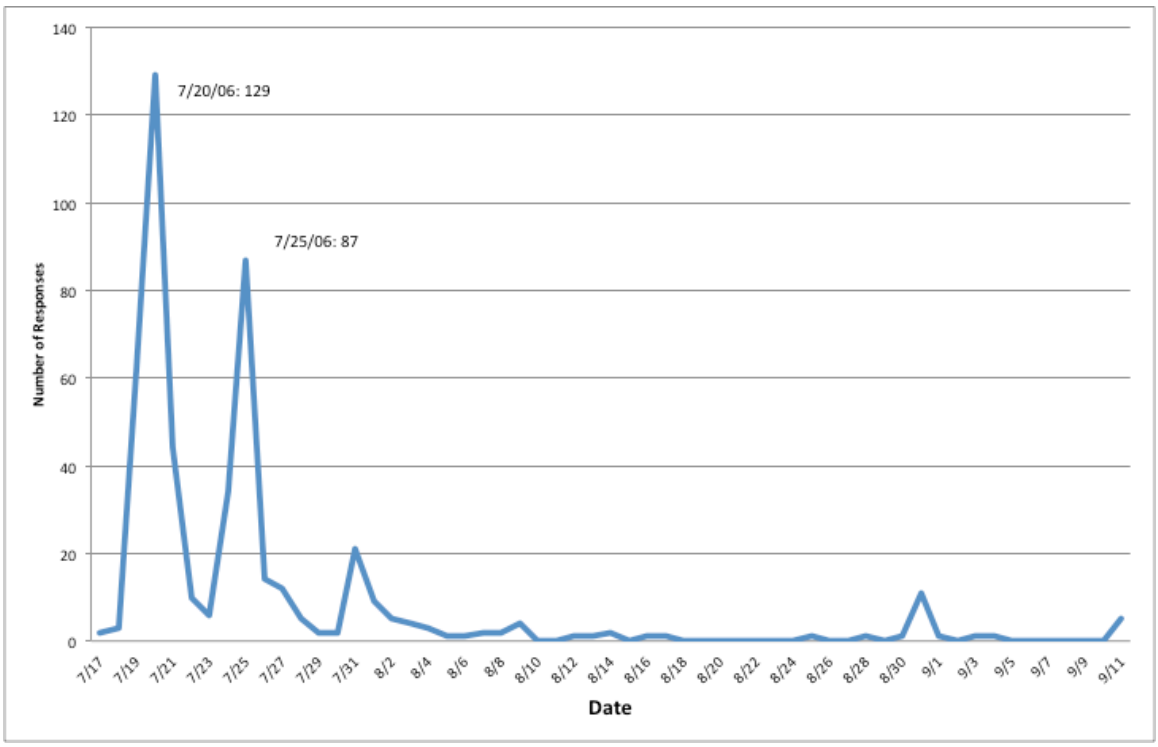

Figure 3.2 Number of responses to the 2006 online survey by date. Peak dates were 7/20/06 with 129 responses and 7/25/06 with 87 responses.

Responses about air temperature on these two dates were compared to instrument data from Boulder, Denver, Lakewood, and Northglenn. Respondents were asked questions about the high and low air temperatures one day prior, two days prior, and one week prior.

On July 20th, up to 110 respondents answered questions about the weather and demographic or social information (this is lower than the total response rate since not all the respondents answered questions about the recent weather). The total number for each response will be given. For the July 20th responses, the average high air temperature on July 19th (one day prior) was 95°F (35°C) and the range for the four weather stations was 93-97°F (33.89-36.11°C). All responses in the 90-99°F (32.22-37.22°C) were considered

accurate. For this day, 74% (*n* = 81 out of 110 responses) of the respondents were accurate for the high air temperature (see figure 3.3). For the low air temperature, the average low air temperature was 64.75°F (18.19°C), with a range of 62-68°F (16.67-20.00°C). 55% (*n* = 61 out of 110 responses) were accurate for the low air temperature (see figure 3.4).

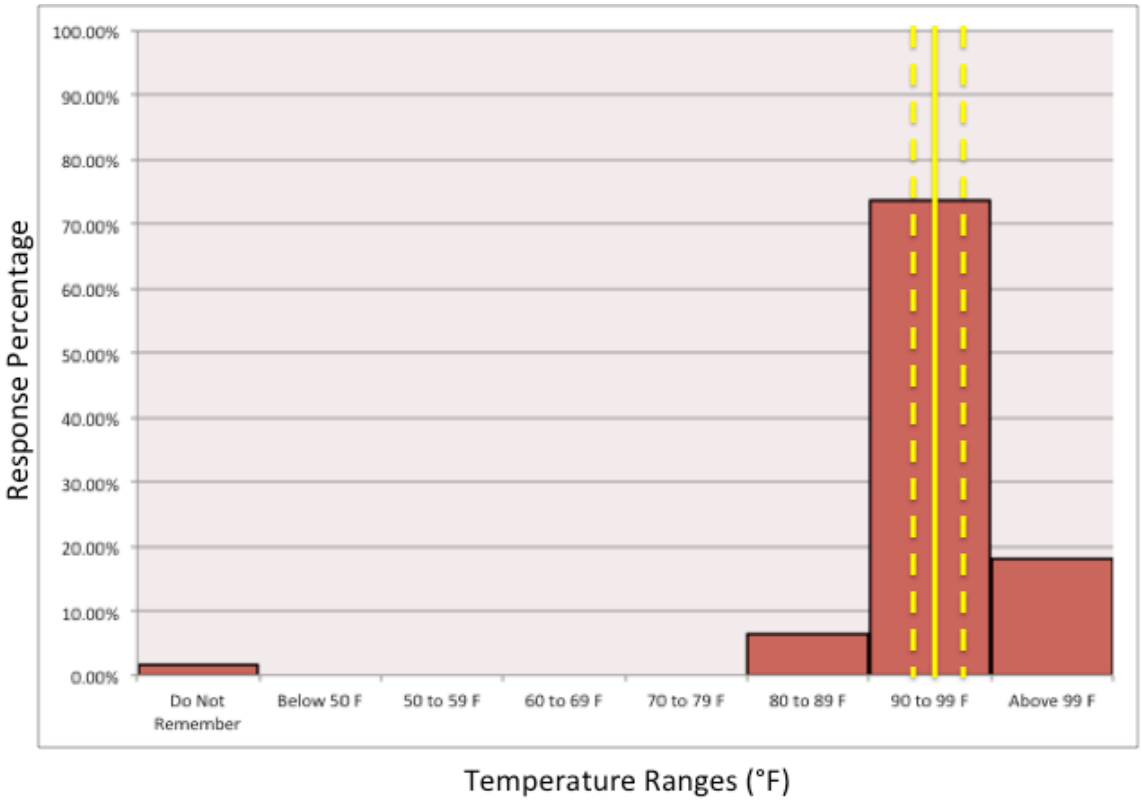

Figure 3.3 July 20th responses about the high air temperature for one day ago (July 19th). The solid yellow line is the average high air temperature (95°F (35°C)) and the dashed yellow lines show the range of air temperatures (93-97°F (33.89-36.11°C)). 74% of respondents (*n* = 81 out of 110 responses) chose the correct range.

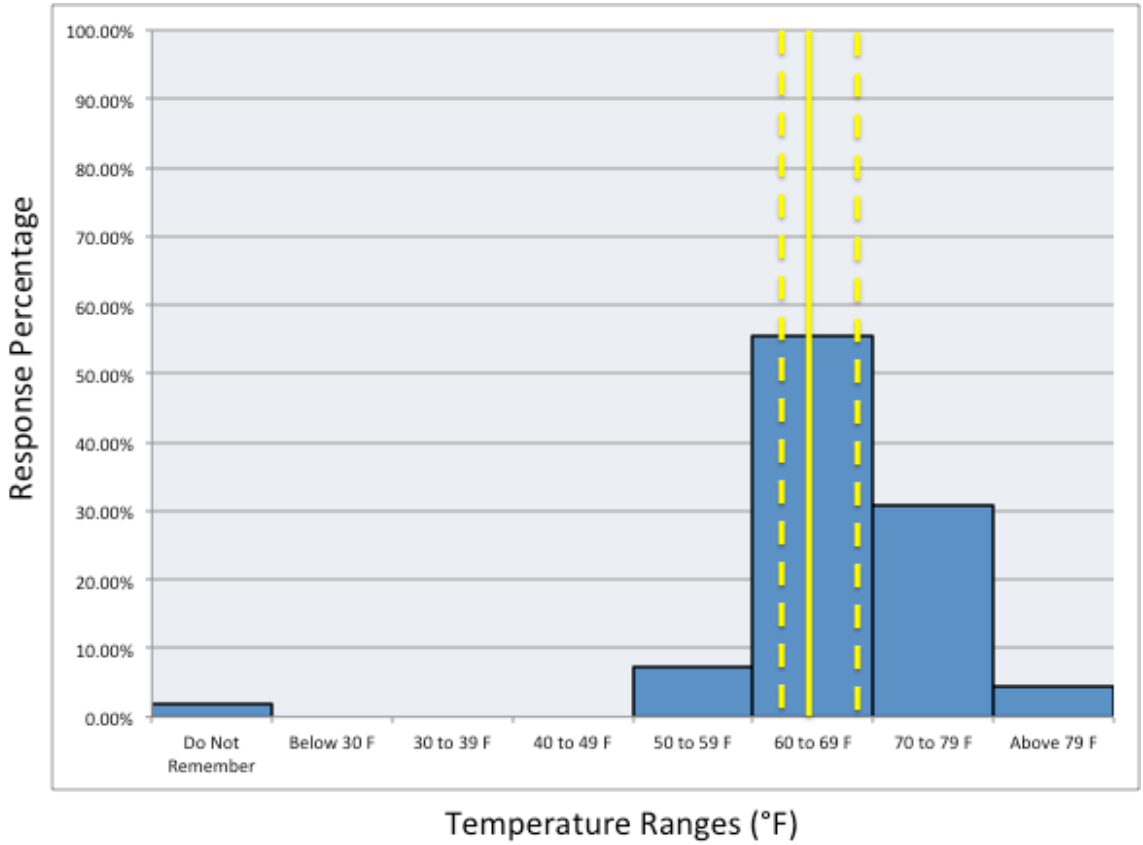

Figure 3.4 July 20th responses about the low air temperature for one day ago (July 19th). The solid yellow line is the average low air temperature (64.75°F (18.19°C)) and the dashed yellow lines show the range of air temperatures (62-68°F (16.67-20.00°C)). 55% (n = 61 out of 110 responses) chose the correct range.

The high air temperature two days prior (July 18th) had an average of 91.25°F (32.92°C) and a range of 90-93°F (32.22-33.89°C). 63% (*n* = 67 responses out of 106 total) responded accurately (see figure 3.5). The low air temperature had an average of 62.75°F (17.08°C) and a range of 60-66°F (15.56-18.89°C). 48% (*n* = 51 responses out of 106 total) answered correctly (see figure 3.6).

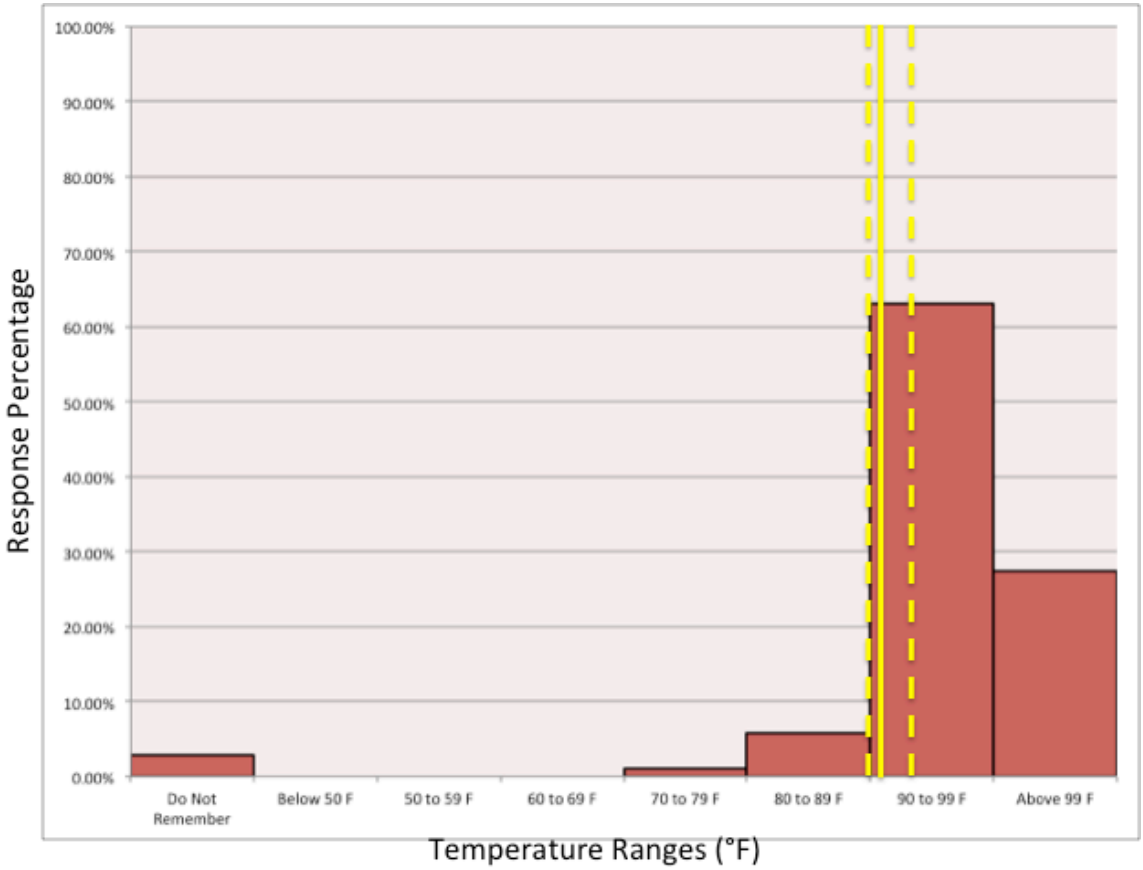

Figure 3.5 July 20th responses about the high air temperature for two days ago (July 18th). The solid yellow line is the average high air temperature (91.25°F (32.92°C)) and the dashed yellow lines show the range of air temperatures (90-93°F (32.22-33.89°C)). 63% (*n* = 67 responses out of 106 total) chose the correct range.

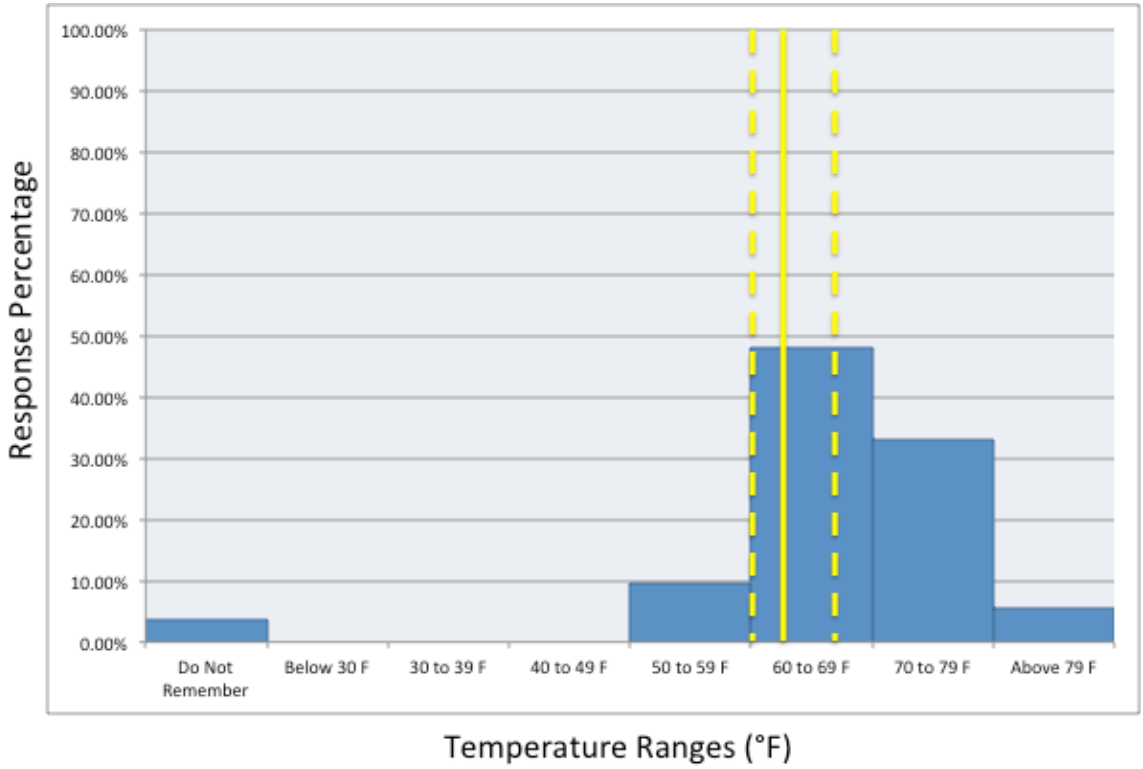

Figure 3.6 July 20th responses about the low air temperature for two days ago (July 18th). The solid yellow line is the average low air temperature (62.75°F (17.08°C)) and the dashed yellow lines show the range of air temperatures (60-66°F (15.56-18.89°C)). 48% (*n* = 51 responses out of 106 total) chose the correct range.

One week prior to July 20th was July 13th. On this day, the average high air temperature was 95.75°F (35.42°C), with a range of 94-99°F (34.44-37.22°C). 42% of respondents (*n* = 44 out of 105 total respondents) answered correctly (see figure 3.7). The average low air temperature was 61°F (16.11°C), with a range of 60-63°F (15.56-17.22°C). 45% (*n* = 47 out of 105 total respondents) answered accurately (see figure 3.8).

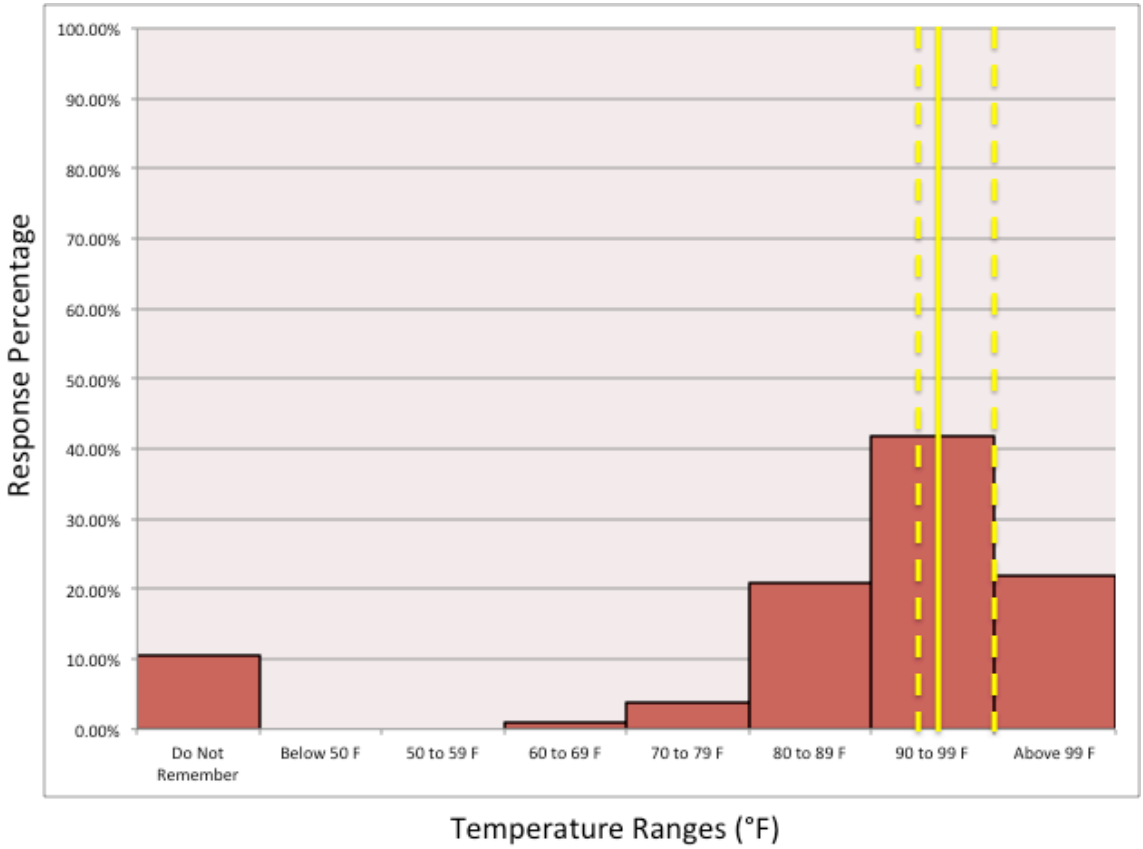

Figure 3.7 July 20th responses about the high air temperature for one week ago (July 13th). The solid yellow line is the average high air temperature (95.75°F (35.42°C)) and the dashed yellow lines show the range of air temperatures (94-99°F (34.44-37.22°C)). 42% of respondents (*n* = 44 out of 105 total respondents) chose the correct range.

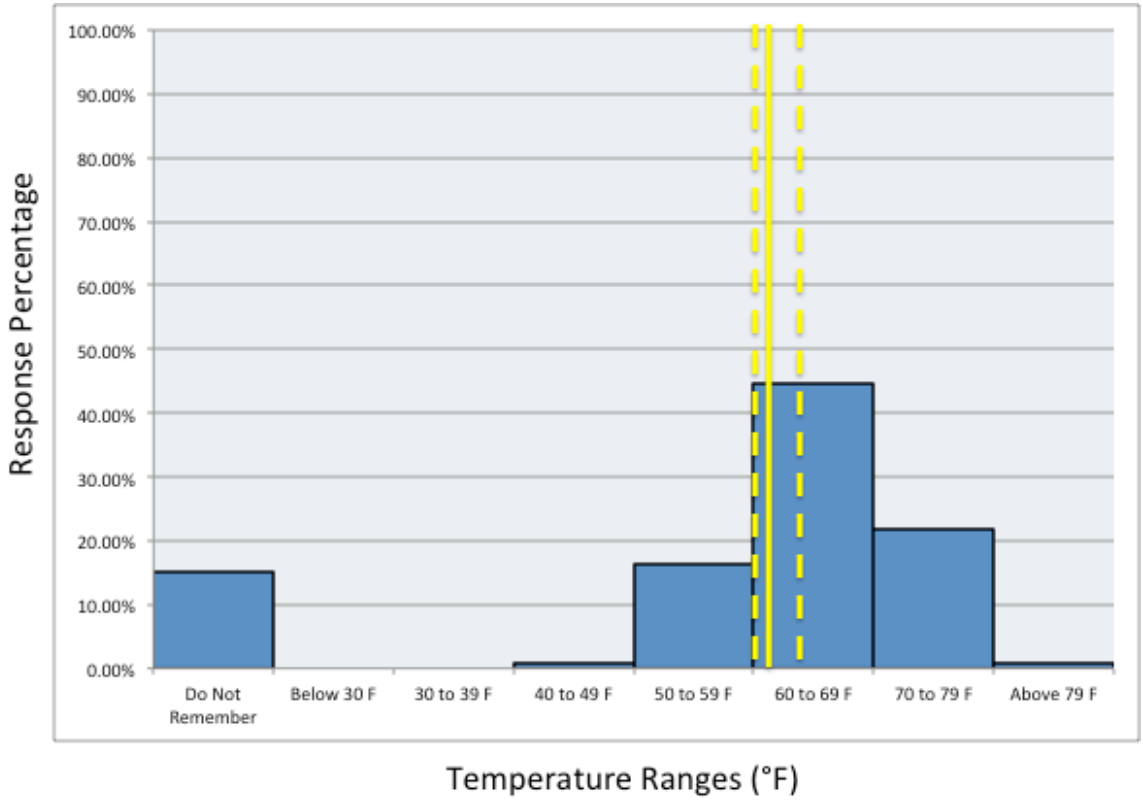

Figure 3.8 July 20th responses about the low air temperature for one week ago (July 13th). The solid yellow line is the average low air temperature (61°F (16.11°C)) and the dashed yellow lines show the range of air temperatures (60-63°F (15.56-17.22°C)). 45% (*n* = 47 out of 105 total respondents) chose the correct range.

Next, responses from July 25th were analyzed for the air temperatures one day prior (July 24th), two days prior (July 23rd) and one week prior (July 18th). For one day prior on July 24th, the average high air temperature for the four stations was 95.25°F (35.14°C), with a range of 94-98°F (34.44-36.67°C). 73% (*n* = 55 out of 75 total responses) responded accurately (see figure 3.9). The average low air temperature was 62.50°F (16.94°C), with a range of 61-64°F (16.11-17.78°C). 60% (*n* = 45 out of 75 total responses) responded accurately (see figure 3.10).

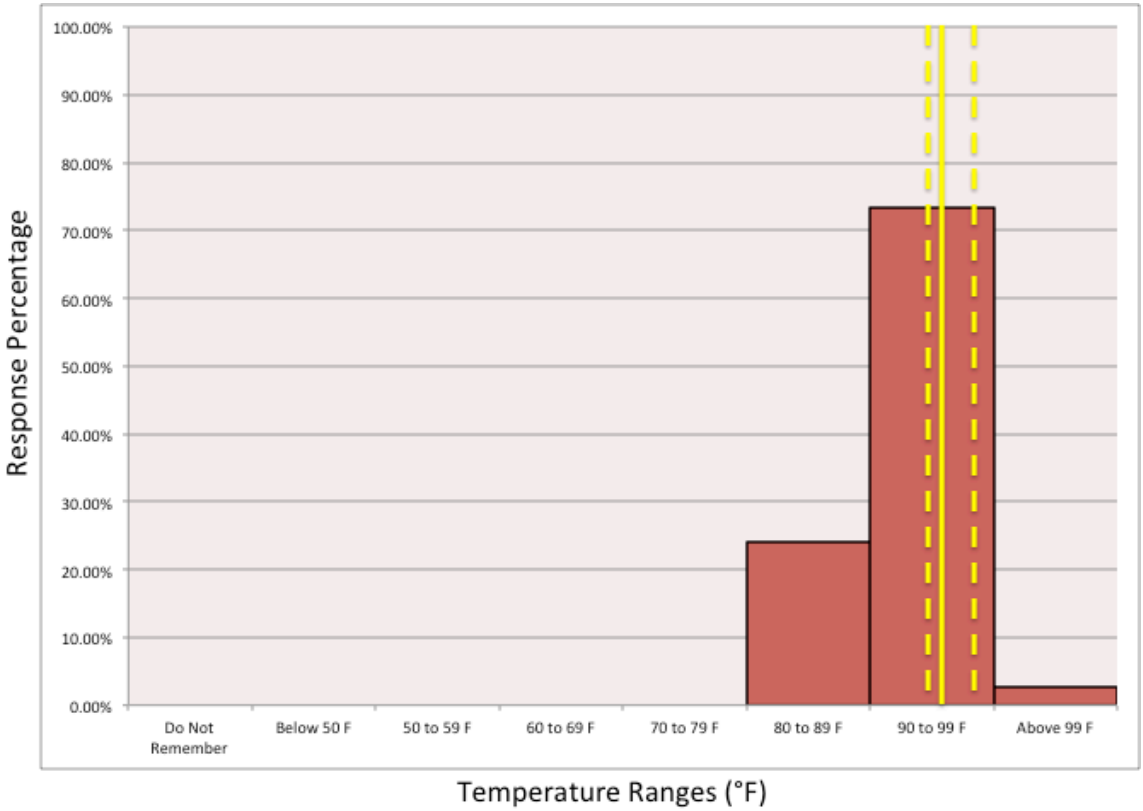

Figure 3.9 July 25th responses about the high air temperature for one day ago (July 24th). The solid yellow line is the average high air temperature (95.25°F (35.14°C)) and the dashed yellow lines show the range of air temperatures (94-98°F (34.44-36.67°C)). 73% (*n* = 55 out of 75 total responses) chose the correct range.

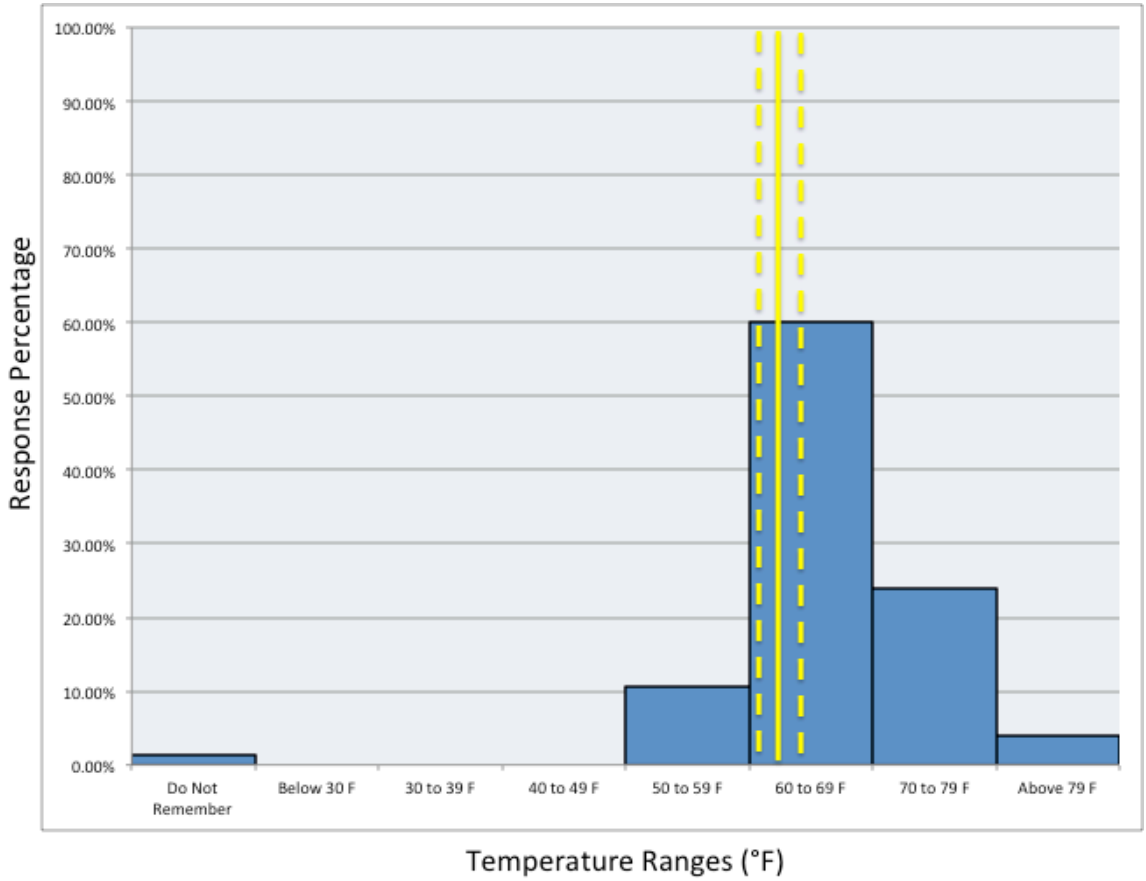

Figure 3.10 July 25th responses about the low air temperature for one day ago (July 24th). The solid yellow line is the average low air temperature (62.50°F (16.94°C)) and the dashed yellow lines show the range of air temperatures (61-64°F (16.11-17.78°C)). 60% (*n* = 45 out of 75 total responses) chose the correct range.

On July 23rd, two days prior to July 25th, the average high air temperature was 90°F (32.22°C), with a range of 87-93°F (30.56-33.89°C). 94% (*n* = 65 out of 69 total responses) answered correctly. Note that the range of air temperatures included two possible answers as correct (see figure 3.11). The average low air temperature was 59.5°F (15.28°C), with a range of 57-61°F (13.89-16.11°C). 81% (*n* = 56 out of 69 total responses) answered correctly; again note that the range of air temperatures included two possible answers as correct (see figure 3.12).

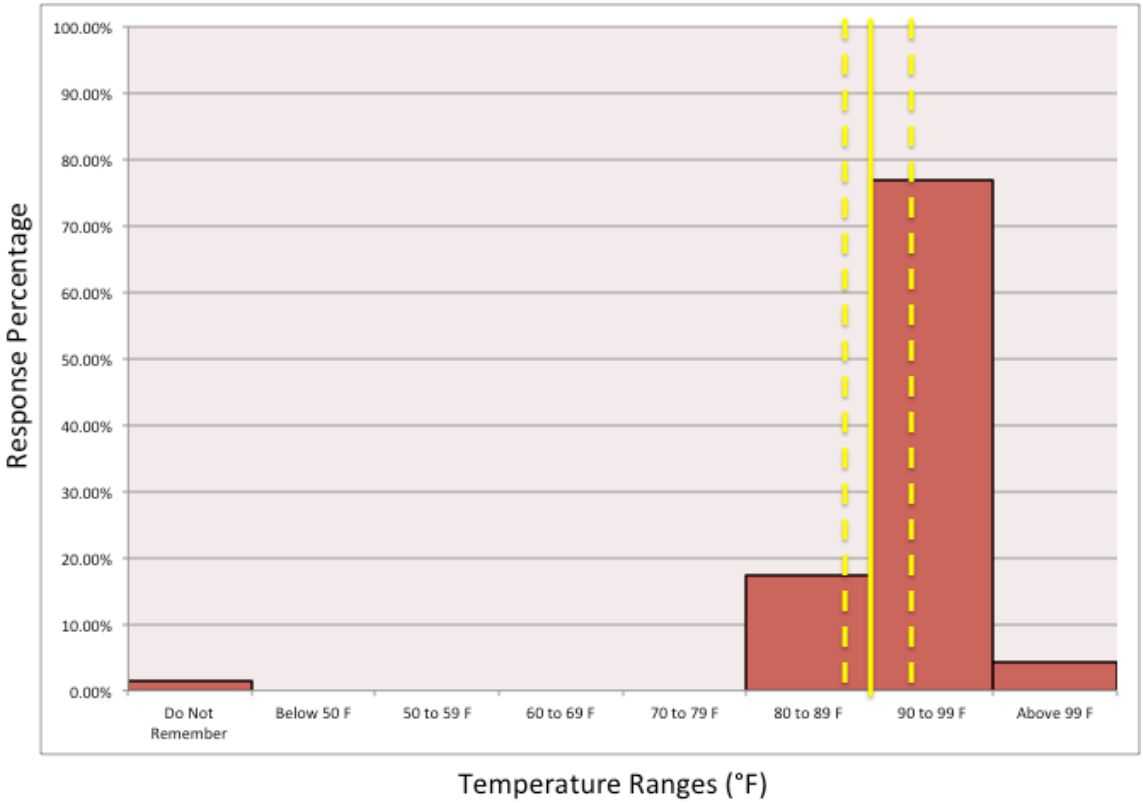

Figure 3.11 July 25th responses about the high air temperature for two days ago (July 23rd). The solid yellow line is the average high air temperature (90°F (32.22°C)) and the dashed yellow lines show the range of air temperatures (87-93°F (30.56-33.89°C)). 94% (*n* = 65 out of 69 total responses) chose one of the correct ranges.

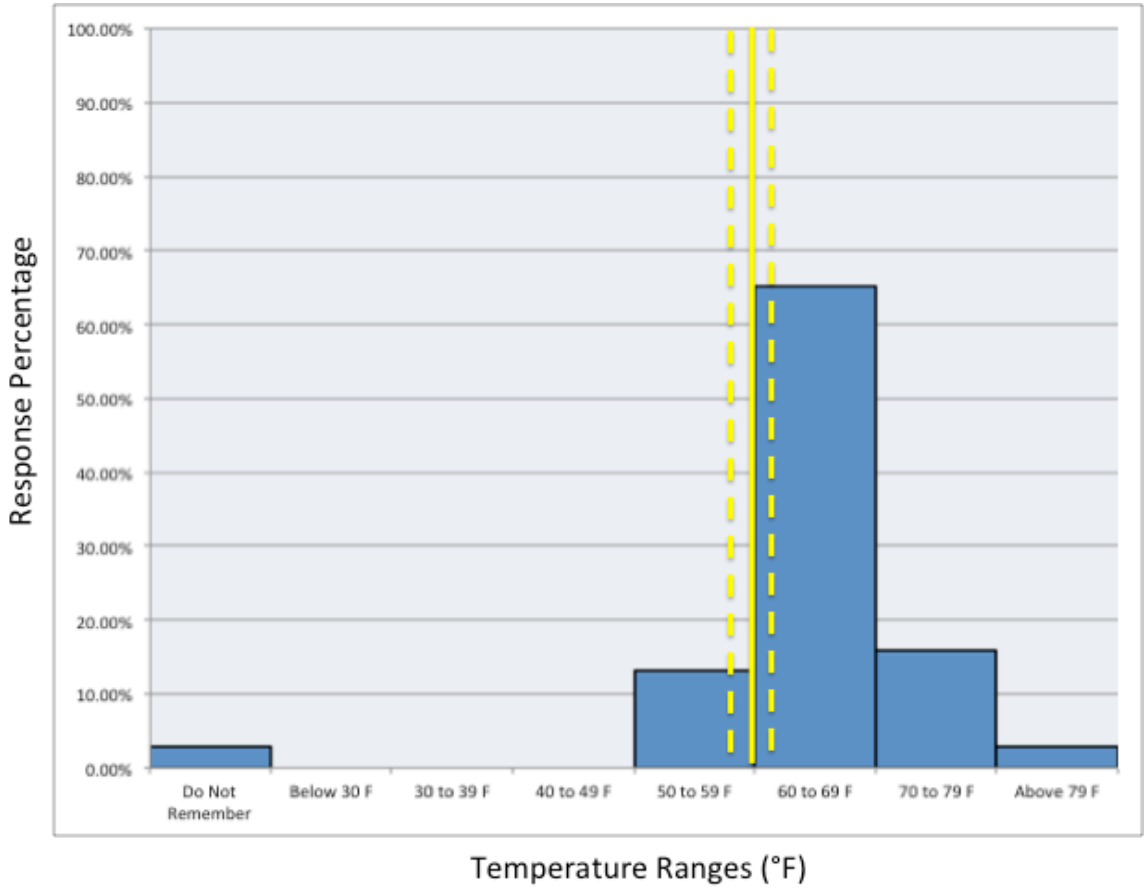

Figure 3.12 July 25th responses about the low air temperature for two days ago (July 23rd). The solid yellow line is the average low air temperature (59.5°F (15.28°C)) and the dashed yellow lines show the range of air temperatures (57-61°F (13.89-16.11°C)). 81% (*n* = 56 out of 69 total responses) chose one of the correct ranges.

July 18th, one week prior to July 25th, had an average high air temperature of 91.25°F (32.92°C) and a range of 90-93°F (32.22-33.89°C). 58% (*n* = 39 responses out of 67 total) responded accurately (see figure 3.13). The average low air temperature was 62.75°F (17.08°C), with a range of 60-66°F (15.56-18.89°C). 45% (*n* = 30 out of 67 total) responded accurately (see figure 3.14).

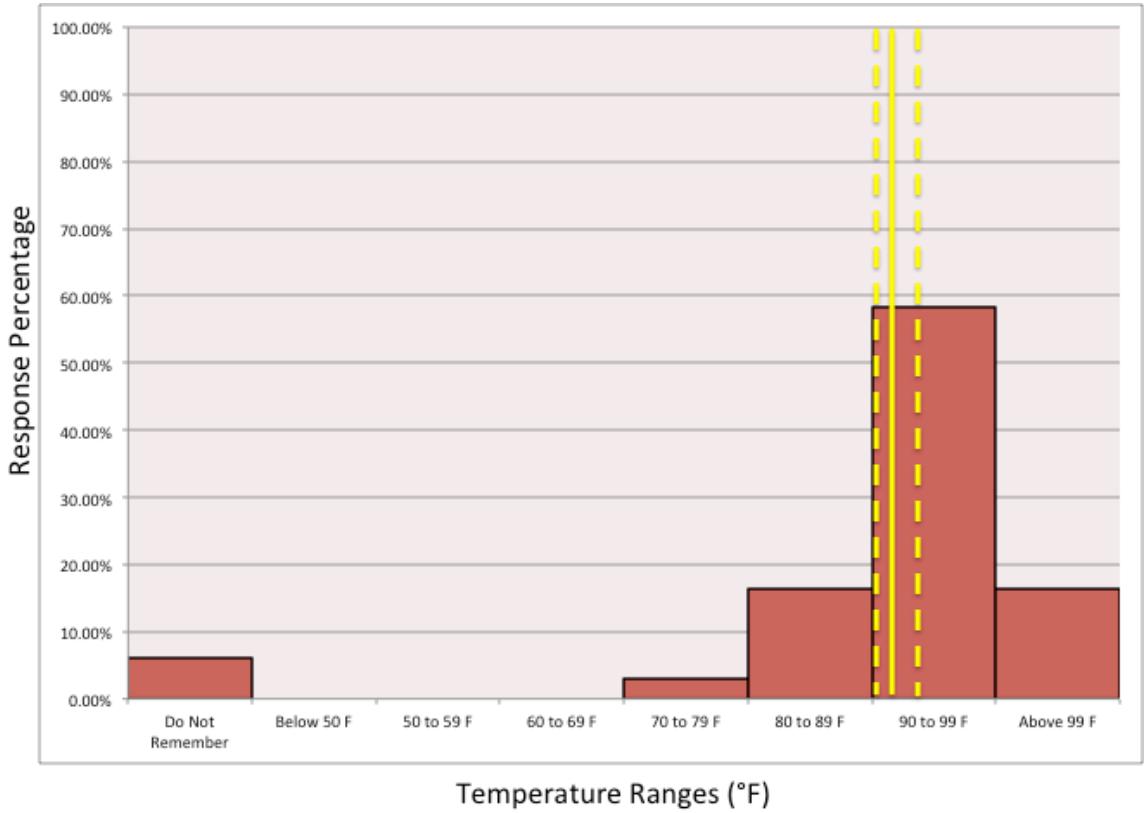

Figure 3.13 July 25th responses about the high air temperature for one week ago (July 18th). The solid yellow line is the average high air temperature (91.25°F (32.92°C)) and the dashed yellow lines show the range of air temperatures (90-93°F (32.22-33.89°C)). 58% (n = 39 responses out of 67 total) chose the correct range.

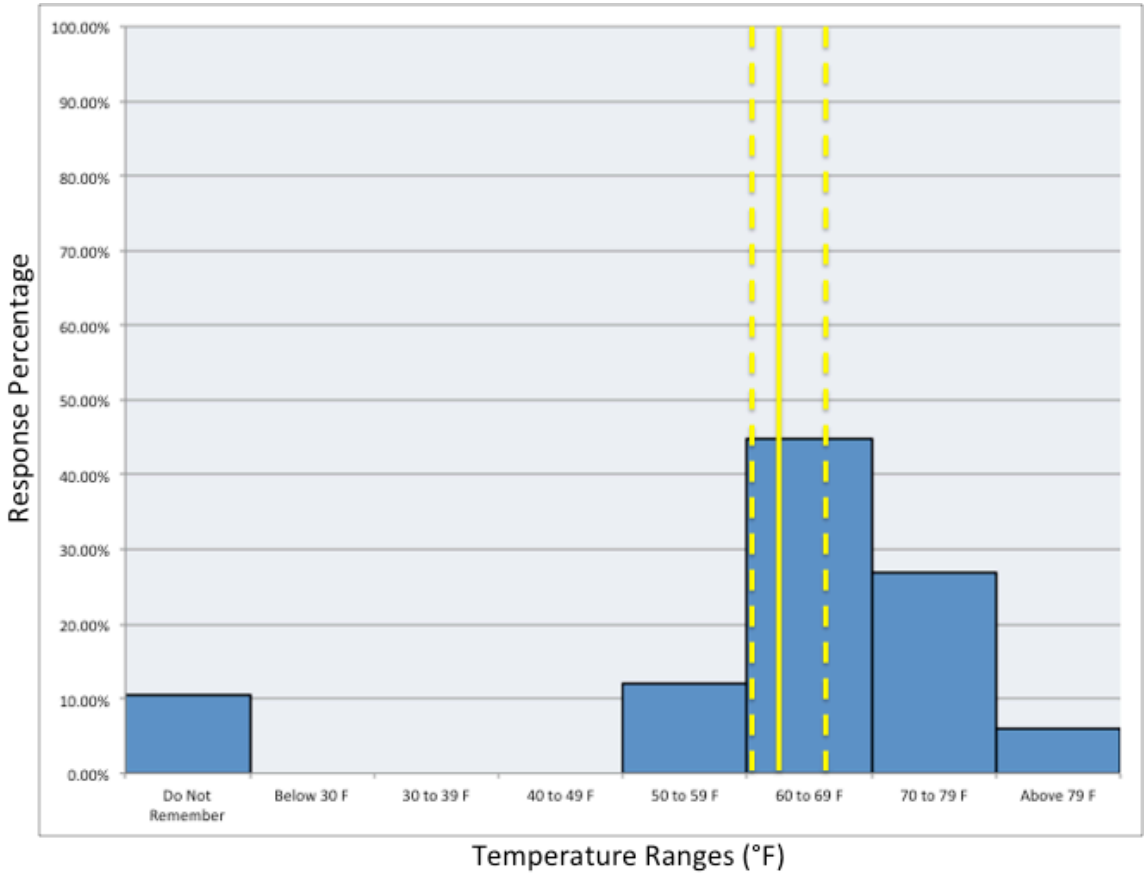

Figure 3.14 July 25th responses about the low air temperature for one week ago (July 18th). The solid yellow line is the average low air temperature (62.75°F (17.08°C)) and the dashed yellow lines show the range of air temperatures (60-66°F (15.56-18.89°C)). 45% (n = 30 out of 67 total) chose the correct range.

For the 2010-2011 in-person interviews, two dates were chosen based upon the highest response rate (see figure 3.15). These were November 29, 2010 (n = 7 or 16%) and December 03, 2010 (n = 6 or 14%). The answers to these questions were also compared to the station data for Boulder, Denver, Lakewood, and Northglenn. While the interviews took place in Boulder, the respondents were not all in Boulder for the one day, two days, or one week prior. However, in order to be included, the respondent had to be in the Denver metropolitan area for at least one of the time periods. For these questions, respondents were asked to describe the weather for the specified recent dates. If they did

remember, the respondents were asked to specify an air temperature or air temperature range. For comparison to the 2006 online interviews, the responses were analyzed by ranges (e.g., 30-39°F).

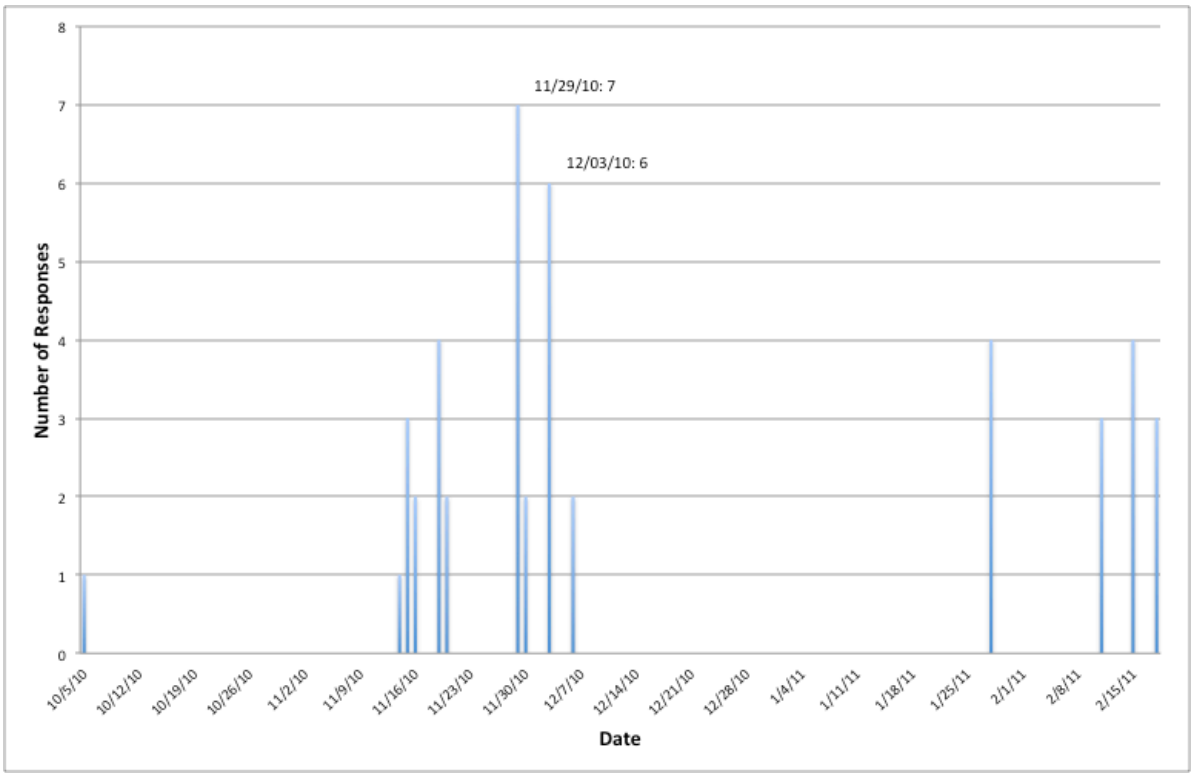

Figure 3.15 Number of responses to the 2010-2011 in-person interviews by date. Peak dates were 11/29/10 with 7 responses and 12/03/10 with 6 responses.

Respondents who were interviewed on November 29, 2010 were asked questions about the weather one day prior (November 28), two days prior (November 27), and one week prior (November 22). On November 28, the average high air temperature was 55.75°F (13.19°C), with a range of 53-57°F (11.67-13.89°C). 71% of the respondents (*n* = 5 out of 7 total) answered this one correctly (see figure 3.16). The average low air temperature for November 28 was 24.25°F (-4.31°C), with a range of 21-28°F (-6.11 - -2.22°C). 43% (*n* = 3 out of 7 possible) answered this accurately as compared to instrument data (see figure 3.17).

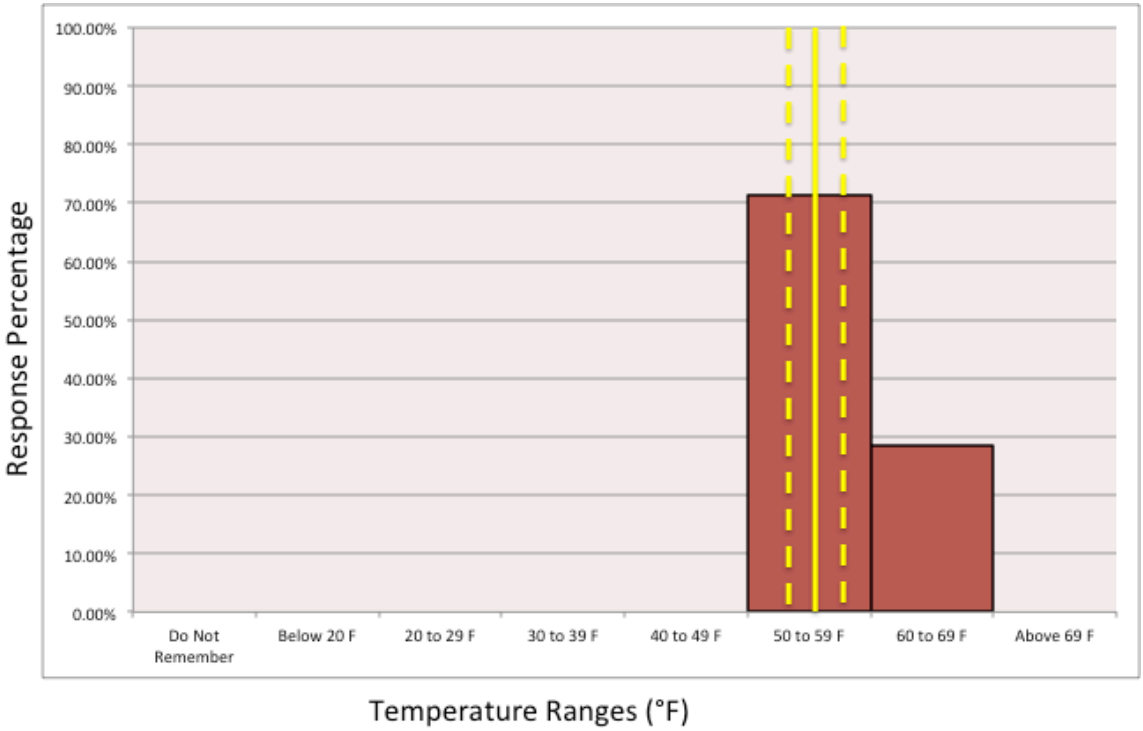

Figure 3.16 November 29th responses about the high air temperature for one day ago (November 28th). The solid yellow line is the average high air temperature (55.75°F (13.19°C)) and the dashed yellow lines show the range of air temperatures (53-57°F (11.67-13.89°C)). 71% of the respondents (*n* = 5 out of 7 total) chose the correct range.

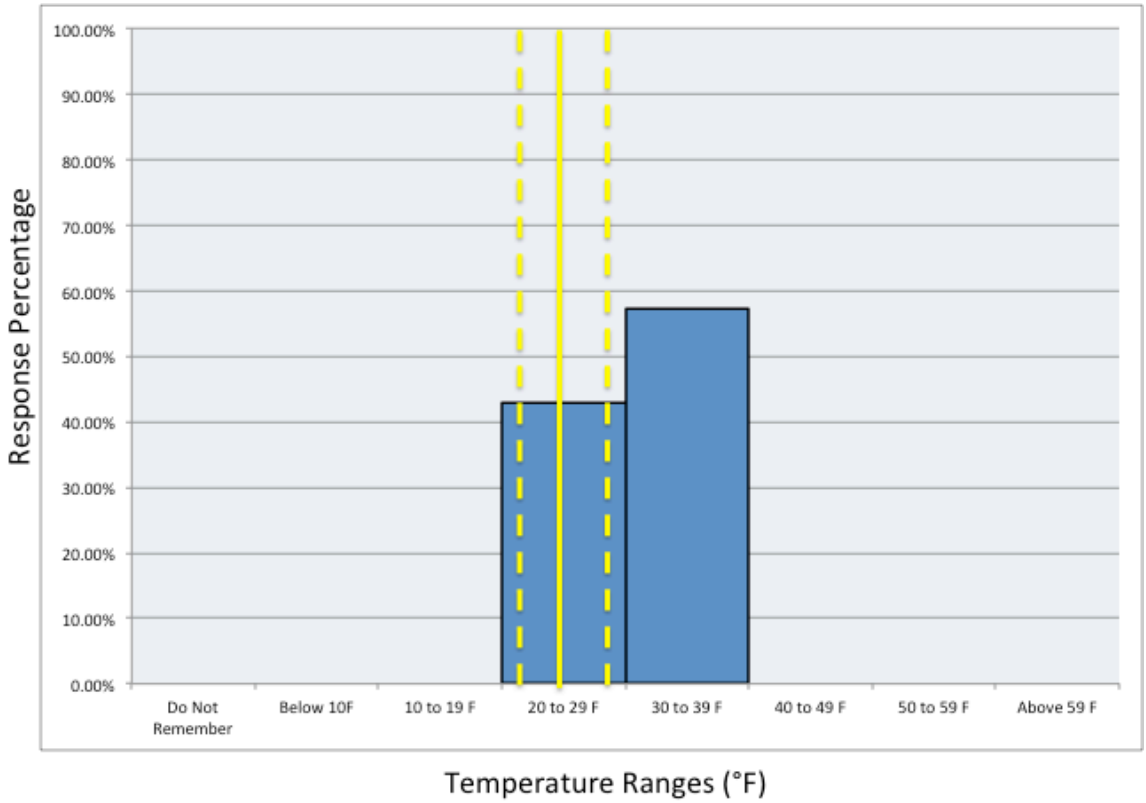

Figure 3.17 November 29th responses about the low air temperature for one day ago (November 28th). The solid yellow line is the average low air temperature (24.25°F (-4.31°C)) and the dashed yellow lines show the range of air temperatures (21-28°F (-6.11 - -2.22°C)). 43% (*n* = 3 out of 7 possible) chose the correct range.

For two days prior to November 29th (November 27th), the average high air temperature was 54.25°F (12.36°C); the range was 52-56°F (11.11-13.33°C). 71% of the respondents (*n* = 5 out of 7) answered correctly (see figure 3.18). The average low air temperature was 20.5°F (-6.39°C), with a range of 16-24°F (-8.89- -4.44°C). This answer was in two possible ranges and 57% (*n* = 4 out of 7) answered for either one of those ranges (see figure 3.19).

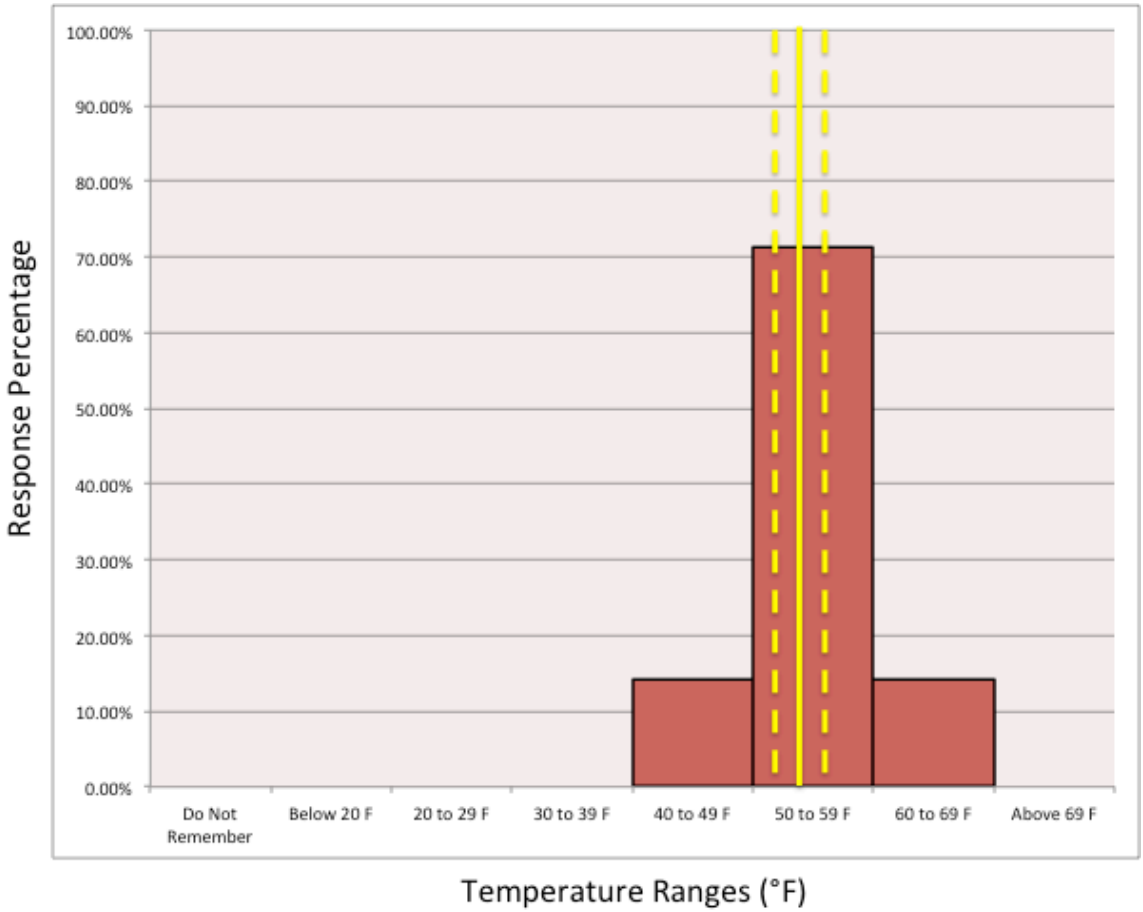

Figure 3.18 November 29th responses about the high air temperature for two days ago (November 27th). The solid yellow line is the average high air temperature (54.25°F (12.36°C)) and the dashed yellow lines show the range of air temperatures (52-56°F (11.11-13.33°C)). 71% of the respondents (*n* = 5 out of 7 total) chose the correct range.

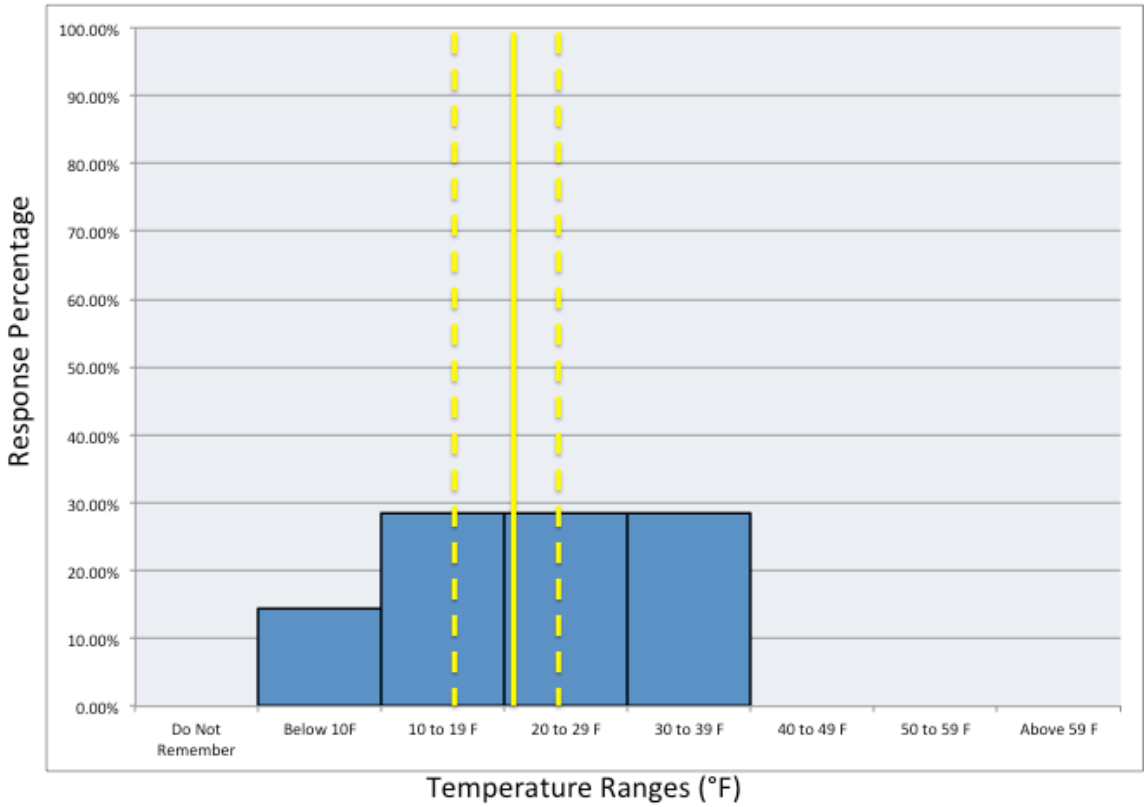

Figure 3.19 November 29th responses about the low air temperature for two days ago (November 27th). The solid yellow line is the average low air temperature (20.5°F (-6.39°C)) and the dashed yellow lines show the range of air temperatures (16-24°F (-8.89- -4.44°C)). 57% (*n* = 4 out of 7) chose the correct range.

For one week prior to November 29th (November 22nd), the average high air temperature was 43.5°F (6.39°C), with a range of 41-45°F (5.00-7.22°C). One person out of seven (14%) answered this correctly (see figure 3.20). The average low air temperature was 21.15°F (-6.03°C), with a range of 17-25°F (-8.33- --3.89°C). The range crossed into two possible answers and one person (14%) gave one of those answers (see figure 3.21).

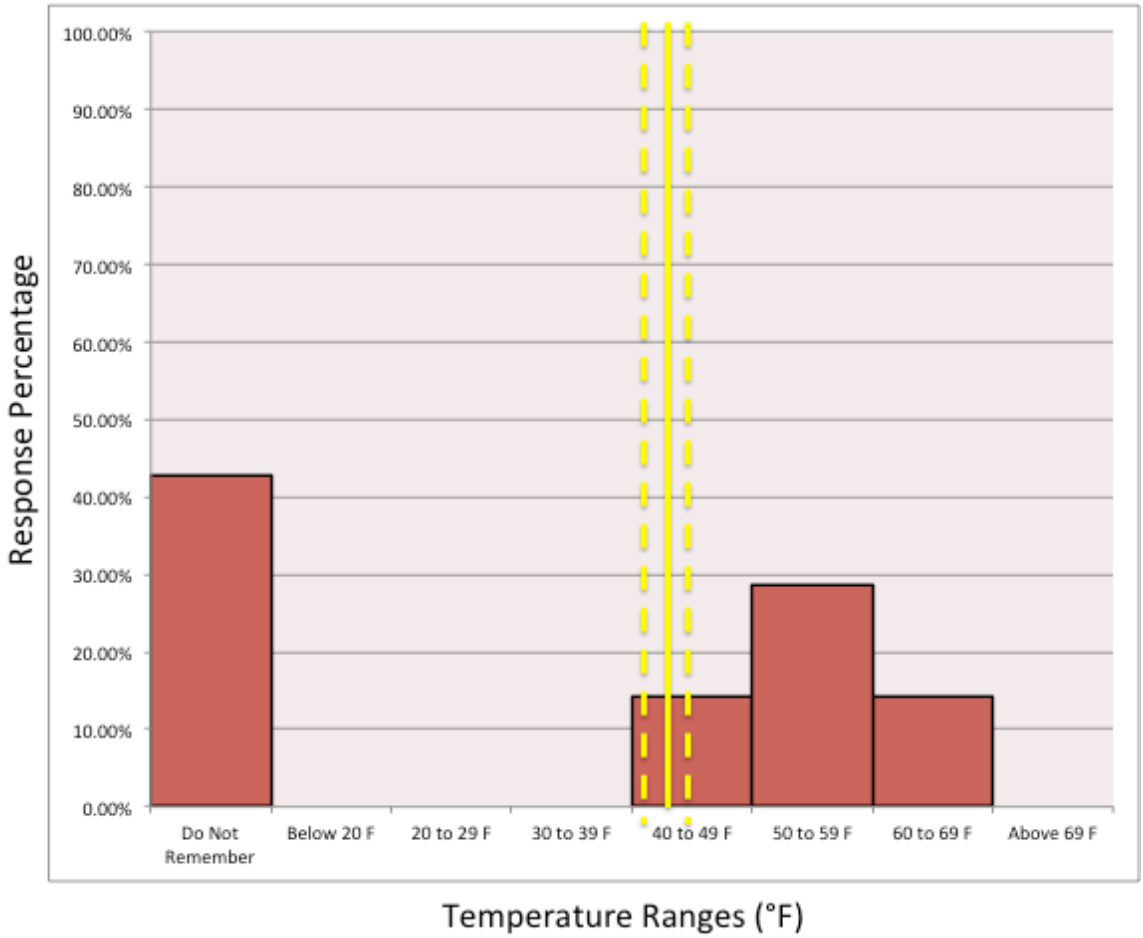

Figure 3.20 November 29th responses about the high air temperature for one week ago (November 22nd). The solid yellow line is the average high air temperature (43.5°F (6.39°C)) and the dashed yellow lines show the range of air temperatures (41-45°F (5.00-7.22°C)). 14% of the respondents (*n* = 1 out of 7 total) chose the correct range.

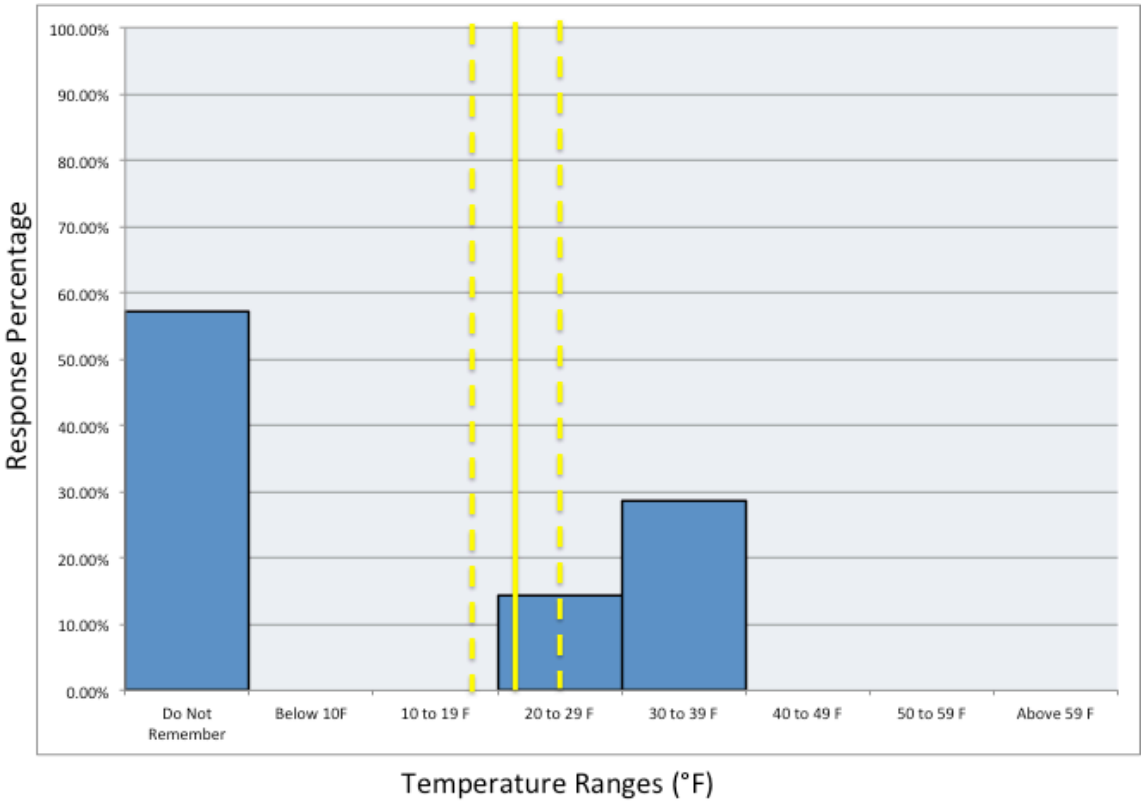

Figure 3.21 November 29th responses about the low air temperature for one week ago (November 22nd). The solid yellow line is the average low air temperature (21.15°F (-6.03°C)) and the dashed yellow lines show the range of air temperatures (17-25°F (-8.33--3.89°C)). 14% (*n* = 1 out of 7) chose one of the correct ranges.

The second highest response day was December 3, 2010. On that day, six people were interviewed. Again, the respondents were asked about the weather one day prior (December 2nd), two days prior (December 1st), and one week prior (November 26th). For one day prior (December 2nd), the average high air temperature was 58.25°F (14.58°C), with a range of 56-61°F (13.33-16.11°C). This crossed into two ranges and 83% (*n* = 5 out of 6 possible) answered correctly (see figure 3.22). The average low air temperature was 31.25°F (-0.41°C), with a range of 28-33°F (-2.22 – 0.56°C). This crossed into two ranges and 67% (*n* = 4 out of 6) answered correctly (see figure 3.23).

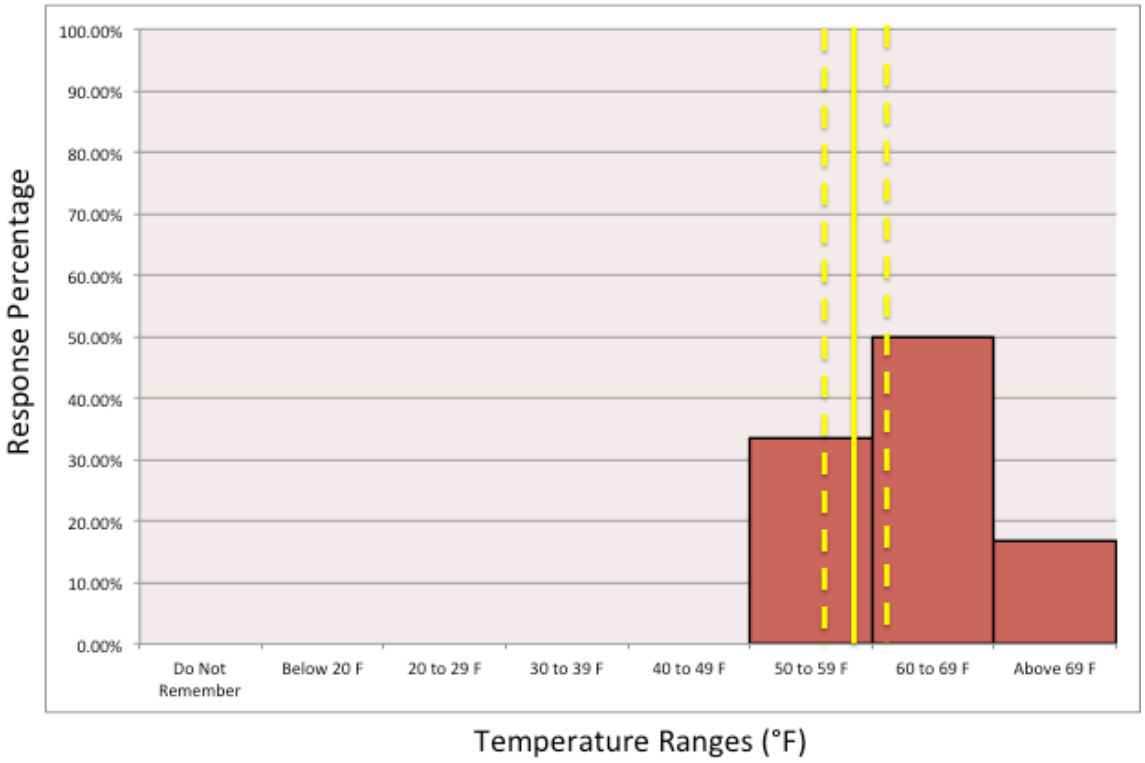

Figure 3.22 December 3rd responses about the high air temperature for one day ago (December 2nd). The solid yellow line is the average high air temperature (56-61°F (13.33-16.11°C)) and the dashed yellow lines show the range of air temperatures (41-45°F (5.00-7.22°C)). 83% of the respondents (n = 5 out of 6 possible) chose one of the correct ranges.

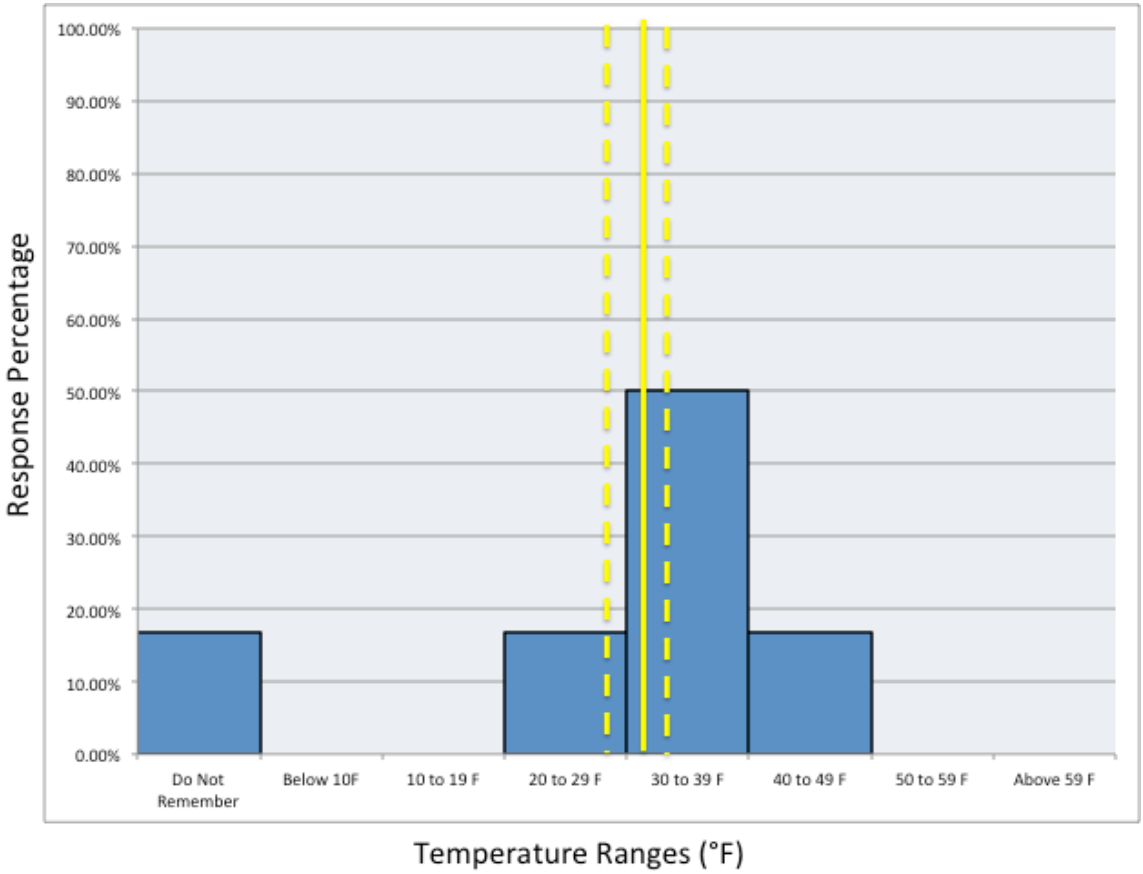

Figure 3.23 December 3rd responses about the low air temperature for one day ago (December 2nd). The solid yellow line is the average low air temperature (31.25°F (-0.41°C)) and the dashed yellow lines show the range of air temperatures (28-33°F (-2.22 – 0.56°C)). 67% (*n* = 4 out of 6) chose one of the correct ranges.

The six respondents on December 3rd were also asked about the air temperatures for two days prior, which was December 1st. On this day, the average high air temperature was 46.25°F (7.92°C), with a range at the four weather stations of 43-49°F (6.11-9.44°C). Half of the respondents answered this correct (*n* = 3 out of 6) (see figure 3.24). The average low air temperature was 19.25°F (-7.08°C), with a range of 15-24°F (-9.44 - -4.44°C). The range of temperatures crossed two possibly answers and 33% of the respondents (*n* = 2 out of 6) answered in one of these two ranges (see figure 3.25).

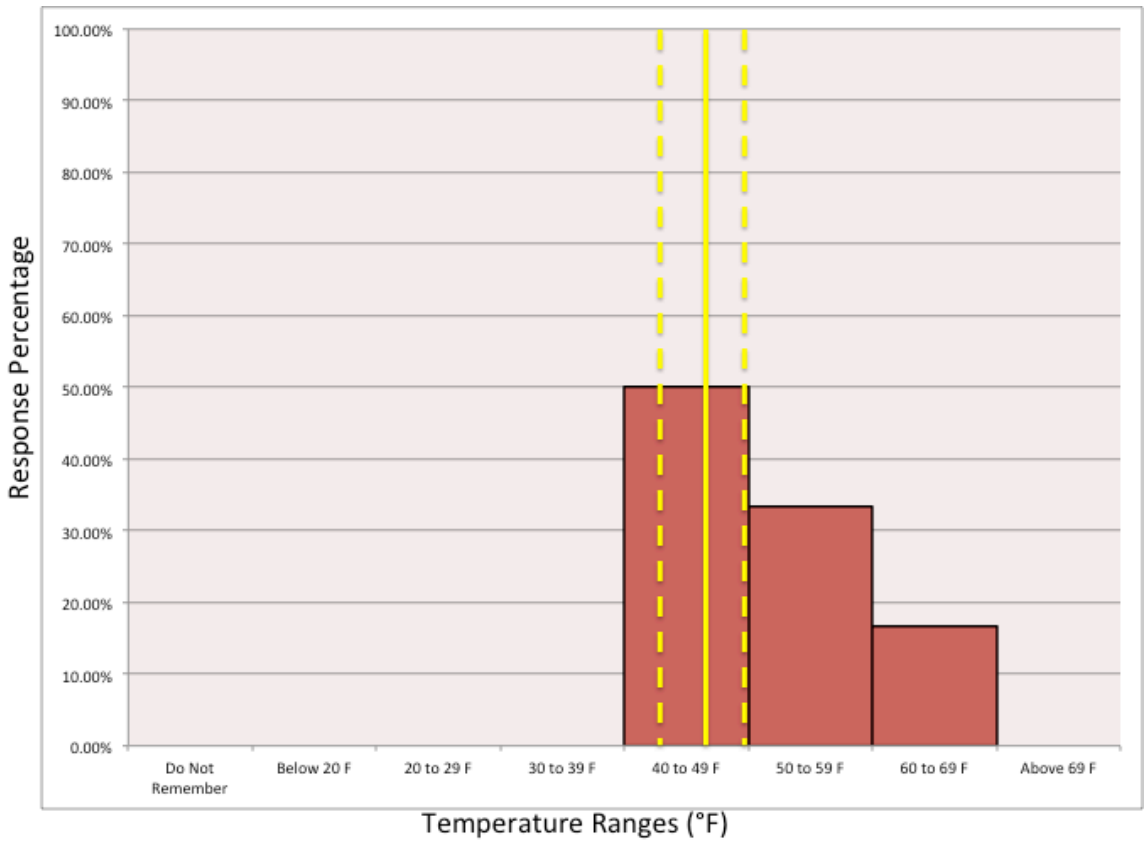

Figure 3.24 December 3rd responses about the high air temperature for two days ago (December 1st). The solid yellow line is the average high air temperature (46.25°F (7.92°C)) and the dashed yellow lines show the range of air temperatures (43-49°F (6.11-9.44°C)). 50% of the respondents (*n* = 3 out of 6 possible) chose the correct range.

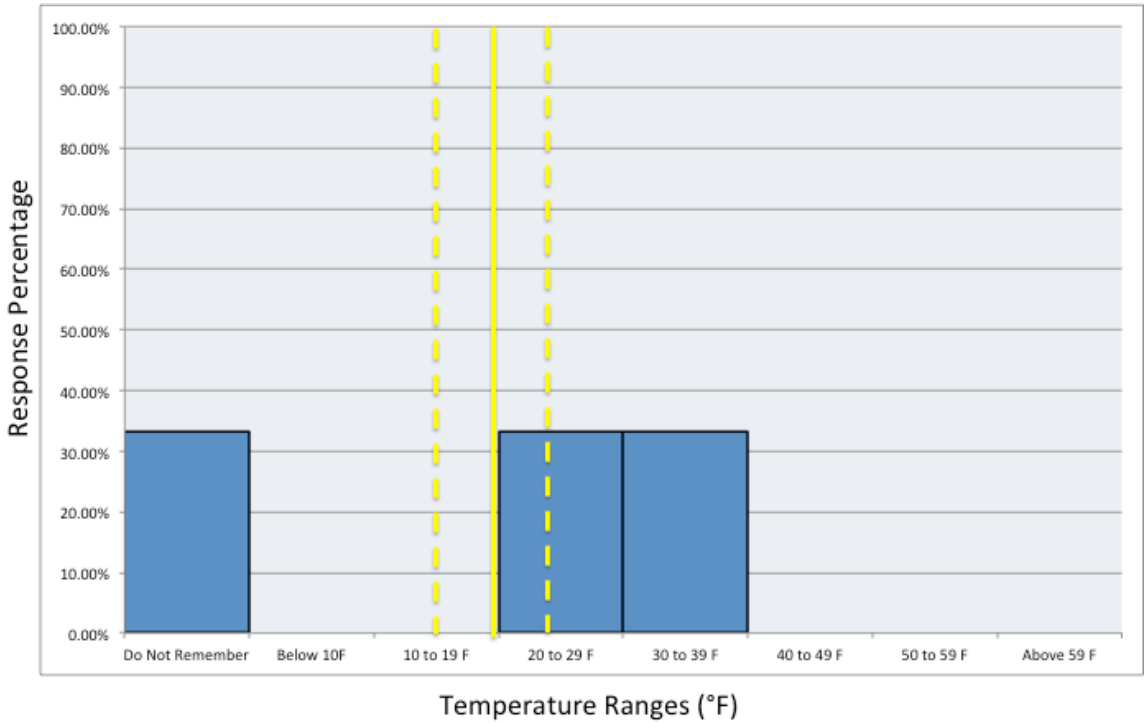

Figure 3.25 December 3rd responses about the low air temperature for two days ago (December 1st). The solid yellow line is the average low air temperature (19.25°F (-7.08°C)) and the dashed yellow lines show the range of air temperatures (15-24°F (-9.44 - -4.44°C)). 33% (*n* = 2 out of 6) chose one of the correct ranges.

The final weather date asked about on December 3rd was one week ago, November 26th. For that day, the average high air temperature was 44°F (6.67°C) and the range was 41-49°F (5.00-9.44°C). 17% (*n* = 1 out of 6) answered correctly (see figure 3.26). The average low air temperature was 16.25°F (-8.75°C), with a range of 14-18°F (-10.00 - -7.78°C). 67% (*n* = 4 out of 6) responded correctly (see figure 3.27).

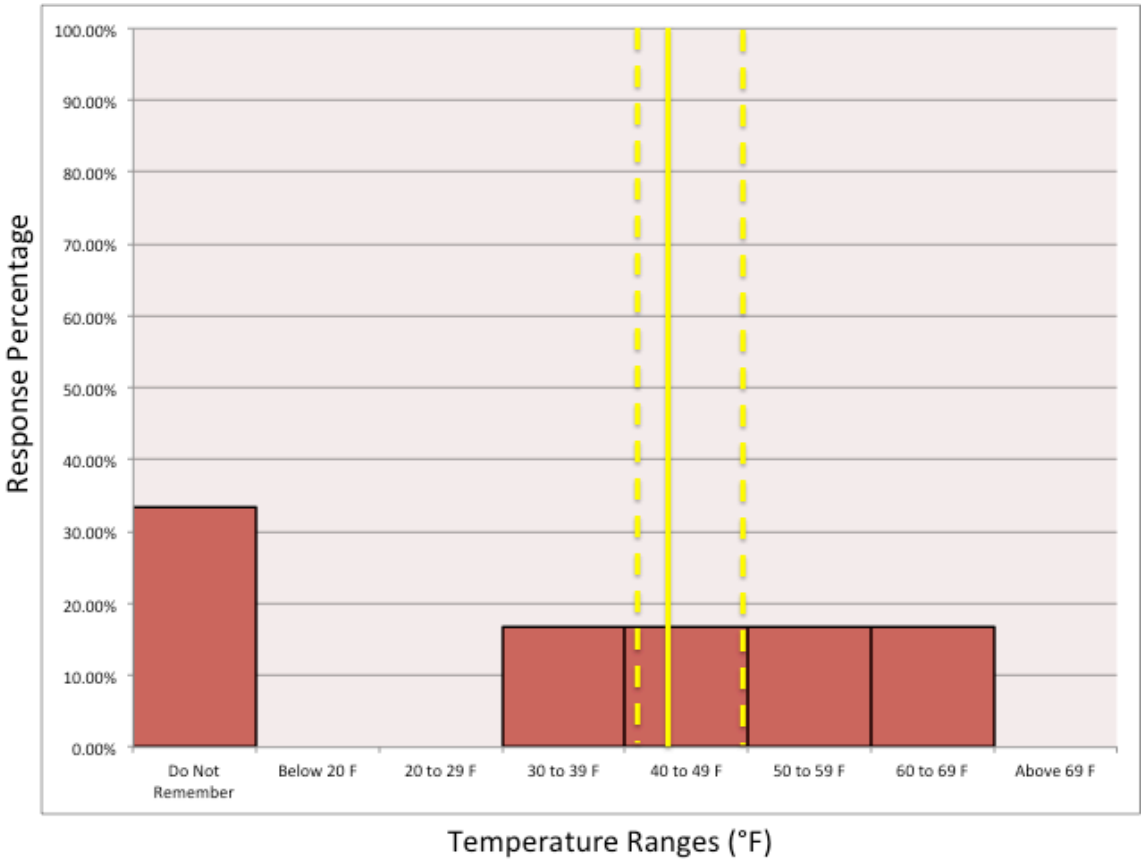

Figure 3.26 December 3rd responses about the high air temperature for one week ago (November 26th). The solid yellow line is the average high air temperature (44°F (6.67°C)) and the dashed yellow lines show the range of air temperatures (41-49°F (5.00-9.44°C)). 17% (n = 1 out of 6) chose the correct range.

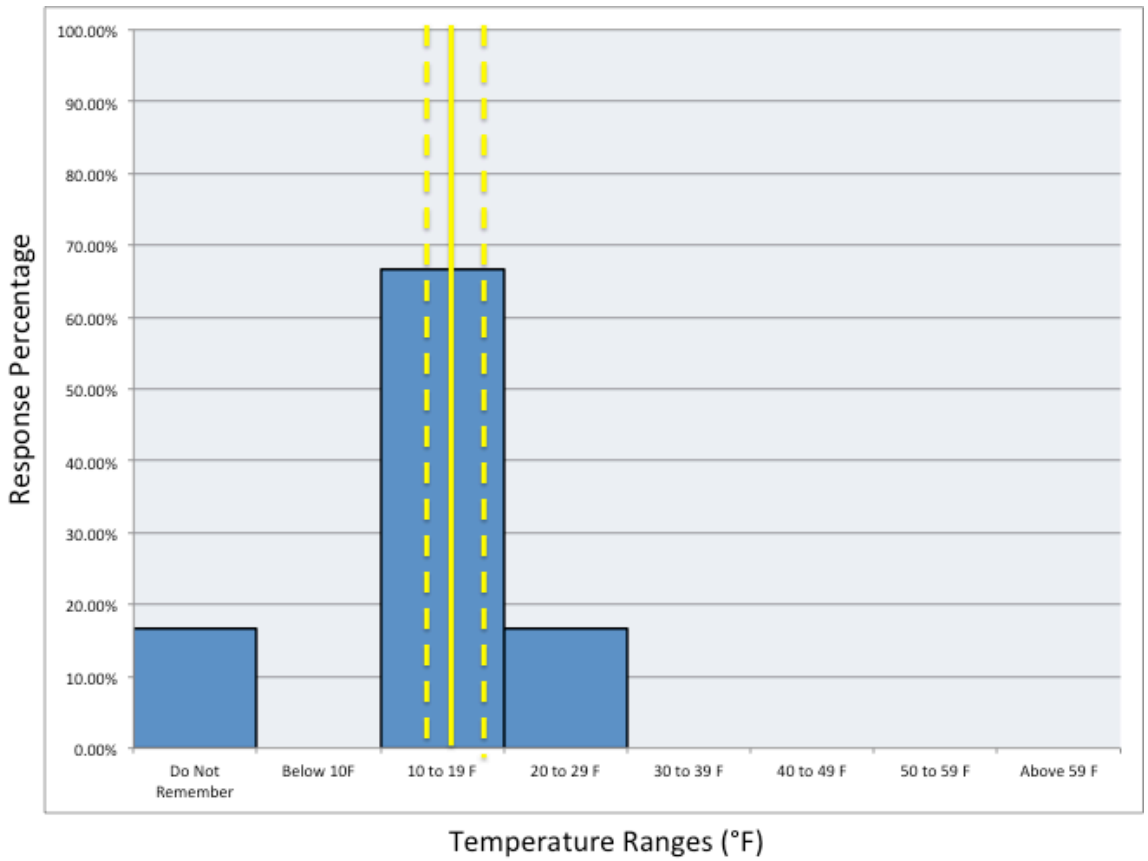

Figure 3.27 December 3rd responses about the low air temperature for one week ago (November 26th). The solid yellow line is the average low air temperature (16.25°F (-8.75°C)) and the dashed yellow lines show the range of air temperatures 14-18°F (-10.00 - -7.78°C)). 67% (n = 4 out of 6) chose the correct range.

Tables summarizing correct responses (see table 3.1) as well as "Do Not Remember" responses are below (see table 3.2).

Table 3.1 Percent of correct responses by days prior. On the left are high air temperatures; on the right are low air temperatures. An * indicates the range of temperatures crossed into two possible answers.

	Percent Correct					
	High Air Temperature			Low Air Temperature		
Date	**One Day Prior**	**Two Days Prior**	**One Week Prior**	**One Day Prior**	**Two Days Prior**	**One Week Prior**
20-Jul-06	74%	63%	42%	55%	48%	45%
25-Jul-06	73%	94% *	58%	60%	81% *	45%
29-Nov-10	100% *	71%	14%	43%	57% *	14%
3-Dec-10	83% *	50%	17%	67%	33% *	67%
Overall	**83%**	**70%**	**33%**	**56%**	**55%**	**43%**

Table 3.2 Percent of "Do Not Remember" responses by days prior. On the left are high air temperatures; on the right are low air temperatures.

	Percent "Do Not Remember"					
	High Temperature			Low Temperature		
Date	**One Day Prior**	**Two Days Prior**	**One Week Prior**	**One Day Prior**	**Two Days Prior**	**One Week Prior**
20-Jul-06	1.82%	2.83%	10.48%	1.82%	3.77%	15.24%
25-Jul-06	0.00%	1.45%	5.97%	1.33%	2.90%	10.45%
29-Nov-10	0.00%	0.00%	42.86%	0.00%	0.00%	57.14%
3-Dec-10	0.00%	0.00%	33.33%	16.67%	33.33%	16.67%

When broken down into groupings, the overall accuracy of respondents for the four dates selected was 53%. Respondents were more accurate about high air temperatures than low air temperatures (58% versus 50%) and accuracy decreased the further back in time (see table 3.3).

Table 3.3 Accuracy percentages broken up into groupings of overall, accuracy of high temperature responses, accuracy of low temperature responses, and accuracy for one day, two days, and one week prior to the survey or interview.

	Accuracy Percentages					
Date	**Overall**	**High Temperatures**	**Low Temperatures**	**One Day Prior**	**Two Days Prior**	**One Week Prior**
20-Jul-06	51.36%	58.76%	47.71%	64.55%	53.64%	41.36%
25-Jul-06	64.22%	71.11%	57.33%	67.33%	79.33%	46.67%
29-Nov-10	45.24%	52.38%	38.10%	57.14%	64.29%	14.29%
3-Dec-10	52.78%	50.00%	55.56%	75.00%	41.67%	41.67%
Overall	**53.40%**	**58.06%**	**49.67%**	**66.01%**	**59.73%**	**36.00%**

It should also be noted that in the 24 possible previous weather recollections, more people answered that it was warmer than it actually was versus colder than it actually was for 16 of the 24 time periods (67%). This means if the actual temperature fell in the 80-89°F range, if the respondent did not guess the correct range, he or she was more like to answer that it was 90-99°F than to answer that it was 70-79°F.

3.4.b Objective 2

Objective 2: Do social, demographic, or environmental factors influence the accuracy of recent weather recollections?

In order to determine the influence of social and demographic factors on the accuracy of recent weather recollection, a chi-square test was performed on two survey dates in the 2006 online survey. The two dates, July 20 and July 25, 2006, were selected due to the high number of responses for those dates (see figure 3.7). Values were calculated for gender, education level, time spent outdoors, whether or not weather or climate was important to the respondent's career, and whether or not the respondent had ever taken or was currently taking a course about weather or climate (see table 3.4). It was found that whether or not a person had taken a weather or climate class had the highest likelihood for accurately recollecting recent weather. 61% of those who had taken a weather or climate class recollected recent weather accurately. Next, those who spent more time outdoors (greater than 6 hours per day) recollected the recent weather better than those who spent less time outdoors, although this was a small sample size (n = 3).

Table 3.4 Accuracy of responses about recent weather by category, the Chi-squared, degrees of freedom, and *p*-values.

Category	**Accuracy**	**χ^2 value**	**df**	***p*-value**
Weather/Climate Class	Yes (n=74): 61.11% No (n=91): 52.20	0.701	1	0.402
Time Spent Outside	<2 hours (n=75): 56.14% 2 to 6 hours (n=87): 56.06% >6 hours (n=3): 66.67%	1.766	2	0.414
Education Level	High School/Assoc (n=20): 62.50% Bachelors (n=41): 52.92% Graduate (n=103): 56.89%	0.847	2	0.655
Gender	Female (n=105): 58.47% Male (n=60): 54.92%	0.111	1	0.739
Weather/Climate Related Profession	Yes (n=51): 56.92% No (n=114): 55.90%	0.012	1	0.913

When responses for the weather or climate class category class were analyzed, it was found that people who had taken a weather or climate class were more accurate for weather recollections for low air temperatures and two days prior. In general, those with a prior weather or climate class were more accurate for all categories (high air temperatures, low air temperatures, one day prior, two days prior, and one week prior) than those who had not had a weather or climate class, with the exception of one week prior.

Regarding responses for gender recollections of recent weather memories, it was found that males were slightly more accurate for more of the factors. Males were slightly more accurate for low air temperatures, two days prior, and one week prior. Females were slightly more accurate for one day prior and for high air temperatures.

Weather conditions at the time of the interviews had no significant relationships with accuracy of recent weather recollections (table 3.6).

Table 3.6 The relationships between accuracy of recent weather recollections and ambient meteorological conditions at the times of the 2010-2011 interviews

Category	*r*	*p value*
Total radiation	-0.351	0.7717
Visible radiation	-0.299	0.8067
Air temperature	0.143	0.9087
Relative humidity	0.013	0.9917

3.4.c Objective 3

Objective 3: How do current perceptions of climate change influence memories of recent weather?

The next objective was to look at how beliefs about whether or not global warming is occurring as well as human impact on global warming impact recent weather recollections. Beliefs about local impacts of global warming (air temperature change in the Denver metropolitan area and the start of winter) were compared to memories of recent weather from the 2006 online survey (see table 3.7). The category with the strongest relationship was asking people how the start of winter in the Denver metropolitan area is changing. (The start of winter was chosen since this was the next in time from the dates of the 2006 online survey. For the sake of brevity of the survey, the start of spring was not included.) However, those who answered it is the "same" and those answering that it is starting "a lot later" had about the same accuracy for recent weather recollections (~56%). Those answering that winters were starting "a littler earlier" had an accuracy of 44%, although the sample size was small (n = 5). The next category with a possible relationship was whether or not humans have an impact on

global warming. People who responded that humans have a moderate or significant impact on global warming were more accurate (63% and 56%, respectively) than those who responded that humans have no impact or a minor impact (52% and 48%, respectively).

Table 3.7 Accuracy of responses about recent weather as compared to beliefs about climate change, the Chi-squared, degrees of freedom, and *p*-values.

Category	Accuracy	χ^2 value	df	*p*-value
Start of Winter	Little Earlier (n=5): 44.44% Same (n=90): 56.67% Little Later (n=52): 54.78% Lot Later (n=10): 56.06%	2.807	3	0.422
Human Impact	None (n=9): 52.08% Minor (n=13): 48.21% Moderate (n=28): 63.10% Signficant (n=115): 55.56%	2.391	3	0.495
Climate Change	Yes (n=148): 56.56% No (n=17): 53.12%	0.226	1	0.635
Temperature Change	Little Cooler (n=1): 50% Same (n=32): 52.84% Little Warmer (n=102): 55.185% Lot Warmer (n=27):58.93 %	1.182	3	0.757

3.4.d Objective 4

Objective 4: How do people remember the weather for specific events?

In the 2010-2011 in-person interviews, people were asked to rank the weather from one to six (with 1 being bad weather, 6 being good weather) for specific weather events. Two of the events were of their choosing and then two specific events; the September 11, 2001 terrorist attacks and the Fourmile Canyon Fire on September 6, 2010

(note that respondents had to be in Boulder for the Fourmile Canyon Fire). Additionally, respondents were asked to rank the event itself from one to six to determine if this was a positive, neutral, or negative event.

To see how the respondents classified good weather versus bad weather, they were asked to describe each. Word clouds were created using wordle.net for good weather (figure 3.28) and bad weather (figure 3.29). After copying and pasting text into the Wordle web site, a program runs to sort words by popularity. Word size changes according to frequency (the bigger the word, the more frequently it appears). Common words in the English language like "the", "a", "of", etc. are not included in the word cloud.

Figure 3.28 A word cloud of respondents' descriptions of "good weather"

Figure 3.29 A word cloud of respondents' descriptions of "bad weather".

When asked to pick any two events from their life, the average rating for the event was 4.45 (on a scale of 1 to 6, with 1 being a bad event, 6 being a good event) and the average weather rating for the event was 4.23 (on a scale of 1 to 6, with 1 being bad weather and 6 being good weather). There was no significant relationship between ranking of the event and ranking of the weather for the event ($p = 0.6696$, $r^2 = 0.246$). There were also no significant relationships between the ambient meteorological conditions at the time of the interviews and the rating of the event or the rating of the weather during the event (table 3.8).

Table 3.7 Ambient meteorological conditions at the time of the 2010-2011 interviews as compared to responses about the rating of events and the rating of weather during the events

	Rating of Event		Rating of Weather during Event	
Category	***r***	***p value***	***r***	***p value***
Air Temperature	-0.049	0.969	0.209	0.866
Relative Humidity	0.116	0.926	-0.093	0.941
Visible Radiation	-0.046	0.971	-0.099	0.937
Total Solar Radiation	-0.098	0.938	-0.061	0.961

Respondents were asked to rank the event and the weather on September 11, 2001. The average rating for the day was 1.5 and the average rating for the weather on September 11, 2001 was 3.86. There was no relationship between the rating of the weather and the rating of the event ($p = 0.949$, $r = 0.080$). Figure 3.30 shows a weather map from September 11, 2001 at 8:00 am EDT. The majority of the country was reporting clear skies, warm air temperatures, and almost no significant weather. In the Denver metropolitan area for September 11, 2001, the average high air temperature for the four Denver metropolitan stations (Boulder, Denver, Lakewood, and Northglenn) was 85.5°F (29.72°C), with a range from 80-92°F (26.67-33.33°C) and no precipitation reported.

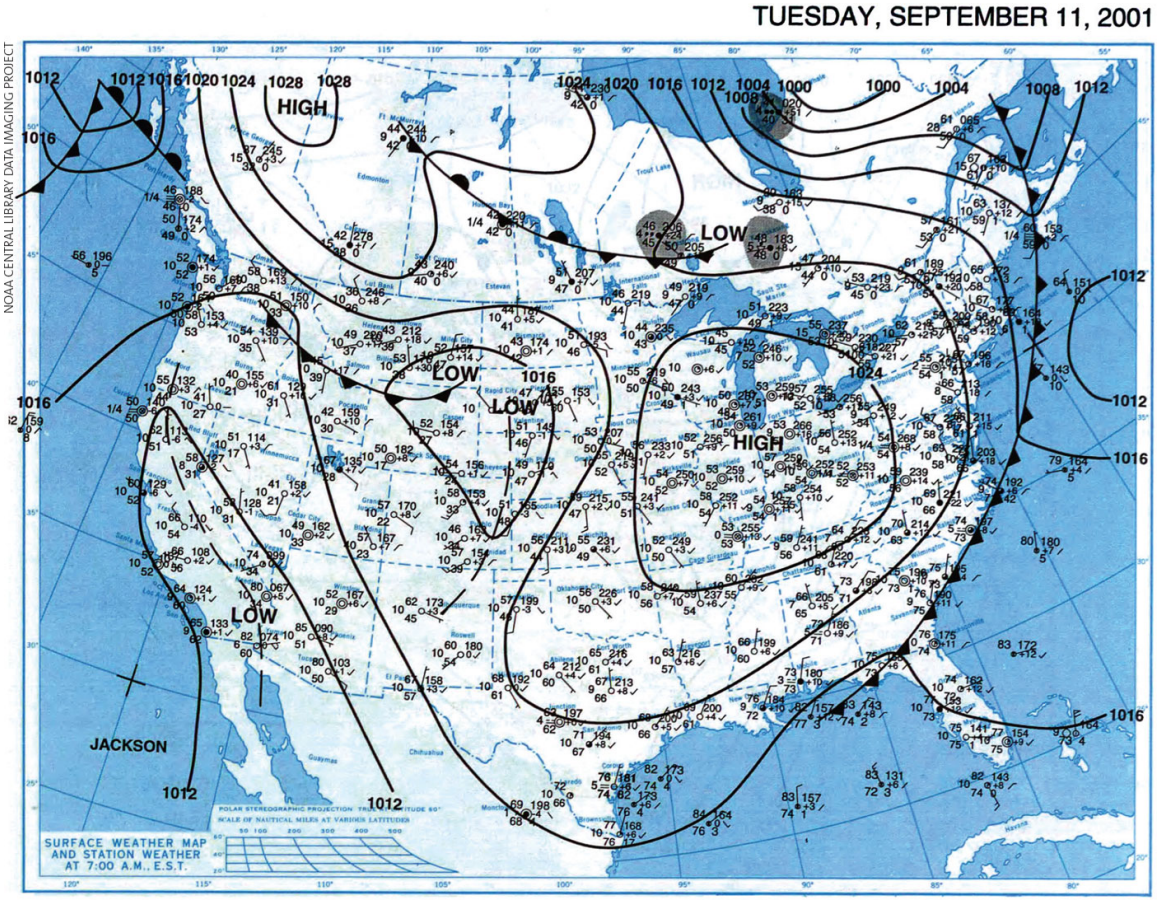

Figure 3.30 NOAA/NWS Daily Weather Map for 8:00 am EDT, September 11, 2001. Clear skies and warm temperatures were present across most of the United States (Potter 2011).

Next, respondents were asked about the Fourmile Canyon Fire. If they were in the Boulder area that day, they were asked to rank the event and the weather on September 6, 2010, which was the first day of the fire. The average ranking of the event was 1.95 and the average ranking of the weather was 3.38 (both on a scale of 1 to 6, with one being bad, 6 being good). The Fourmile Canyon Fire started on September 6, 2010, burned 6,181 acres over 5 days (approximately 5,700 acres on September 6th), destroyed 162 homes, and was the third most expensive wildfire in Colorado history (it was surpassed by the High Park fire and the Waldo Canyon fire in June 2012) (Graham et al. 2012). On September 6, 2010, it was a dry day (relative humidities of less than 10%

were reported until 6:00 pm), with high winds (sustained winds of 15 mph, with gusts up to 41 miles per hour), and warm (a high of 84°F (28.89°C)) (Graham et al. 2012). Respondents rated the weather September 6 for before the fire started; the morning it was warm and sunny, although the winds were starting to increase before the fire started.

3.5 Discussion

Respondents for this research remember the recent weather a little over 50% of the time. This number decreased over time (ranging from 66% accuracy for one day prior to 36% accuracy for one week prior) and was more accurate for high than low air temperatures. This is most likely due to respondents generally being outside during warmer parts of the day. However, since minimum air temperatures are believed to warm more than maximum air temperatures, accuracy for low air temperatures is important. Although remembering high better than low air temperatures was not the case for weather recollections for one week prior's low temperatures on November 29, 2010. This could potentially be due to cold of that day, with the average low air temperature of 16.25°F (-8.75°C). When trying to remember the recent weather in the 2010-2011 in-person interviews, respondents were asked what they were thinking about to remember the temperatures. Many of them mentioned thinking about what they were wearing, where they went, and what they were doing. None of the respondents mentioned seeing a weather forecast or reading about the weather in the news, all of them based the recent weather on how it personally affected them. Since these respondents were all undergraduate students, this information could be different for older adults.

Another interesting note is that if people did not answer the correct temperature response, they tended to guess higher temperatures than were actually reported. Since respondents tended to think of warm, sunny days as good weather, did the respondents improve the past weather in their recollections? Or did beliefs about climate change, with over 80% of the respondents saying climate change is happening, create a lens for how past weather was remembered?

The next area of discussion is to see how social, demographic, and environmental factors influence recent weather recollections. The strongest relationship was found between a previous weather and climate class and recent weather memory accuracy; people who had taken a weather or climate class were more accurate than those who had not. However, this was not statistically significant. Time spent outdoors was close behind, with those spending a lot of time outdoors (> 6 hours per day) being more accurate than those who spent less time outdoors. Education level, gender, and a weather or climate related profession had little impact on the accuracy of weather recollections. Political affiliation, rating of current weather, and rating of current mood seemed to have no relationship with accuracy of weather recollections, although the sample size was small for these categories (n = 13). Additionally, none of the ambient meteorological conditions collected at the time of the 2010-2011 in-person interviews had a relationship to recent weather recollections. Again the sample size was small (n = 13). This did not support research by Hamilton and Stampone (2013), which found anomalously high temperatures led to increased beliefs about climate change as well as human impact on climate change. However, temperatures during the interviews were not extreme during the 2010-2011 in-person interviews. While there was no significant relationship, there

was a slight negative relationship between total solar radiation and the memory accuracy. This supported the work by Forgas et al. (2009) that bad weather leads to better retention of everyday events.

The next objective was to see how current perceptions of climate change influence recent weather recollections. In general, there was a weak relationship between climate change beliefs and weather recollections. However, about 90% of the respondents believe that climate change is happening; a more interesting relationship might be found in a more diverse population. This would seem to say that the current perceptions lens might not have as much of an impact on recent weather recollections as actually improving memories of the past might.

Finally, data for how people remembered the weather for specific events was examined. When the respondents picked their own events, they picked mainly positive events and described positive weather going along with those events. According to the respondents in the interviews, warm, sunny days were good weather days and cold, windy days were bad weather days. However, a small, yet noticeable, contingent described good weather as snowy and cold. Due to the proximity of the University of Colorado at Boulder to the mountains, the number of skiers and snowboarders in this study may have been disproportionately high. There was no relationship between the meteorological conditions at the time of the interviews and the rating of the events or the rating of the weather at the events. This does not support findings in other studies that people tend to "match" recollections to what is presently happening (Parrott and Sabini 1990, Aggleton and Waskett 2010).

Participants in the 2010-2011 interviews were then asked about specific events that could qualify as flashbulb memory events. First, when asked about the terrorist attacks on September 11, 2001, the respondents gave a lower average weather rating than they did for their chosen events (3.86 as compared to 4.23). However, according to the definition of a good weather day by the respondents, September 11, 2001, was a good weather day across almost the entire United States. Bernsten and Thomsen (2005) found similar results in their study about Danes and the occupation of Denmark; they tended to describe the weather more negatively than actually what happened. It seems that the negative event (September 11, 2001), caused a negative bias for reporting about the weather as well. Additionally, since this was a very publicized event, people may have remembered details from photographs or videos of the terrorist attack as personal memories. Even though the weather in New York City was good on September 11, 2001, images of smoke or fire may have influenced weather recollections.

For the Fourmile Canyon Fire, the average weather ranking was 3.38, although people were asked to rate the weather before the fire started. It was a warm and sunny day, which again corresponds to a good weather definition by the respondents. However, some of the respondents may have been remembering the winds; "windy" was part of the definition of a bad weather day.

In all, it does seem that time is the biggest predictor for accuracy of memories about recent weather. Accuracy for recent weather recollections decreased from 66% for one day prior to 60% for two days prior and then down to 36% for one week prior. For high air temperatures, accuracy decreased from 83% for one day prior to 33% for one week prior and decreased from 56% to 43% for low air temperatures. Taking a class

about the weather or climate and spending time outdoors also led to more accurate accounts of recent weather. When remembering the negative event of September 11, 2001, the respondents rated the weather associated with that event more negatively than they probably would have for a more positive event.

Now, what does this imply? Recollections about weather are accurate to a certain degree, but the accuracy decreases quickly with time and can be shaped by other factors. Recollections about air temperature are more accurate than those about precipitation and recollections about high air temperature are more accurate than low air temperature. A study by Hamilton and Stampone (2013), found that temperature anomalies greatly influenced independent voters' beliefs about climate change and human impacts on climate change; particularly higher temperatures leading to high probability of belief in climate change. If this is the case, then perhaps scientists and policy makers should publicize climate change mitigation and adaption policies one to two days after extremely warm events, before the memories of the anomalies begin to fade.

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CHAPTER 4

Social, Demographic, and Environmental Influences on Perceptions of Climate Change

4.1 Introduction

Al Gore, the United Nations and the Intergovernmental Panel on Climate Change, and the Nobel Prize committee have all identified global warming as a preeminent threat to ecological and social well-being. Yet, current research indicates that perceptions of global warming as a risk and willingness to act to change possible mitigation practices are not in agreement. Between 63% and 70% of Americans are concerned about impacts of global warming (Leiserowitz 2006, Leiserowitz et al. 2013a) and between 51% (Leiserowitz et al. 2013a) and 76% (Leiserowitz 2005) of Americans think global warming is a "somewhat serious" to "very serious" problem. However, there have not been many large-scale mitigation or adaptation measures taken to alleviate the risks of global warming, with exceptions in Boulder, Colorado. Emotions like fear and worry motivate people to change their environments in ways that will reduce the feelings of being at risk (Weber 2006). What are some possible causes of this disconnect between people saying that global warming is a serious problem yet not taking actions to reduce

the risk? And, since cities like Boulder are starting to pass legislation to mitigate and adapt to climate change, are perceptions changing?

This chapter seeks to find out possible causes and looks at social, demographic, and environmental influences on perceptions of climate change.

4.1.a Personal Relevance

In the topic of personal relevance of global warming, three sub-areas will be discussed. These include the scale of global warming, a lack of affective imagery and personal experience of local climate change, and the idea that global warming will actually improve the climate in some areas.

In one study, it was also found that only 13% of the respondents were concerned about the impacts of global warming on themselves, their families, or their local communities (Leiserowitz 2006). People think global warming is a geographically distant problem (Duerden 2004, Leiserowitz 2006, Lorenzoni and Pidgeon 2006). If people do not relate to an issue or see how it is personally relevant, they are less likely to take action to mitigate the problem. One possible reason that global warming is not seen as a personal issue is how global warming is often addressed. Many studies focus on global implications and make large generalizations about global warming. These large-scale generalizations make it difficult for people to relate to global warming or see how it is going to affect their lives (Duerden 2004, Wilbanks and Kates 1999). Stern (1992) states that environmental concern is a function of "egoism." In other words, people care about global warming only to the extent that it may affect themselves and their families.

A second topic addressing personal relevance is the lack of an image or personal experience of global warming. Even though the images that people do have of global warming are usually negative (Lorenzoni and Pidgeon 2006, Leiserowitz 2006), the majority of people lack a vivid, concrete, and personally relevant image of global warming (Leiserowitz 2006). Research has shown that personal images of an event help people sort out problems, assess the potential risks, and then make decisions (e.g., Riebsame 1986). In order to create vivid images and have a response, people need to have personal experience with the situation (Weber 2006). The lack of personal experience to create a relevant image of global warming could be a reason for the lack of response.

Finally, global warming is not seen as a bad thing in all areas. People in areas where global warming could potentially improve the climate (e.g., warmer temperatures in The Netherlands), were found to be less worried about global warming than people in other areas. For example, only 21% of the respondents in The Netherlands, where the idea of warmer weather is pleasant (even with the risk of sea-level rise), were worried about global warming compared to 63% in Greece (Lorenzoni and Pidgeon 2006).

If people do not perceive global warming as being a personal risk, they are less likely to take steps to address the problem (O'Connor et al. 1999. Kahan et al. 2012). Scale issues, the lack of personal experience, and the idea that global warming could be a good thing all lead to the lack of personal relevance.

Part of this study will seek to find out how people in the Denver metropolitan area visualize climate change and, when asked, how they visualize climate change along the Colorado Front Range. In the Yale Project on Climate Communication's "Climate

Change in the Coloradan Mind" report issued in July 2013, most Coloradans reported belief in global warming (70%) and about half (48%) believed global warming is caused by human activity (Leiserowitz et al. 2013b). Additionally, Coloradans reported concerns about drought and decreased snowpack (70%) and increase in wildfires (66%) (Leiserowitz et al. 2013b). This study sought to find out how this compares to respondents based exclusively in the Denver metropolitan area. Leiserowitz et al.'s 2013 study was a statewide phone survey of 800 Colorado adults ages 18 and older, conducted June 19-26, 2013.

4.1.b Political Affiliation

In order for actions to happen, people need to make decisions and then act upon these decisions. Politically, the main way for this to happen is by voting. Leiserowitz (2006) found that white, politically conservative males who were also registered voters believed that global warming is a small risk compared to other demographic groups. The registered voters group as a whole was all less likely to believe global warming is a serious risk than other demographic groups (Leiserowitz 2006). Since voting is the way that political decisions are made, it would make sense that action to mitigate global warming would not be important ballot measures to registered voters. If the people who are voting do not think global warming is an important issue or that humans have an impact on global warming, actions are less likely to occur. This study also sought to find out how political affiliation influences beliefs about global warming and human impact on global warming in the Denver metropolitan area.

4.1.c Misunderstandings and Uncertainties

Due to all the possible variables, the huge quantity of data, and the chaotic nature of weather, global warming is a confusing topic, even to people working exclusively on the topic. Misunderstandings about global warming are very prevalent in public knowledge (Harrison 1982, Kempton et al. 1996, Duerden 2004, Lorenzoni and Pidgeon 2006). Studies have shown that people do not understand what climate change is, what causes it, or how to alleviate the problem (Kempton et al. 1996, Lorenzoni and Pidgeon 2006). People are also uncertain about how global warming could impact human activity, particularly on a local scale (Duerden 2004).

Most of the public gets information about global warming from the media, including television, newspaper, radio (Harrison 1982), and even blockbuster movies and best-selling novels. There is so much scientific information about global warming available, that a layperson could not possibly digest all of it. However, the media needs to make money, so they will often sensationalize stories about global warming. Rather than sharing more objective findings, the media will share more spectacular results in the newspaper or on the evening news (Harrison 1982).

Uncertainty and misunderstandings about global warming could lead to a lack of action. If people are not sure what the actual problem is, it is hard to make a decision and to justify the costs of that decision. How do people in the Denver metropolitan area understand local impacts of global warming? And, what influences these perceptions?

4.2 Objectives

The purpose of this chapter is to investigate what social, demographic, and environmental factors may influence the general population's answers about global and local climate change. The four main objectives of this section phrased as questions are:

1. What are the beliefs of the general population of the Denver Metropolitan area about climate change?
2. What does the general population believe about climate change on local versus global scales?
3. Do social or demographic factors influence these beliefs?
4. How do ambient meteorological conditions at the time of interviews influence beliefs about climate change, both globally and locally?

4.3 Methods

Methods in addition to those described in chapter one are described below. For this part of the research, respondents in both the 2006 online survey and the 2010-2011 in-person interviews were asked about their beliefs in climate change and human impact on climate change. Additionally, respondents were asked if climate change is happening on a local scale and what might happen in the future. Finally, participants in the 2010-2011 in-person interviews were asked to draw or describe climate change and also climate change locally.

4.4 Results

The results will be discussed for each of the four objectives.

4.1.a. Objective 1

Objective 1: What are the beliefs of the general population of the Denver Metropolitan area about climate change?

In order to address general beliefs about climate change in the Denver Metropolitan area, both the 2006 online survey and the 2010-2011 in-person interviews included questions about climate change and human impact on climate change. For the 2006 survey, respondents were asked, "Global warming is defined by *The American Heritage Dictionary of the English Language* (2006) as, 'An increase in the average temperature of the earth's atmosphere, especially a sustained increase sufficient to cause climatic change.' Do you think global warming is happening? Yes or No." For this question, 88.54% of respondents said "Yes" (n = 309) and 11.46% said "No" (n = 40). When asked a similar question in the 2010-2011 in-person interviews, "Do you think global warming is occurring? Yes or No", 82% of respondents said "Yes" (n = 36) and 18% said "No" (n = 8) (figure 4.1).

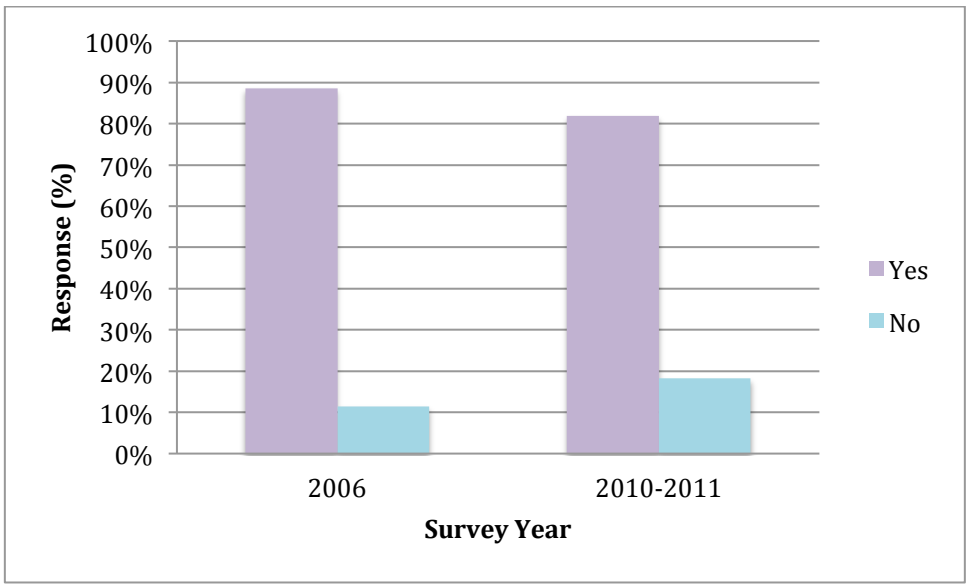

Figure 4.1. Responses about belief in global warming. For 2006 (*n* = 349), 88.54% of respondents said answered that global warming is occurring and for 2010-2011 (*n* = 44), 82% of respondents answered that global warming is occurring.

The next question on both the 2006 online survey and the 2010-2011 in-person interviews asked whether or not the respondents thought humans have an impact on global warming. For the 2006 online survey, it was broken down into degrees of impact (no, minor, moderate, or significant impact), whereas for the 2010-2011 in-person interviews, it was a yes or no question. For the 2006 online survey, 6.90% of the respondents said "No Impact" (*n* = 24), 9.77% said "Minor Impact" (*n* = 34), 19.54% said "Moderate Impact" (*n* = 68), and 63.79% said "Significant Impact" (*n* = 222) (figure 4.2)

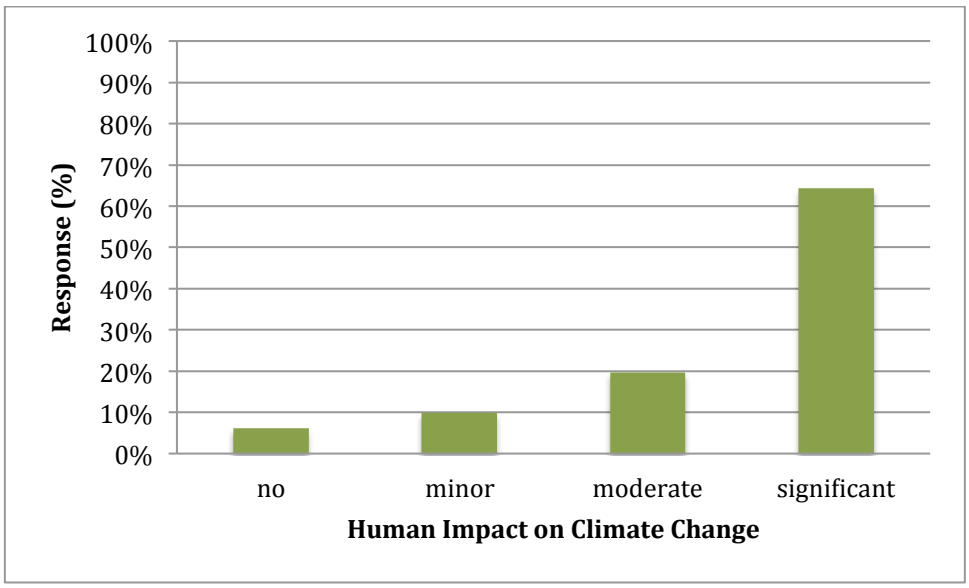

Figure 4.2 Graph showing answer to the question, "Do you think that humans have an impact on global climate change?" from the 2006 online survey (*n* = 348).

When broken down into impact versus no impact, 7% said "No" (*n* = 24) and 93% said "Yes" (*n* = 324) for the 2006 online survey. In the 2010-2011 in-person interviews, 82% of respondents said humans have an impact (*n* = 36) and 18% said humans do not have an impact on global warming (*n* = 8) (figure 4.3).

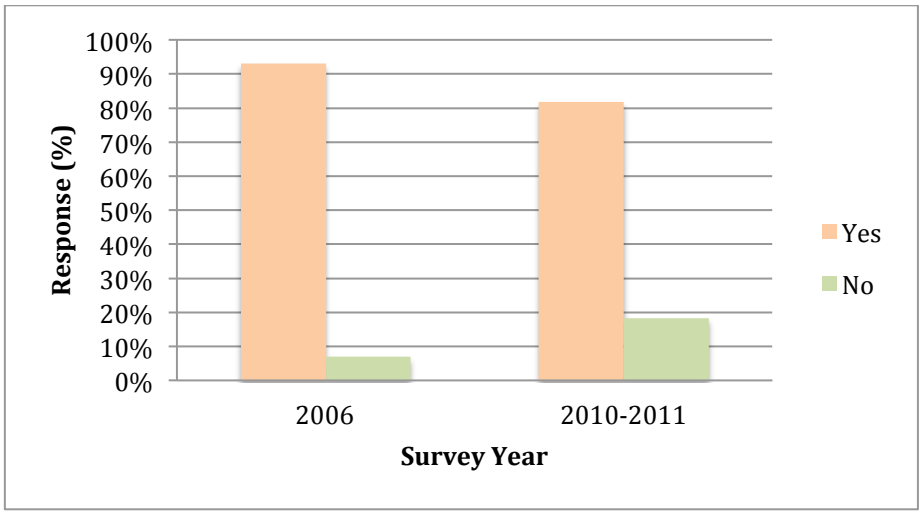

Figure 4.3. Responses about human impact on global warming. In 2006 (*n* = 348), 93.10% said humans have an impact; in 2010-2011 (*n* = 44), 82% said humans have an impact.

The last question about general beliefs about climate change in the 2010-2011 in-person interviews asked respondents to "Describe (or draw) the first image that comes to mind when thinking about global warming." In total, 21 of the respondents drew an image about climate change (see Appendix D for all images). These images, could be broken into five themes chosen by the researcher: sea level rise or melting ice (33% of the images) (figure 4.4), heating of the globe (24%) (figure 4.5), pollution or greenhouse gases (24%) (figure 4.6), Polar Bears (14%) (figure 4.7), and other (5%).

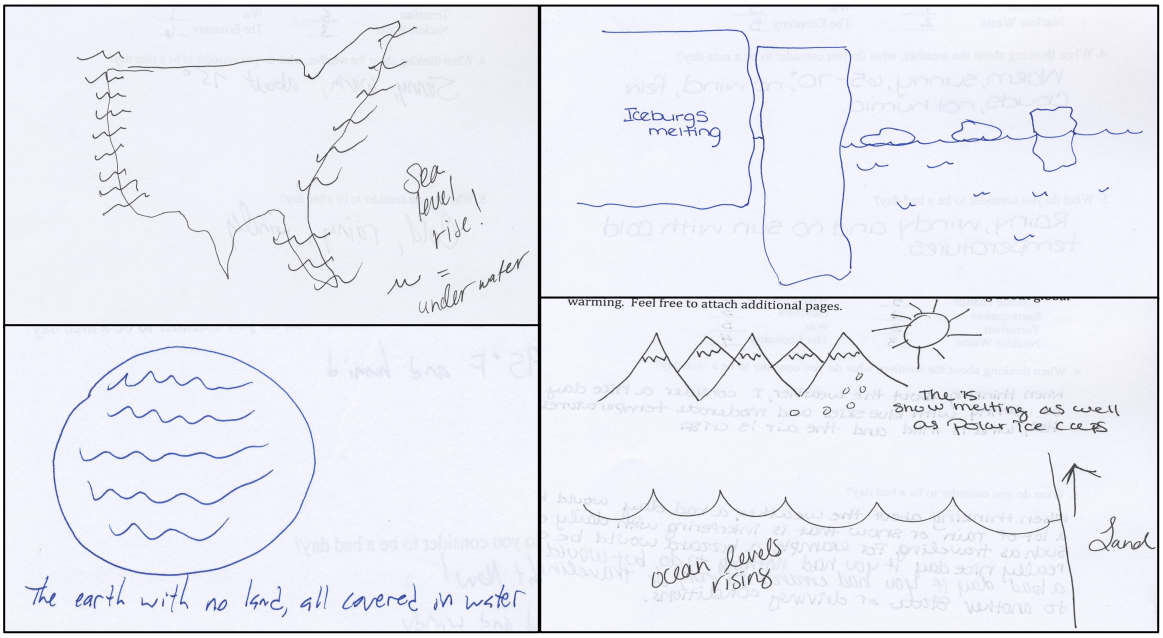

Figure 4.4. A sampling of images from the 2010-2011 in-person interviews representing "Sea Level Rise or Melting Ice"

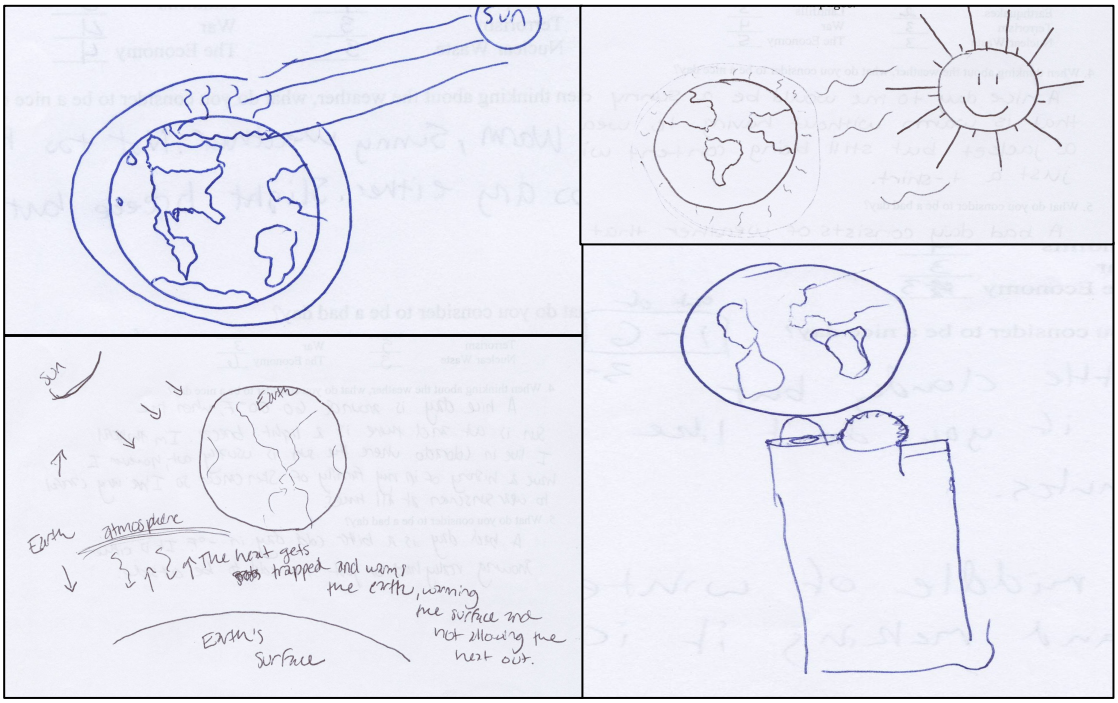

Figure 4.5. A sampling of images from the 2010-2011 in-person interviews representing "Heating of the Globe"

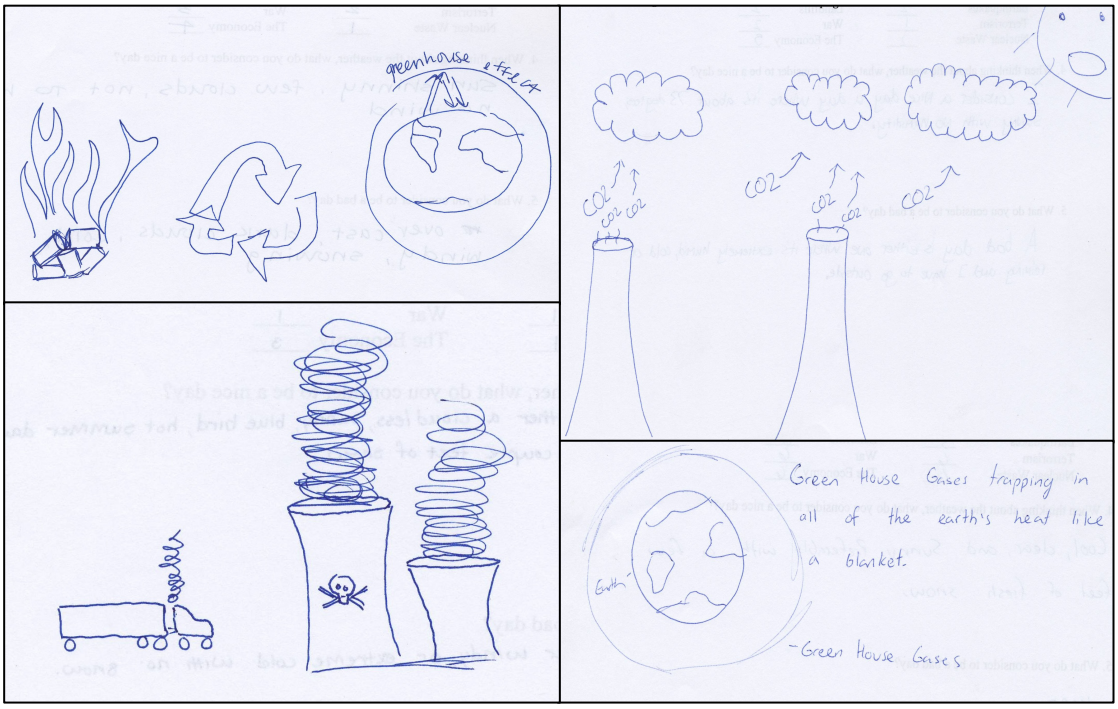

Figure 4.6. Images from the 2010-2011 in-person interviews representing "Pollution or Greenhouse Gases"

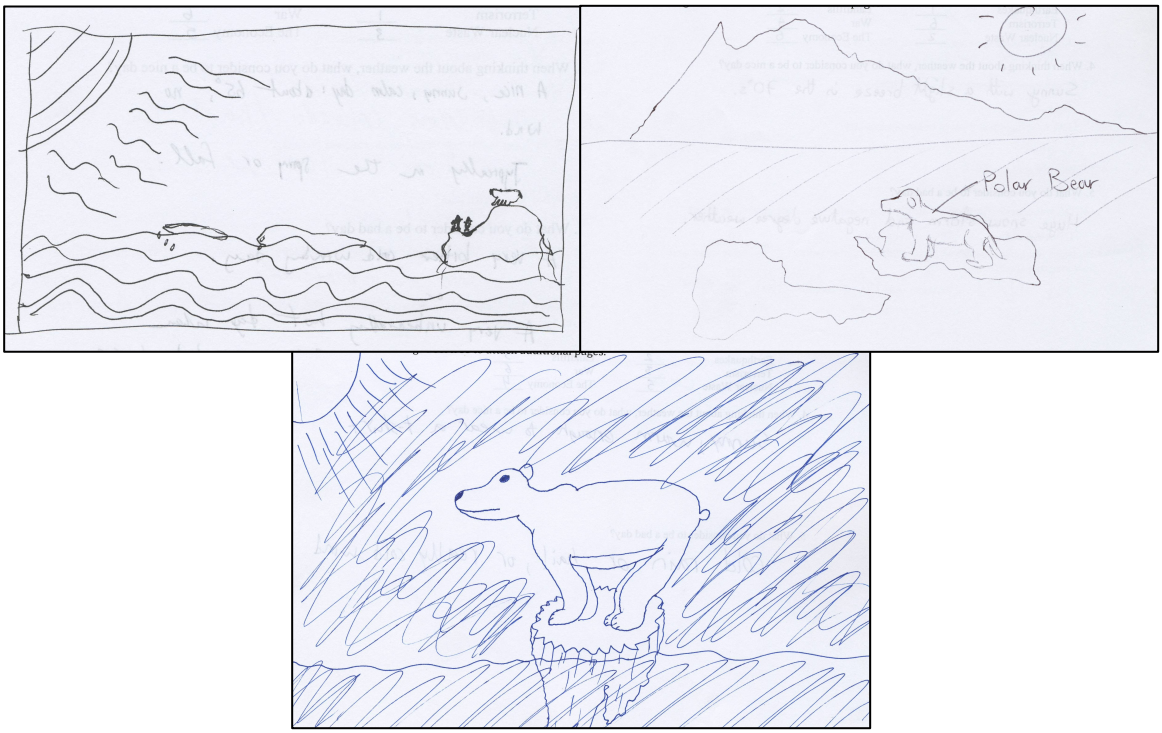

Figure 4.7. Images from the 2010-2011 in-person interviews representing "Polar Bears"

None of the responses about general climate change had a positive feel to them and all of them were either distantly located (e.g., polar bears) or world-wide (e.g., sea level rise).

For people who preferred to write their answers, word clouds were created using www.wordle.net. After copying and pasting the text describing climate change in the Worlde web site, a program runs to sort words by popularity. Word size changes according to frequency (the bigger the word, the more frequently it appears). Common words in the English language like "the", "a", "of", etc. are not included in the word cloud (figure 4.8). Any response of "I don't know" was changed to "unsure" and responses for people who did not think climate change is happening were changed to "n/a". One-word responses were chosen because Wordle does not make word clouds for phrases. In the word cloud, the words that appear the most often are melting, hot, polar

bears, and words about ice. These are similar to the categories of drawings for the same question.

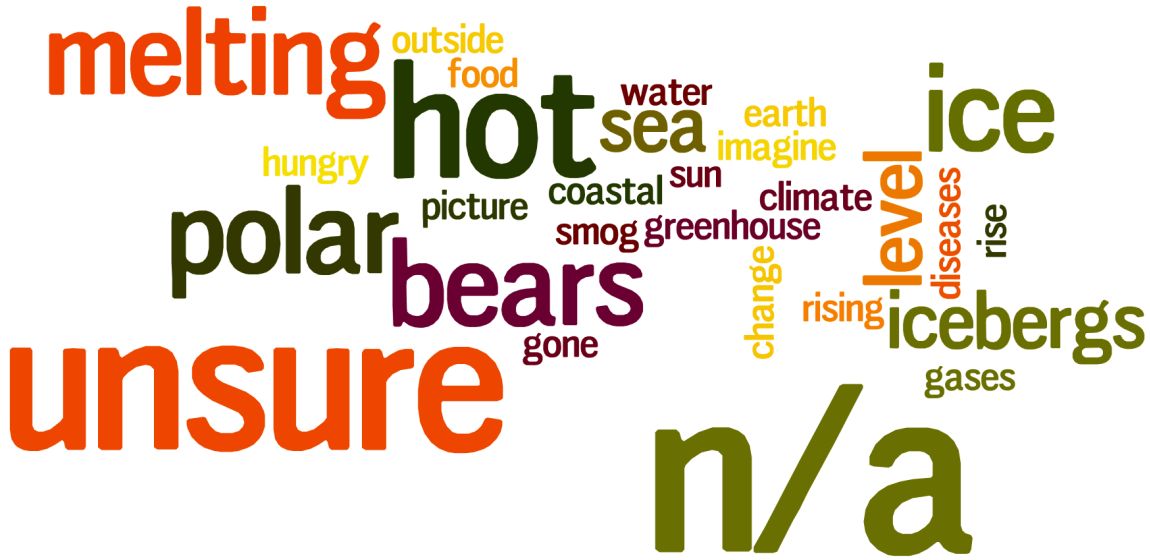

Figure 4.8. A word cloud of written responses for the question "Describe (or draw) the first image that comes to mind when thinking about global warming." Any expression of uncertainty or "I don't know" was changed to "unsure." Any disbelief of climate change was changed to "n/a".

4.1.b. Objective 2

Objective 2: What does the general population believe about climate change on local versus global scales?

To address local climate change, questions about climate change in Denver or Colorado were asked on both the 2006 online survey as well as the 2010-2011 in-person interviews. For the 2006 online survey, two questions directly addressed local climate change. One question asked, "In general, do you think the temperature in the Denver

Metropolitan area is getting a) A lot warmer, b) A little warmer, c) Staying about the same, d) A little colder, or e) A lot colder." One person (0.29%) answered that temperatures are getting "a little colder" and 16.91% of respondents (*n* = 58) answered that the temperatures are "staying the same." 82.80% (*n* = 284) answered that temperatures are getting warmer, with 68% (*n* = 232) saying "a little warmer" and 15.16% (*n* = 52) saying "a lot warmer" (figure 4.9).

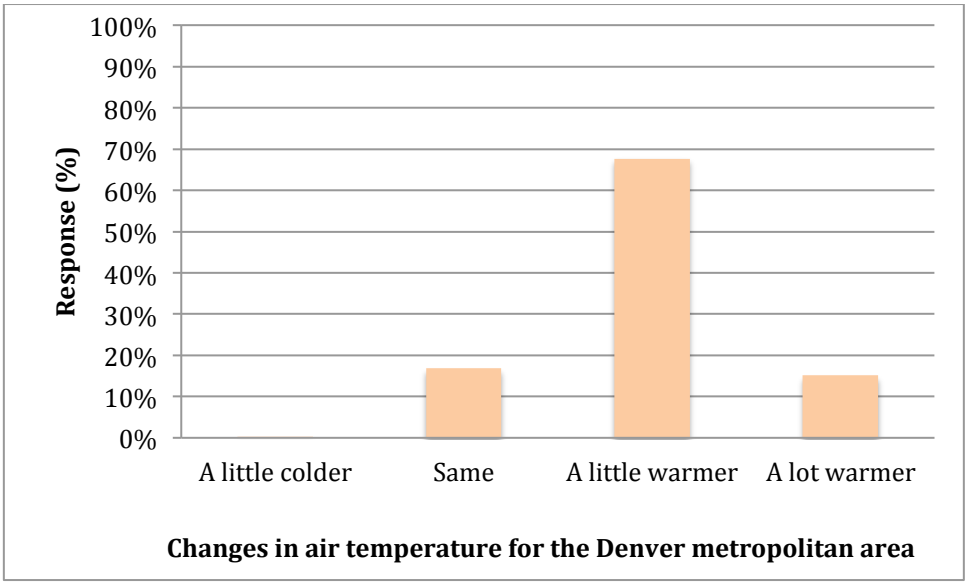

Figure 4.9. Responses to the 2006 online survey question asking about changes in the air temperature for the Denver metropolitan area. 82.80% (*n* = 284) responded that temperatures are getting warmer.

The next question on the 2006 online survey addressing local climate changed asked, "Would you say winters in the Denver metropolitan area are starting a) A lot earlier, b) A little earlier, c) At about the same time, d) A little later, or e) A lot later?" This question was intended to be a proxy for seeing if respondents believe that climate change is impacting Denver. For this question, 3.24% of respondents (*n* = 11) said that winters in Denver are starting a little earlier, 51.33% of respondents (*n* = 174) said that

winters are starting at about the same time, 39.82% (*n* = 135) said that winters are starting a little later, and 5.60% (*n* = 19) said that winters are starting a lot later (figure 4.10).

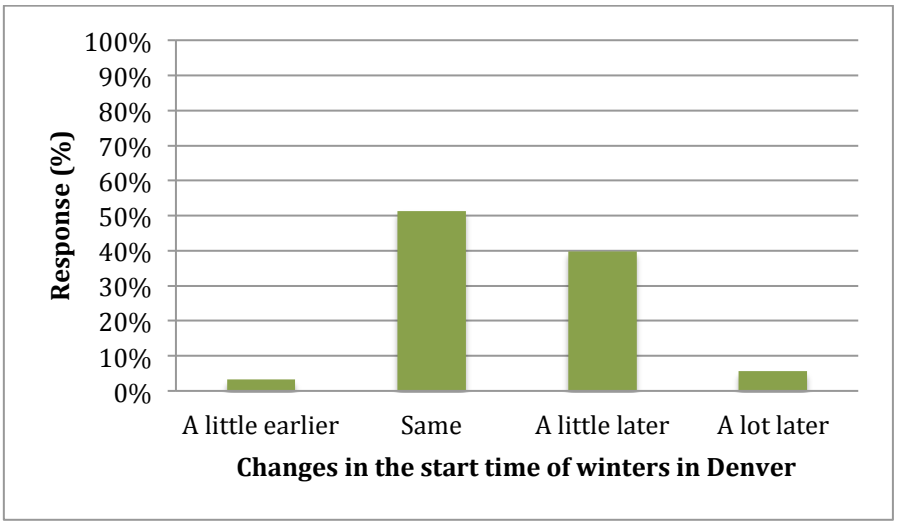

Figure 4.10. Responses from the 2006 online survey about how the start time of winters in Denver are changing over time.

One question in the 2010-2011 in-person interviews specifically addressed local climate change. Respondents were asked to "Describe (or draw) the first image that comes to mind when thinking about global warming along the Colorado Front Range." In total, 15 people drew pictures and these could be grouped into five themes chosen by the research: outdoor fun, which represented 33% (*n* = 5) of the responses (figure 4.11); drought, which represented 27% of the responses (*n* = 4) (figure 4.12); pollution, which represented 20% (*n* = 3) of the responses (figure 4.13); fire, which represented 13% (*n* = 2) of the responses (figure 4.14); and sea level rise, which represented 7% (*n* = 1) of the responses (figure 4.15).

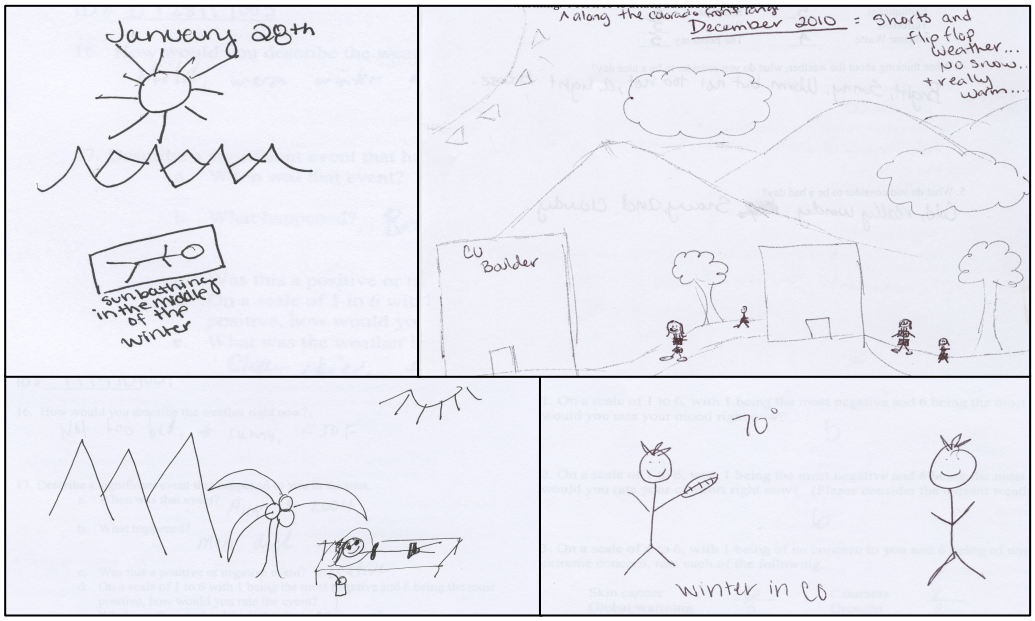

Figure 4.11 Images representing "Outdoor Fun" responses for the 2010-2011 in-person interview question about climate change along the Colorado Front Range

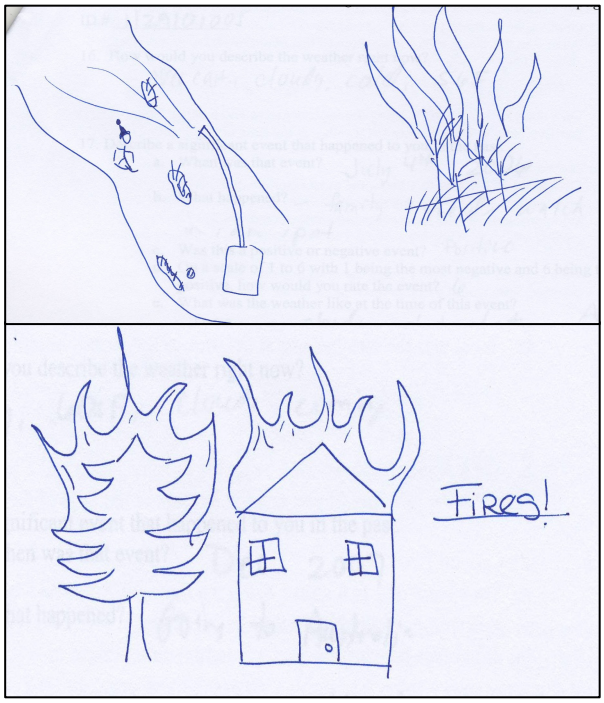

Figure 4.12 Images representing "Fire" responses for the 2010-2011 in-person interview question about climate change along the Colorado Front Range

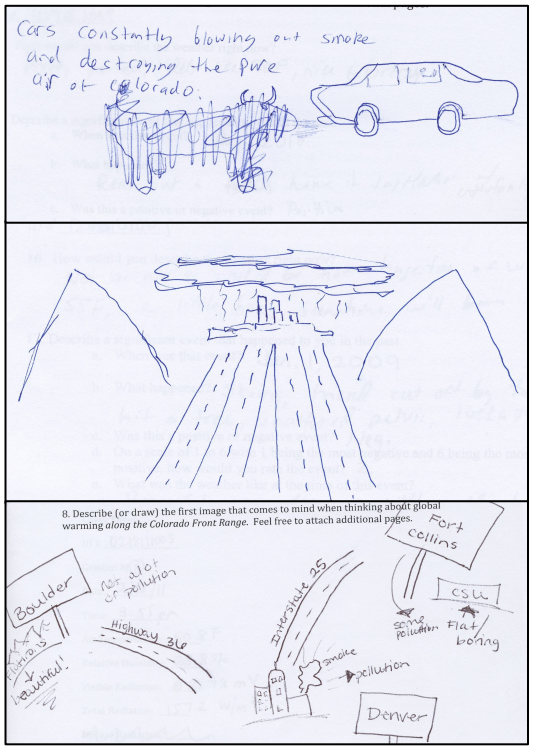

Figure 4.13 Images representing "Pollution" responses for the 2010-2011 in-person interview question about climate change along the Colorado Front Range

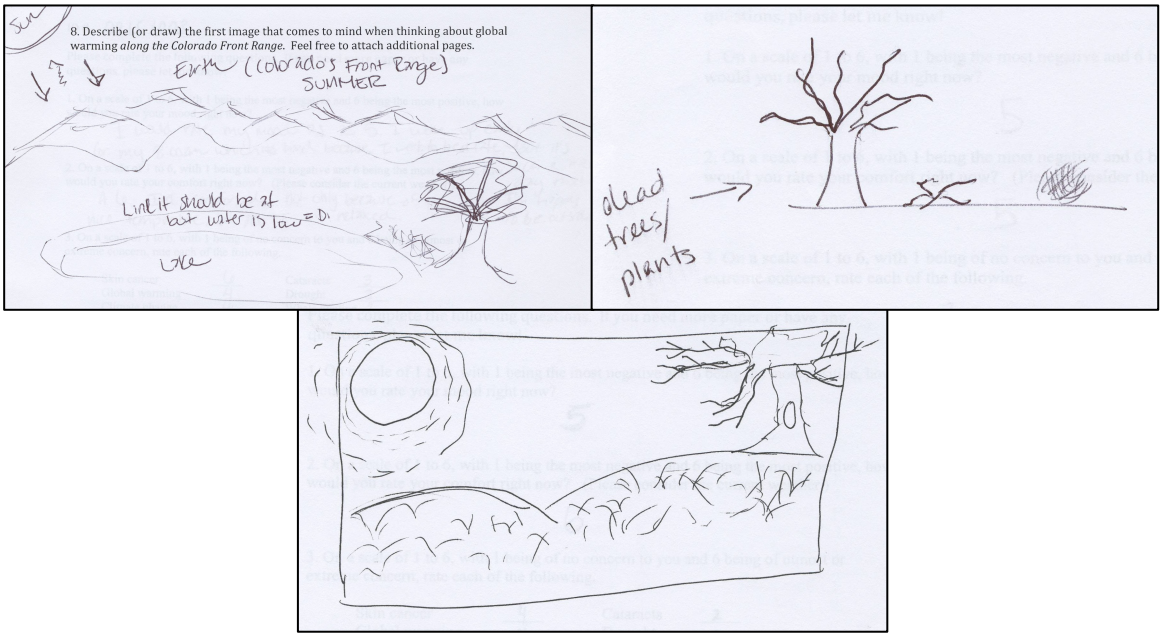

Figure 4.14 Images representing "Drought" responses for the 2010-2011 in-person interview question about climate change along the Colorado Front Range

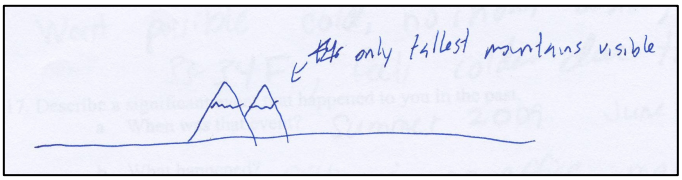

Figure 4.15 Image representing "Sea Level Rise" response for the 2010-2011 in-person interview question about climate change along the Colorado Front Range

Of all the drawings, five (33%) had a positive feel (e.g., people sunbathing in winter or playing outdoors). 39% of the respondents (n = 17) were not able to think of anything to draw or write when thinking about local climate change, as compared to 11% of the respondents (n = 5) when asked about global warming in general. For people who preferred to write their answers, a word cloud was created of their responses (figure 4.16). The most common response was "unsure," however people also wrote about heat and droughts, which agree with the drawings for the same question.

Figure 4.16 A word cloud of written responses for the 2010-2011 in-person interview question "Describe (or draw) the first image that comes to mind when thinking about global warming along the Colorado Front Range." Any expression of uncertainty or "I don't know" was changed to "unsure." Any disbelief of climate change was changed to "n/a".

4.1.c. Objective 3

Objective 3: Do social or demographic factors influence these beliefs about global climate change or local climate change?

In order to see if social or demographic factors influence beliefs about global climate change or local climate change, several variables were analyzed (table 4.1). For the 2006 online survey, responses about gender, education level, a previous weather or climate class, time spent outdoors, and whether or not the respondent had a weather or climate related profession were compared to answers about whether or not climate change is happening and then also whether humans have an impact on climate change. First, chi-squared and p-values were calculated for social or demographic effects on beliefs about global climate change. It was found that the variable with the highest likelihood of a possible relationship was whether or not the respondent had a prior class in weather or climate. For this, people with a previous weather or climate class were slightly more likely to say that climate change is happening. Next was education level; as education level increased, respondents were more likely to say that global warming is happening.

Table 4.1 Chi-squared, degrees of freedom, and *p*-values for social and demographic responses about global warming from the 2006 online survey.

Category	Respondents Answering "Yes"	χ^2 value	df	*p*-value
Weather/Climate Class	Yes (n=145): 93.10% No (n=205): 84.88%	0.386	1	0.534
Education Level	High School/Assoc (n=51): 80.39% Bachelors (n=106): 86.79% Graduate (n=188): 92.02%	0.921	2	0.631
Gender	Female (n=201): 90.55% Male (n=147): 85.71%	0.136	1	0.702
Time Spent Outside	<2 hours (n=145): 90.34% 2 to 6 hours (n=193): 87.56% >6 hours (n=11): 81.82%	0.558	2	0.757
Weather/Climate Related Profession	Yes (n=115): 86.09% No (n=233): 89.70%	0.085	1	0.771

Next, responses to whether or not there is a human impact on global warming and social and demographic variables were compared. For these, no variable was statistically significant (table 4.2).

Table 4.2 Chi-squared, degrees of freedom, and *p*-values for social and demographic responses about human impact on global warming.

Category	Respondents Answering "Yes"	χ^2 value	df	*p* -value
Weather/Climate Class	Yes (n=145): 96.56% No (n=205): 92.29%	0.136	1	0.712
Gender	Female (n=201): 95.52% Male (n=147): 91.84%	0.080	1	0.777
Weather/Climate Related Profession	Yes (n=115): 95.65% No (n=233): 93.13%	0.070	1	0.791
Education Level	High School/Assoc (n=51): 88.24% Bachelors (n=106): 93.40% Graduate (n=188): 95.74%	0.330	2	0.848
Time Spent Outside	<2 hours (n=145): 93.10% 2 to 6 hours (n=193): 94.82% >6 hours (n=11): 90.91%	0.083	2	0.959

Two additional questions on the 2006 online survey addressed local climate change, which could then be compared to social and demographic responses. The first questions asked, "In general, do you think the temperature in the Denver metropolitan area is getting a) a lot warmer, b) a little warmer, c) staying about the same, d) a little colder, or e) a lot colder." When analyzing the results from this question to answering whether temperatures are getting warmer, it was found that the factor with a possible relationship was gender; more females than males answered that temperatures are getting warmer (table 4.3).

Table 4.3 Chi-squared, degrees of freedom, and *p*-values for social and demographic relationships to answering that temperatures in Denver are generally getting warmer.

Category	Respondents Answering "Warmer"	χ^2 value	df	*p*-value
Gender	Female (n=201): 84.58% Male (n=147): 78.774%	0.256	1	0.613
Time Spent Outside	<2 hours (n=145): 81.38% 2 to 6 hours (n=193): 80.83% >6 hours (n=11): 90.91%	0.826	2	0.662
Weather/Climate Class	Yes (n=145): 83.45% No (n=205): 79.51%	0.161	1	0.678
Weather/Climate Related Profession	Yes (n=115): 82.61% No (n=233): 80.69%	0.077	1	0.781
Education Level	High School/Assoc (n=51):82.35% Bachelors (n=106): 84.91% Graduate (n=188): 79.79%	0.181	2	0.914

The second local climate question on the 2006 online survey asked about the start of winter in Denver. The question stated, "Would you say winters in the Denver metropolitan area are starting a) a lot earlier, b) a little earlier, c) at about the same time, d) a little later, or e) a lot later." Social and demographic information was then compared for respondents who answered that winters are starting later in the Denver metropolitan area. A significant factor for saying that winters are starting later was time spent

outdoors. Those who spend more than six hours outside per day answered that winters are starting later 63.65% of the time. This compared to 44.88% of all respondents and led to a significance level of 98.90% (table 4.4).

Table 4.4 Chi-squared, degrees of freedom, and *p*-values for social and demographic relationships to answering that winters in the Denver metropolitan area are starting later.

Category	Respondents Answering "Later"	χ^2 value	df	*p*-value
Time Spent Outside	<2 hours (n=145): 48.97% 2 to 6 hours (n=193): 38.86% >6 hours (n=11): 63.64%	9.018	2	0.011
Education Level	High School/Assoc (n=51): 45.10% Bachelors (n=106): 50.94% Graduate (n=188): 39.36%	1.499	2	0.473
Weather/Climate Class	Yes (n=145): 43.45% No (n=205): 41.46%	0.306	1	0.580
Gender	Female (n=201): 45.58% Male (n=147): 42.29%	0.160	1	0.689
Weather/Climate Related Profession	Yes (n=115): 42.61% No (n=233): 44.64%	0.116	1	0.733

From the 2010-2011 interviews, questions asked about gender, major, political affiliation, and prior weather or climate class. This information was then compared to answers about general beliefs about global warming and human impacts on global warming. For both general beliefs about global warming and beliefs about human impact on global warming, political affiliation was statistically significant. Those identifying as politically conservative, responded "yes" to belief in global warming and belief that humans impact global warming only 36% of the time. Those identifying as politically moderate responded "yes" to belief in global warming and belief that humans impact global warming 93.75% of the time (note: respondents did not necessarily answer the same way for both questions). Those identifying as politically liberal responded, "yes"

100% of the time. For belief about global warming, undergraduate major was not statistically significant, but a possible relationship existed. 94% of science majors responded "yes" to belief in global warming versus 74% of non-science majors responding yes (table 4.5).

Table 4.5 Chi-squared, degrees of freedom, and *p*-values for social and demographic responses as compared to responding "yes" that global warming is happening.

Category	**Responded "Yes"**	**χ^2 value**	**df**	***p*-value**
Political Affiliation	Conservative (n=11): 36.36% Moderate (n=16): 93.75% Liberal (n=17): 100%	31.033	2	0.000
Major	Science (n=17): 94.12% Non-Science (n=27): 74.07%	2.582	1	0.108
Gender	Female (n=20): 85.00% Male (n=24): 79.17%	0.210	1	0.647
Weather/Climate Class	Yes (n=19): 78.95% No (n=25): 84.00%	0.159	1	0.690

As already stated above, political affiliation had a strong relationship to answering, "yes" about beliefs that human are affecting global warming. Additionally, whether or not students had a prior class in weather or climate and gender also showed a relationship. It should be noted that for a prior class, 92% of respondents with no prior class answered, "yes" about belief in human impacts on global warming whereas 68% of respondents with a prior class answered, "yes" about belief in human impacts on global warming, which is opposite of what was expected. Although it was only counted as one response, one respondent indicated having three prior classes in weather or climate and answered "no" about belief in human impact on global warming (table 4.6).

Table 4.6 Chi-squared, degrees of freedom, and *p*-values for social and demographic responses as compared to responding "yes" that humans have an impact on global warming for the 2010-2011 in-person interviews.

Category	Responded "Yes"	χ^2 value	df	*p*-value
Political Affiliation	Conservative (n=11): 36.36% Moderate (n=16): 93.75% Liberal (n=17): 100.00%	31.033	2	0.000
Weather/Climate Class	Yes (n=19): 68.42% No (n=25): 92.00%	3.461	1	0.063
Gender	Female (n=20): 75.00% Male (n=24): 87.50%	0.963	1	0.326
Major	Science (n=17):82.35% Non-Science (n=27): 81.48%	0.005	1	0.944

"I don't know" responses to how climate change will impact the Colorado Front Range and those who answered in the "outdoor fun" theme for the 2010-2011 in-person interviews were analyzed in more detail. Social and demographic factors for those who responded, "I don't know" to how climate change will affect the Colorado Front Range were analyzed. In total, 34% (n = 15) of respondents said they were unsure about how climate change would affect the Colorado Front Range. Of these 15 respondents, one did not belief that global warming is happening and one (different from the previous respondent) said that humans do not have an impact on global warming. 11 of the 15 (73%) were male, 60% were non-science majors, 1 was conservative, 7 were moderate, and 7 were liberal. Four of the respondents had a prior class in weather or climate.

Next, those answered in the "outdoor fun" theme for describing local climate change were analyzed. These respondents drew pictures of or described beach scenes or being outside in shorts in the winter. In total, 16% of the respondents (n = 7) drew or described an "outdoor fun" future. Of these, five were female and two were male; all believed in global warming and one did not believe that humans have an impact on global

warming; two were science majors; four were liberal, three conservative, zero moderate; and five had a prior class in weather or climate.

4.1.c. Objective 4

Objective 4: How do ambient meteorological conditions at the time of interviews influence beliefs about climate change, both globally and locally?

Meteorological conditions were collected during the 2010-2011 in-person interviews, which took place from October 5, 2010 until February 18, 2011. Meteorological variables recorded at the time of the interviews were air temperature, relative humidity, visible radiation, and total radiation (table 4.7).

Table 4.7 Meteorological conditions during the 2010-2011 in-person interviews. Variables were air temperature, relative humidity, visible radiation, and total radiation. Table displays the minimum and maximum values recorded as well as the mean and the median.

Variable	Minimum	Maximum	Mean	Median
Air Temperature	-1.89°C	22.72°C	7.69°C	6.89°C
Relative Humidity	17.90%	88.30%	38.03%	35%
Visible Radiation	0.3 klux	109.8 klux	28.1 klux	12.4 klux
Total Radiation	0 W/m2	669.9 W/m2	204.8 W/m2	149.6 W/m2

For these data, higher incoming solar radiation values and visible radiation were significantly related to people responding that climate change is happening (table 4.8). None of the meteorological variables were significant for responses about human impact on climate change (table 4.9).

Table 4.8 Chi-squared, degrees of freedom, and *p*-values for comparing meteorological conditions to answers about belief in global warming for the 2010-2011 in-person interviews.

Category	Responses about Climate Change	χ^2 value	df	*p*-value
Total Incoming Solar Radiation	Yes (n=36): 219.24 W/m2 No (n=8): 139.6 W/m2	21.775	1	0.000
Visible Radiation	Yes (n=36): 30.69 klux No (n=8): 16.4 klux	5.110	1	0.024
Air Temperature	Yes (n=36): 8.14°C No (n=8): 5.69°C	0.546	1	0.460
Relative Humidity	Yes (n=36): 37.93% No (n=8): 38.45%	0.005	1	0.944

Table 4.9 Chi-squared, degrees of freedom, and *p*-values for comparing meteorological conditions to answers about belief in human impact on global warming.

Category	Responses about Human Impact	χ^2 value	df	*p*-value
Total Incoming Solar Radiation	Yes (n=36): 203.68 W/m2 No (n=8): 209.63 W/m2	0.120	1	0.729
Visible Radiation	Yes (n=36): 28.97 klux No (n=8): 24.15 klux	0.582	1	0.446
Air Temperature	Yes (n=36): 7.62˚C No (n=8): 8.02˚C	0.015	1	0.903
Relative Humidity	Yes (n=36): 39.33% No (n=8): 32.16%	0.950	1	0.330

4.5. Discussion

How do people in the Denver metropolitan area perceive climate change and human impact on climate change? And, what influences these perceptions? From the 2006 online survey and the 2010-2011 in-person interviews, over 80% of the respondents believe that global warming is occurring and that humans have an impact on global warming. These are higher percentages than what Leiserowitz et al. found in their 2013 study about Coloradans' perspectives on climate change (global warming = 70%, human

impact = 48%). This may be due to the fact that the Denver metropolitan area is more politically liberal than many other areas in Colorado, particularly in the eastern plains (figure 4.17). When asked to think about global warming in the 2010-2011 in-person interviews, respondents described or drew global-scale or distant issues (e.g., polar bears on melting ice, sea-level rise around the world). This is interesting since people in the Denver metropolitan area (particularly in Boulder) are voting positively on measures to address climate change even though *local* climate change is not the first thing that comes to mind when thinking about climate change.

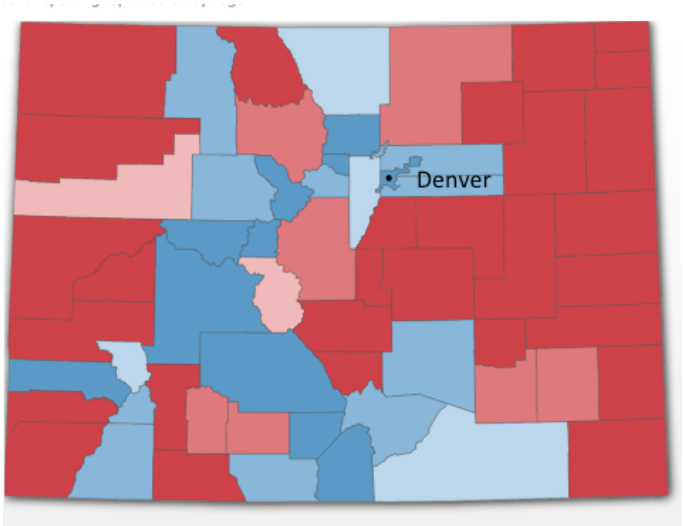

Figure 4.22 Colorado election results for president for the 2012 Presidential Election. Red counties voted for Romney, blue counties voted for Obama. The darker the shade, the higher percentage of the county voted for Romney (red) or Obama (blue). The black dot marks Denver County. Figure adapted from The Denver Post (2013).

When asked about local climate change, again over 80% of the respondents believed that global warming is impacting Colorado and the Denver metropolitan area. From the 2006 online survey, over 80% believe that air temperature in the Denver

metropolitan area is getting higher, including 15% that believe it is getting a lot higher. From the 2010-2011 in-person interviews, not all the respondents viewed global warming as a bad thing. Of those who drew pictures, a third drew pictures of happy people sunbathing or participating in outdoor recreational activities, several with palm trees in the picture. A majority did describe more daunting scenarios and either described or drew drought, lack of snowpack, and fires, which matched Leiserowitz et al.'s (2013b) findings about Coloradans' beliefs about climate change. This ability to visualize climate change on a local scale, even if not always negative, could be one of the reasons voters in the Denver metropolitan area are acting to mitigate global warming.

When examining social and demographic factors influencing perceptions of global warming, the only clearly significant factor for both beliefs about climate change and human impact on climate change was political affiliation. Those identifying themselves as politically conservative were significantly less likely to believe that global warming is happening or that humans have an impact on global warming, which agreed with a study by Hamilton and Stampone (2013). From the 2010-2011 in-person interviews, it was found that science majors were more likely to believe in global warming and those with a prior weather and climate class were actually less likely to believe that humans have an impact on global warming. This would be an interesting future study; is a little bit of knowledge dangerous? In an avalanche study by McCammon (2000), it was found that over half of avalanche victims were people who had some basic knowledge about avalanches. This number decreased to 14% for those who had advanced training. Is there a parallel for understanding of global warming and human impact on global warming? Another study by Kahan et al. (2012) found that

those with the most knowledge about climate change were also among the most apathetic about climate change.

Finally, people were more likely to respond that climate change is happening when the incoming solar radiation and the visible radiation were higher. While air temperature was not found to be significant, this could support the Hamilton and Stampone (2013) study, which found that anomalously high air temperatures correlated with higher probabilities in response that climate change is happening and is caused by humans.

This chapter produced many possible topics for future research. For one, it would be interesting to see how respondents in a more politically conservative area visualized local climate change. Boulder, Colorado's Climate Action Plan (https://bouldercolorado.gov/climate) is one of the leading programs in the United States for reducing greenhouse gas emissions and addressing anthropogenic impacts on global warming. Citizens in Boulder are localizing climate change and acting upon it (e.g., voting to create a local utility company using more renewable energy than the Xcel Energy (Jaffe 2013)). However, many other areas in the state and the country do not have similar programs in place.

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CHAPTER 5

Conclusions

Understanding the relationship between human cognition and understanding of our environment is a necessary, yet difficult task. There is a need for this understanding to potentially fill in spatial and temporal gaps in the climate record with human recollections. Additionally, the ways people understand weather and climate might determine how they vote and make decisions about climate change adaptation and mitigation. The conclusions for this research will be discussed by each of the four main objectives and then possible future research topics will be discussed.

5.1 Objective 1

Objective 1: How accurate, as compared to instrument data, does the general population remember past weather and seasons? Do social or demographic factors influence the accuracy of these recollections?

From this research, it was found that people in the Denver metropolitan area do not remember past seasons well. The most accurate recollections were for recent time periods (the accuracy rate was about 39% for both the two years prior summer air temperatures in the 2006 online survey and the previous summer air temperature for the

2010-2011 in-person interviews). However, accuracy was not as high for time periods further back, for precipitation values, or for winter air temperatures.

Respondents in this research remembered recent weather with more accuracy than past climate. Like climate recollections, weather recollections decreased in accuracy with time and the respondents remembered higher air temperatures better than colder air temperatures. Accuracy was as high as 66% for one day prior weather and 58% for high air temperatures. Additionally, if respondents were not accurate with their responses about recent air temperature, they were more likely to claim it was warmer than it actually was.

For general responses about past weather and climate, respondents were more accurate about higher air temperatures than lower air temperatures (both the diurnal highs and lows as well as the annual highs and lows) and accuracy decreased for times further in the past. For climate responses, accuracy was as low as 1% for summer precipitation 20 years prior in the 2006 online survey and 0% for winter air temperatures in the 2010-2011 in-person interviews. For weather responses, accuracy decreased to 36% for one week prior.

The next question is whether or not social or demographic factors influence these recollections about past weather and climate. The answer is yes. Time spent outdoors, a previous weather or climate class, and gender all seem to influence weather and climate recollections. For past seasons, it was found from the 2006 online survey that time spent outdoors led to higher accuracy the longer time was spent outdoors daily. Additionally, females remembered more accurately than males and those with a previous weather or climate class were slightly more accurate than those with no prior class. The 2010-2011

in-person interviews showed significance with political affiliation. Those identifying as liberal were more likely to be accurate than moderates, who were more likely to be accurate than conservatives. Next, those with a science major were more likely to be accurate than those with a non-science major and those self-identifying as being in a good mood were more likely to be accurate than those in a bad mood. Finally, females were slightly more accurate than males and those with a prior weather or climate class were actually slightly less accurate than those without a prior class. However, more weight should be given to the 2006 online survey due to the much greater sample size (n = 441 versus n = 44).

For weather, a previous weather or climate class was significant, with those having a previous weather or climate class being more accurate than those with no prior class and people who spent more time outdoors were more accurate than those who spent less time outdoors.

During the 2010-2011 in-person interviews, participants were also asked about the weather for specific events in their lives. These included two events of their own choosing and two pre-selected events: the September 11, 2001 terrorist attacks and the Fourmile Canyon Fire of September 2010. The respondents were asked to rate each of these events on a scale of 1 to 6, with one being bad and 6 being good, and then rate the weather for each event on a scale of 1 to 6, with one being bad weather and 6 being good weather. Respondents were also asked to describe bad and good weather. The average rating for the two non-specific events was 4.45 and the weather rating was 4.23. There was no significant relationship between the rating of the event and the weather. However, when asked to rate the weather for September 11, 2001, the average was 3.86,

with an event rating of 1.5. The weather for most of the United States, including the Denver metropolitan area, on September 11, 2001 would fit in the description of good weather by most of the respondents. It does seem that there was a negative bias for the weather due to the extreme negativity of the event.

5.2 Objective 2

Objective 2: How do current perceptions of climate change influence recollections of weather and climate?

Perceptions of climate change do influence recollections of climate and possibly influence recollections of weather, according to this research. From the 2006 online survey, those who believe climate change is happening were much more likely to be accurate for past seasons. Additionally, respondents who believe that humans are impacting climate change were more likely to be accurate than those who do not or who believe humans have a minor impact. This was also seen in the 2010-2011 in-person interviews, although not as strongly for the human impact component. Respondents who believe climate change is happening were more likely to be accurate for climate recollections than those who do not.

For recent weather, the relationships were not as clearly defined. From the 2006 online survey, it was found that those who think climate change is happening were slightly more accurate than those who do not. Additionally, those who think humans have a moderate or significant impact on climate change were more accurate than those who believe humans have no impact or a minor impact on climate change.

From this research, it would be essential to know a person's beliefs about climate change when asking about past weather and climate, particularly climate.

5.3 Objective 3

Objective 3: How do ambient meteorological conditions at the time of interviews, such as air temperature and solar radiation, influence the accuracy of recollections of past events and weather associated with these events?

Ambient meteorological conditions were collected during the 2010-2011 in-person interviews. For past climates, the strongest relationship was found between air temperature and accuracy for climate recollections, although it was not significant Relative humidity and total radiation also showed some possible relationships, but neither was as strong a relationship as for air temperature. When divided into above and below the mean value for each of the meteorological conditions measured, there was no significance.

For recent weather, the sample size was small (n = 13). All of the meteorological variables collected were not significant and it made no difference when divided up into above and below the mean values for each meteorological variable. Additionally, when comparing the ambient meteorological conditions to the recollections of past events and the weather associated with those events, no correlations were found..

5.4 Objective 4

Objective 4: How do people in the Denver metropolitan area view climate change and the human impact on climate change? How do people in the Denver metropolitan area believe climate change is impacting or will impact the Colorado Front Range? Do social or demographic factors influence these perceptions?

Beliefs about climate change and human impact on climate change were asked about in both the 2006 online survey and the 2010-2011 in-person interviews. For both, over 80% of the respondents agreed that climate change is occurring. 93% of the respondents in the 2006 online survey believed that humans have an impact on climate change (10% a minor impact, 19% a moderate impact, and 64% a significant impact). In the 2010-2011 in-person interviews, 81% said humans have an impact on climate change.

When asked to draw the first thing that comes to mind when thinking about global warming in the 2010-2011 in-person interviews, the responses could be divided into five themes, chosen by the researcher. These themes were sea level rise or melting ice (33%), heating of the globe (24%), pollution or greenhouse gases (24%), polar bears (14%), or other (5%). None of the responses about climate change had a positive feel to them and all of them were distantly located (e.g., polar bears) or world-wide (e.g., sea level rise).

Participants in the 2010-2011 in-person interviews were also asked to draw the first thing that came to mind when thinking about global warming along the Colorado Front Range. These drawings could subjectively be grouped into five themes: outdoor fun (33%), drought (27%), pollution (20%), fire (13%), and sea level rise (7%). 33% of the drawings had a positive feel (e.g., people sunbathing in the winter or playing

outdoors). 39% of the respondents (n = 17) were not able to think of anything to draw or write when thinking about local climate change, as compared to 11% of the respondents (n = 5) when asked about global warming in general.

Even with the majority of respondents believing that global warming is occurring, several relationships were found between social and demographic factors and beliefs in global warming. It was found in the 2006 online survey that those with a previous weather or climate class were more likely to believe in global warming than those with no prior class in weather or climate, although this was a somewhat weak relationship. When asked about whether humans have an impact on global warming, none of the social or demographic factors were significant.

For the 2010-2011 in-person interviews, both political affiliation and undergraduate major were significant. Those identifying as politically moderate or liberal were significantly more likely to answer that global warming is happening than those identifying as politically conservative. And, those who majoring in a science field were more likely to say global warming is occurring than those majoring in a non-science field. For human impact, relationships were found between political affiliation, a previous weather or climate class, and gender for answering that humans do have an impact on global warming. Those identifying as politically liberal or moderate were much more likely to say that humans have an impact on global warming than those identifying as politically conservative. And, interestingly enough, those with no previous weather or climate class were more likely to say that humans have an impact on global warming than those with a previous weather or climate class. Males were also more likely than females to say that humans have an impact on global warming. Finally, when

the sun was shining and the incoming solar radiation and visible radiation were higher, people were more like to say that climate change is occurring.

This study does not support previous research about people not localizing climate change in the United States. Respondents for both the 2006 online survey and the 2010-2011 in-person interviews do believe that climate change is impacting Colorado and some are able to visualize what this looks like. Additionally, people in these areas are taking action to mitigate and adapt to climate change.

5.5 Future Research

After reviewing the results of this research, even more questions emerge. For example, why are those who have had a class in weather or climate less likely to say that humans have an impact on climate change? Is it the idea that a little knowledge is dangerous? Or was it due to the small sample size? It would also be interesting to repeat this study in areas with populations with long oral histories to see how the weather and climate in those stories compare to instrument data. Finally, with the extreme weather, including fires and flooding, occurring in the Denver metropolitan area in recent years, it would be interesting to see how people's descriptions of local climate change have evolved.

5.6 Conclusion

In conclusion, this research has answered some questions (e.g., people in the Denver metropolitan area do not remember past seasons very accurately and some social and demographic factors do influence memories and perceptions of weather, climate, and climate change), but also has created many new questions. It is the hope of the investigator that this research can continue for many more years.

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APPENDIX

A. Email Sent to Solicit Respondents for the 2006 Online Research Study

(Note : The link provided in these emails is no longer active. The survey questions are available in Appendix B.)

1) Sent to:
   - University of Colorado at Boulder Department of Geography student and faculty listserv
   - University of Colorado at Boulder Department of Atmospheric and Oceanic Sciences student and faculty listserv
   - University of Colorado at Boulder United Governance of Graduate Students listserv administrator
   - National Center for Atmospheric Research employee email list
   - National Oceanic and Atmospheric Administration – Physical Sciences Division employee email list
   - Western Water Association email usergroup – Denver metropolitan area members only
   - The Denver-Boulder Chapter of the American Meteorological Society email list
   - Adams County School District 14 employee email list
   - Cooperative Institute for Research in Environmental Sciences listserv administrator
   - Institute of Arctic and Alpine Research listserv administrator

Subject: Memories and Perceptions of Climate Research Help

Hello!

I am a graduate student at the University of Colorado at Boulder and am conducting a study about memories and perceptions of weather and climate in the Denver/Boulder Metro area. I am trying to get a reliable data set and was hoping that you could forward this survey on!

It is located at:
http://FreeOnlineSurveys.com/rendersurvey.asp?sid=gc72cdfqnprxju9208223

Please let me know if you have any questions and thank you!

-Julie Malmberg
julie.malmberg@colorado.edu

2) Sent to: Personal contacts in the Denver Metropolitan Area

Subject: Memories and Perceptions of Climate Research Help

Hello!

As many of you know, I am a graduate student at the University of Colorado at Boulder and am conducting a study about memories and perceptions of weather and climate in the Denver/Boulder Metropolitan area. I have created an online survey for my research and am trying to get as many responses as possible in order to have a more reliable dataset. If you have about 15-20 minutes, can you please take this survey? It is located at:

http://FreeOnlineSurveys.com/rendersurvey.asp?sid=gc72cdfqnprxju9208223

Please let me know if you have any questions or feedback! And, I would appreciate it if you could forward this on to anyone living in the Denver/Boulder Metro area.

Thank you!
Julie Malmberg
julie.malmberg@colorado.edu

B. Questionnaire to Subjects in the 2006 Online Research Study

Memories and Perceptions of Weather in the Denver Metropolitan Area

This survey is being given to analyze your memories and perceptions about weather and climate. There are no risks to taking this survey and you may quit at any time. You may also skip any questions. And, this survey is completely anonymous. It should take about 15-25 minutes. The Human Research Committee at the University of Colorado at Boulder has approved the survey.
I am conducting this survey as part of my research for my doctorate.
Thank you!

Julie Malmberg
Julie.malmberg@colorado.edu

Weather and Climate Questions

1. How do you define "weather"?

What was the weather in the Denver metropolitan area like yesterday?

2. Select the option that most closely describes how warm (high temperature) it was during the day.
    a. Below 50F (10C)
    b. 50 to 59F (10 to 15C)
    c. 60 to 69F (15.1 to 21C)
    d. 70 to 79F (21.1 to 26C)
    e. 80 to 89F (26.1 to 31.7C)
    f. 90 to 99F (31.8 to 37.2C)
    g. Above 99F (37.2C)
    h. Do not remember

3. Select the option that most closely describes how cold (low temperature) it was at night.
    a. Below 30F (-1.1C)
    b. 30 to 39F (-1.1 to 3.9C)
    c. 40 to 49F (4 to 9.4C)
    d. 50 to 59F (10 to 15C)
    e. 60 to 69F (15.1 to 21C)
    f. 70 to 79F (21.1 to 26C)
    g. Above 79F (26.1C)
    h. Do not remember

4. Select the option that most closely describes the cloud cover.
    a. Clear (no clouds)

b. A few clouds
c. Cloudy
d. Do not remember

5. Significant weather – please select all that apply.
    a. Rain
    b. Snow
    c. Thunderstorms
    d. Hail
    e. Strong winds
    f. Fog
    g. Haze
    h. Other (please specify)

What was the weather in the Denver Metropolitan area like two days ago?

6. Select the option that most closely describes how warm (high temperature) it was during the day.
    a. Below 50F (10C)
    b. 50 to 59F (10 to 15C)
    c. 60 to 69F (15.1 to 21C)
    d. 70 to 79F (21.1 to 26C)
    e. 80 to 89F (26.1 to 31.7C)
    f. 90 to 99F (31.8 to 37.2C)
    g. Above 99F (37.2C)
    h. Do not remember

7. Select the option that most closely describes how cold (low temperature) it was at night.
    a. Below 30F (-1.1C)
    b. 30 to 39F (-1.1 to 3.9C)
    c. 40 to 49F (4 to 9.4C)
    d. 50 to 59F (10 to 15C)
    e. 60 to 69F (15.1 to 21C)
    f. 70 to 79F (21.1 to 26C)
    g. Above 79F (26.1C)
    h. Do not remember

8. Select the option that most closely describes the cloud cover.
    a. Clear (no clouds)
    b. A few clouds
    c. Cloudy
    d. Do not remember

9. Significant weather – please select all that apply.
    a. Rain
    b. Snow
    c. Thunderstorms
    d. Hail
    e. Strong winds
    f. Fog
    g. Haze
    h. Other (please specify)

What was the weather in the Denver Metropolitan area like seven days (one week) ago?

10. Select the option that most closely describes how warm (high temperature) it was during the day.
    a. Below 50F (10C)
    b. 50 to 59F (10 to 15C)
    c. 60 to 69F (15.1 to 21C)
    d. 70 to 79F (21.1 to 26C)
    e. 80 to 89F (26.1 to 31.7C)
    f. 90 to 99F (31.8 to 37.2C)
    g. Above 99F (37.2C)
    h. Do not remember

11. Select the option that most closely describes how cold (low temperature) it was at night.
    a. Below 30F (-1.1C)
    b. 30 to 39F (-1.1 to 3.9C)
    c. 40 to 49F (4 to 9.4C)
    d. 50 to 59F (10 to 15C)
    e. 60 to 69F (15.1 to 21C)
    f. 70 to 79F (21.1 to 26C)
    g. Above 79F (26.1C)
    h. Do not remember

12. Select the option that most closely describes the cloud cover.
    a. Clear (no clouds)
    b. A few clouds
    c. Cloudy
    d. Do not remember

13. Significant weather – please select all that apply.
    a. Rain
    b. Snow
    c. Thunderstorms
    d. Hail

e. Strong winds
f. Fog
g. Haze
h. Other (please specify)

14. How has the summer of 2006 compared to the summer of 2005?

15. Did you live in the Denver metropolitan area **two years** ago?
    a. Yes
    b. No

16. During the summer **two years** ago (June to August 2004), do you think the air temperature in the Denver metropolitan area was…
    a. Higher
    b. About the same
    c. Lower
    d. Do not remember
    e. Did not live in the Denver Metropolitan Area

17. During the summer **two years** ago (June to August 2004), how did the precipitation (rain, hail) compare to now?
    a. More
    b. About the same
    c. Less
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

18. During the winter **two years** ago (December 2003 to February 2004), was the air temperature in the Denver metropolitan area…
    a. Higher
    b. About the same
    c. Lower
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

19. During the winter **two years** ago (December 2003 – February 2004), how did the precipitation (rain, snow, freezing rain, sleet) compare to now?
    a. More
    b. About the same
    c. Less
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

20. Anything else to add about the summers or winters in the Denver metropolitan area **two years** ago?

21. Did you live in the Denver metropolitan area **10 years** ago?
    a. Yes
    b. No

22. During the summer **10 years** ago (June to August 1996), do you think the air temperature in the Denver metropolitan area was…
    a. Higher
    b. About the same
    c. Lower
    d. Do not remember
    e. Did not live in the Denver Metropolitan Area

23. During the summer **10 years** ago (June to August 1996), how did the precipitation (rain, hail) compare to now?
    a. More
    b. About the same
    c. Less
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

24. During the winter **10 years** ago (December 1995 to February 1996), was the air temperature in the Denver metropolitan area…
    a. Higher
    b. About the same
    c. Lower
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

25. During the winter **10 years** ago (December 1995 – February 1996), how did the precipitation (rain, snow, freezing rain, sleet) compare to now?
    a. More
    b. About the same
    c. Less
    d. Do not remember
    e. Did not live in the Denver Metropolitan area
26. Anything else to add about the summers or winters in the Denver metropolitan area **10 years** ago?

27. Did you live in the Denver metropolitan area **20 years** ago?
    a. Yes
    b. No

28. During the summer **20 years** ago (June to August 1986), do you think the air temperature in the Denver metropolitan area was…
    a. Higher
    b. About the same

c. Lower
d. Do not remember
e. Did not live in the Denver Metropolitan Area

29. During the summer **20 years** ago (June to August 1986), how did the precipitation (rain, hail) compare to now?
    a. More
    b. About the same
    c. Less
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

30. During the winter **20 years** ago (December 1985 to February 1986), was the air temperature in the Denver metropolitan area…
    a. Higher
    b. About the same
    c. Lower
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

31. During the winter **20** ago (December 1985 – February 1986), how did the precipitation (rain, snow, freezing rain, sleet) compare to now?
    a. More
    b. About the same
    c. Less
    d. Do not remember
    e. Did not live in the Denver Metropolitan area

32. Anything else to add about the summers or winters in the Denver metropolitan area **20 years** ago?

General Questions

33. In general, do you think the temperature in the Denver metropolitan area is getting…
    a. A lot warmer
    b. A little warmer
    c. Staying about the same
    d. A little colder
    e. A lot colder

34. How do you define the start of winter?

35. Would you say winters in the Denver metropolitan area are starting…
    a. A lot earlier
    b. A little earlier

c. At about the same time
d. A little later
e. A lot later

36. Global warming is defined by The American Heritage Dictionary of the English Language as, "An increase in the average temperature of the earth's atmosphere, especially a sustained increase sufficient to cause climatic change." Do you think global warming is happening?
    a. Yes
    b. No
    c. Not sure

37. If you do think global change is occurring, do you think that humans had an impact on global climate change?
    a. Yes, a significant impact
    b. Yes, a moderate impact
    c. Yes, a minor impact
    d. No
    e. Not sure
    f. I don't think global change is occurring

38. Following are four possible reasons for global climate change. Please put them in the order of most important to least important in causing global change. 1 is the most important, 4 is the least important. (If you do not think global change is occurring, please skip this question.
    a. Greenhouse gases and emissions from cows, termite hills, and other natural sources
    b. Emissions from cars and houses
    c. Emissions from coal-burning power plants
    d. Emissions from factories

39. Are you male of female?
    a. Male
    b. Female
    c. Prefer not to answer

40. On average, how many hours per day are you outside?
    a. Less than 2
    b. 2 to 6
    c. 6 to 10
    d. More than 10

41. Is the weather important for your job?
    a. Yes
    b. No

42. What is the highest level of education you have completed?
    a. Did not complete high school
    b. High School
    c. Associate's Degree
    d. Bachelor's Degree
    e. Graduate (Master's or Doctorate) Degree
    f. Prefer not to answer

43. Have you taken a class about climate or weather?
    a. Yes
    b. No
    c. Not sure

44. Are you currently take a class about climate or weather?
    a. Yes
    b. No

45. How do you feel temperature-wise right now?
    a. Hot
    b. Warm
    c. Comfortable/neutral
    d. Cool
    e. Cold

46. Any other comments/questions/observations?

C. Questionnaire and Debriefing Form to Subjects In the 2010-2011 Research Study

Cover Sheet:

ID # _____

Gender: M F

Date: _____

Time: _____

Air Temperature: _____

Relative Humidity: _____

Visible Radiation: _____

Total Radiation: _____

Any other comments about the current weather:

ID # _____

1. On a scale of 1 to 6, with 1 being the most negative and 6 being the most positive, how would you rate your mood right now?

2. On a scale of 1 to 6, with 1 being the most negative and 6 being the most positive, how would you rate your comfort right now? (Please consider the current weather.)

3. When thinking about the weather, what do you consider to be a nice day?

4. What do you consider to be a bad day?

5. This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

_____ interested
_____ distressed
_____ excited
_____ upset
_____ strong
_____ guilty
_____ scared
_____ hostile
_____ enthusiastic
_____ proud

_____ irritable
_____ alert
_____ ashamed
_____ inspired
_____ nervous
_____ determined
_____ attentive
_____ jittery
_____ active
_____ afraid

6. Describe (or draw) the first image that comes to mind when thinking about global warming. Feel free to use the back of the paper or to attach additional pages.

7. Describe (or draw) the first image that comes to mind when thinking about global warming along the Colorado Front Range. Feel free to use the back of the paper or to attach additional pages.

8. Do you think global warming is occurring?

□Yes □No □I don't know

9. Do you think humans are having an effect on global warming?

□Yes □No □I don't know

10. On a scale of 1 to 6, with 1 being of no concern to you and 6 being of utmost or extreme concern, rate each of the following.

Skin cancer	_____	Cataracts	_____
Global warming	_____	Drought	_____
Climate change	_____	Whale hunting	_____
Earthquakes	_____	Landfills	_____
Terrorism	_____	War	_____
Nuclear Waste	_____	The Economy	_____

11. Where have you spent most of your life?

12. How long have you lived in or around Boulder?

13. What is your major?

14. Do you consider yourself politically conservative, moderate, liberal, or other?

15. Have you had a class about climate or the weather before? If yes, what was it and how long ago was it?

Oral Questions – to be administered by the PI

ID # _____

16. Describe a significant event that happened to you in the past.
    a. When was that event?
    b. What happened?
    c. Was this a positive or negative event?
    d. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the event?
    e. What was the weather like at the time of this event?
    f. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the weather at the time of the event?

17. Repeat question previous question for a second event.
    a. When was that event?
    b. What happened?
    c. Was this a positive or negative event?
    d. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the event?
    e. What was the weather like at the time of this event?
    f. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the weather at the time of the event?

18. Four Mile Canyon Fire
    a. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the event?
    b. What was the weather like at the time of this event?
    c. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the weather at the time of the event?

19. 9/11
    a. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the event?
    b. What was the weather like at the time of this event?
    c. On a scale of 1 to 6 with 1 being the most negative and 6 being the most positive, how would you rate the weather at the time of the event?

20. What was the weather like yesterday? (Guided to include temperature and precipitation.)

21. What was the weather like two days ago?

22. What was the weather like seven days ago?

23. Did you live in the Denver metro area during the previous winter? If so, what was the weather like? (Guide to answer about temperature and precipitation using specific words like warmer, a lot warmer, about the same, colder, a lot colder; a lot more to a lot less precipitation.)

24. Did you live in the Denver metro area during the previous summer? If so, what was the weather like? (Guide to answer about temperature and precipitation using specific words like warmer, a lot warmer, about the same, colder, a lot colder; a lot more to a lot less precipitation.)

25. Did you live in the Denver metro area during the 2005-2006 winter? If so, what was the weather like? (Guide to answer about temperature and precipitation using specific words like warmer, a lot warmer, about the same, colder, a lot colder; a lot more to a lot less precipitation.)

26. Did you live in the Denver metro area during the 2005 summer? If so, what was the weather like? (Guide to answer about temperature and precipitation using specific words like warmer, a lot warmer, about the same, colder, a lot colder; a lot more to a lot less precipitation.)

Thank you for participating in the Perceptions and Memories of Weather and Climate in the Denver-Boulder Area study. The section that you just completed is the second portion of a research project that has four main objectives:

1. How accurate as compared to instrument data does the general population remember past weather and climate? What influences these memories?
2. How do current perceptions of climate change influence recollections of weather and climate?
3. How does solar radiation influence the mood of the memories of past events and weather associated with that event?
4. How does solar radiation influence opinions on global issues, both related to the weather and climate and not related to weather and climate?

Description of Procedures

In order to complete this portion of the study, I am interviewing approximately 50 participants. Each participant will complete a written survey and then answer questions during a short interview. Questions are about recent weather, past weather, and climate. The questions are short answer, drawings or descriptions, and rating terms on a scale. There are also questions about past events, some of which are the choice of the participant.

Data Collection

Data collected from this survey will be used to complete a PhD dissertation. We will make every effort to maintain the privacy of your data. You have been assigned a number, which will be the only identifier on all documents. A list of names and coordinating numbers will be kept in a separate, locked file cabinet away from the surveys and questionnaires in case further the PI has further questions. After analyzing the data collected, the names and numbers will be destroyed.

Implications of Results

Results of this research study will allow scientists to better understand how to ask questions about past weather and climate. Climate records are far from complete and using weather and climate memories may help fill in gaps in the climate record.

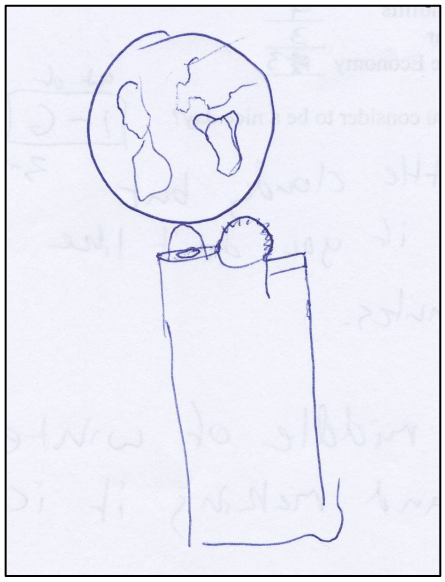
Contact Information

For further information or any questions, please feel free to contact me (Julie Malmberg) at julie.malmberg@colorado.edu.

Thank you!

D. Drawings from 2010-2011 Study

"Describe (or draw) the first image that comes to mind when thinking about global warming."



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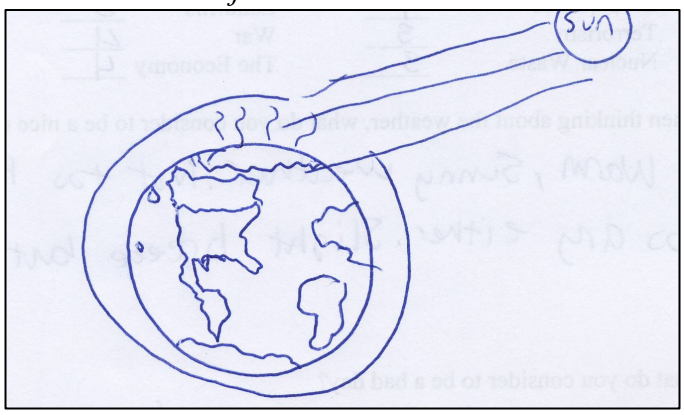

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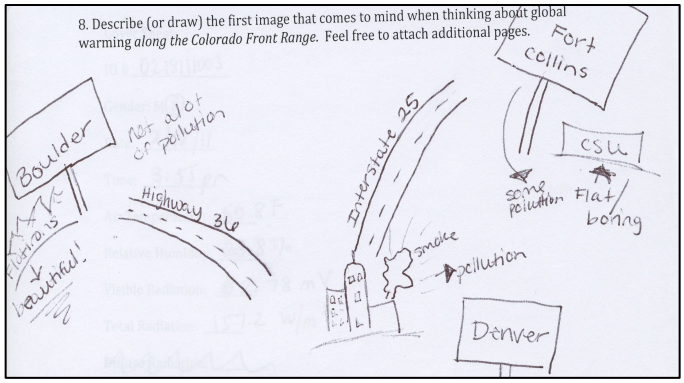

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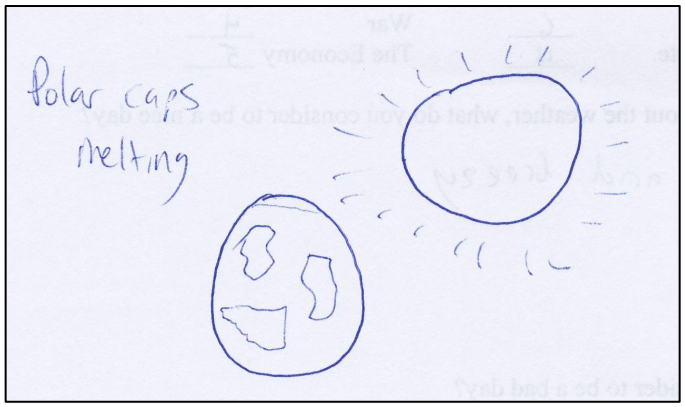

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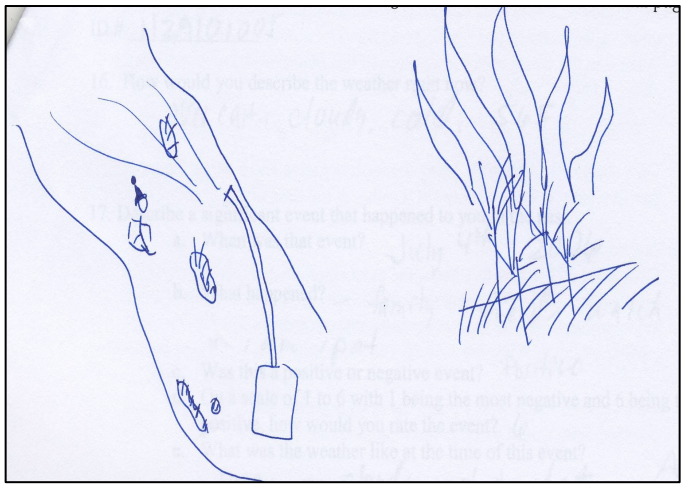

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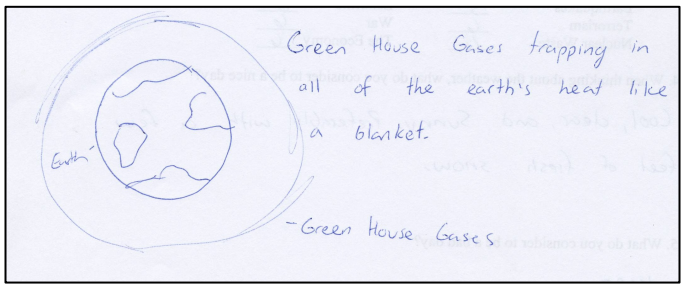

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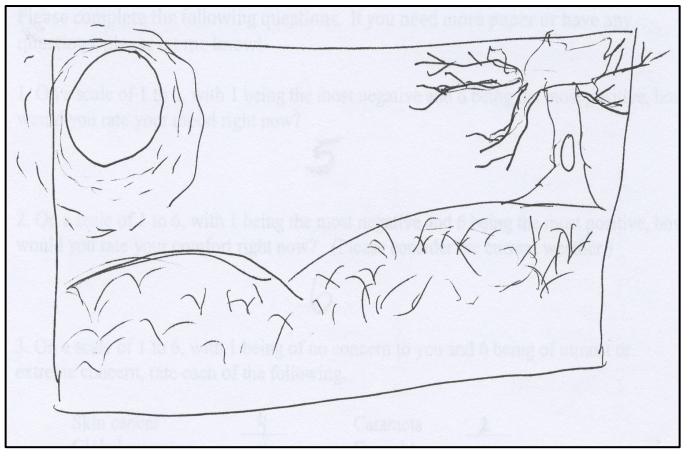

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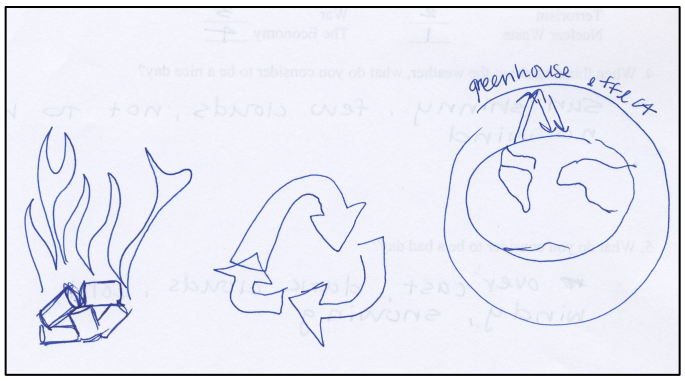

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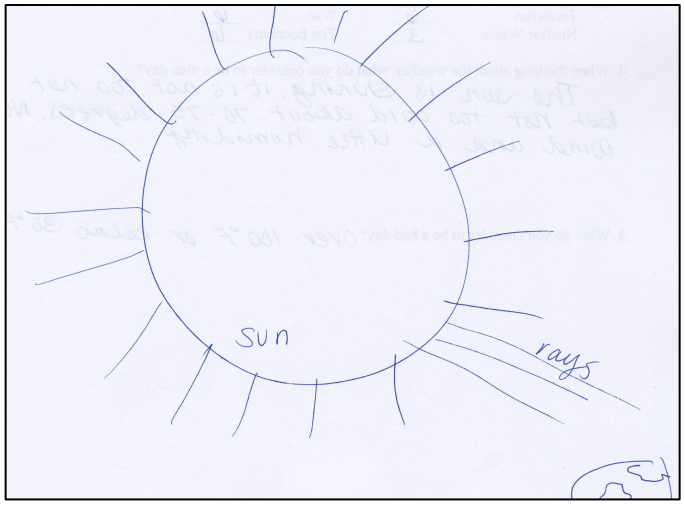

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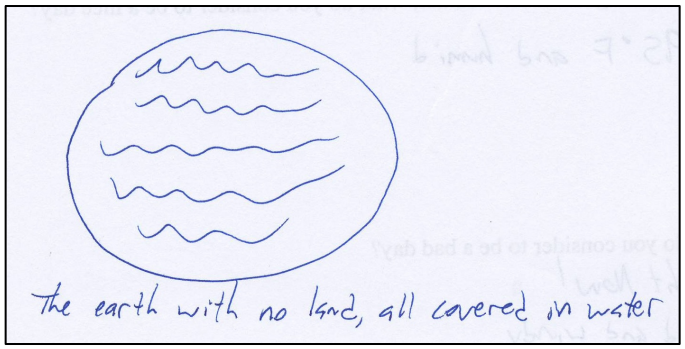

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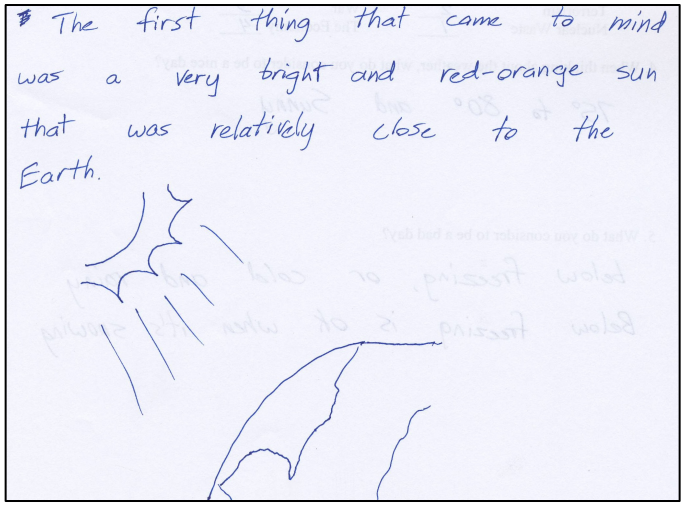

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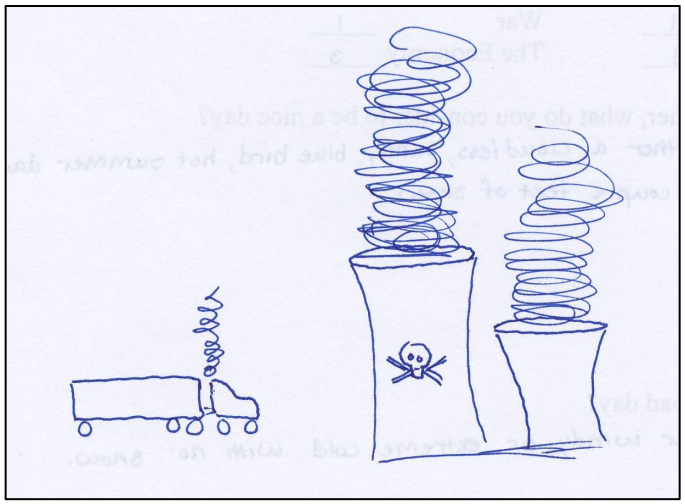

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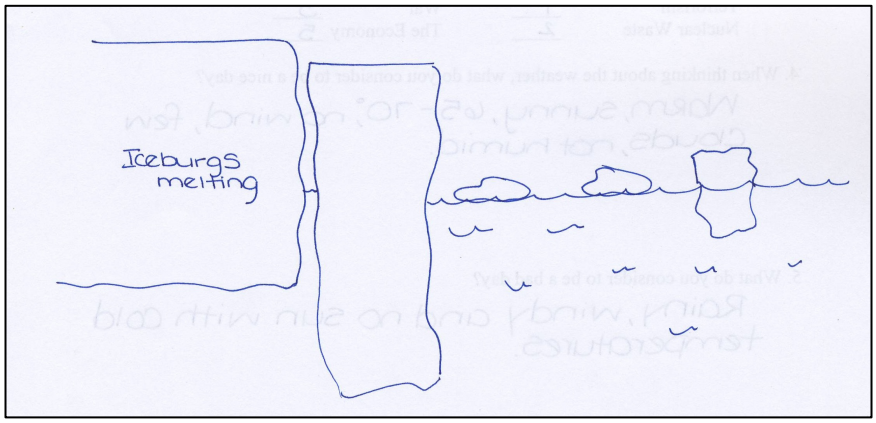
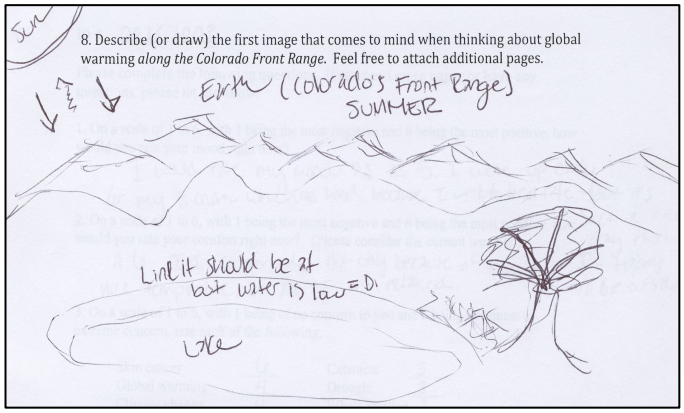


Subject 1203101002

Subject 0128111003



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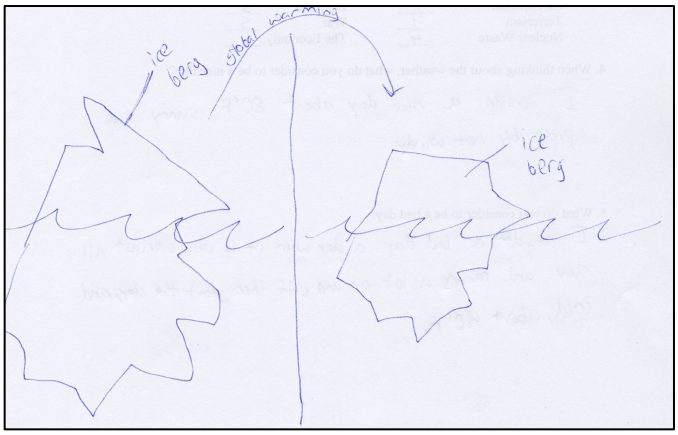

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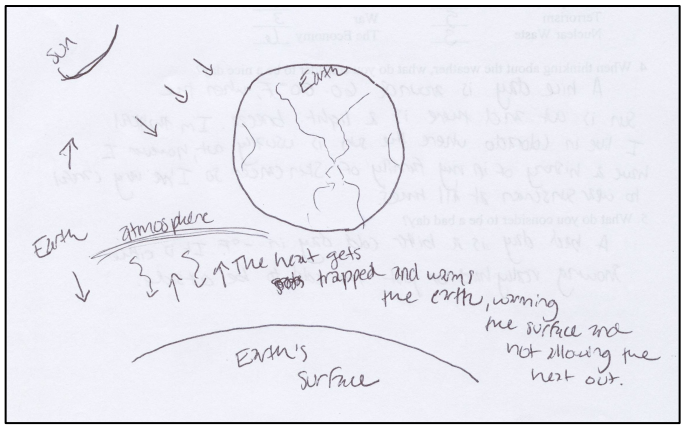

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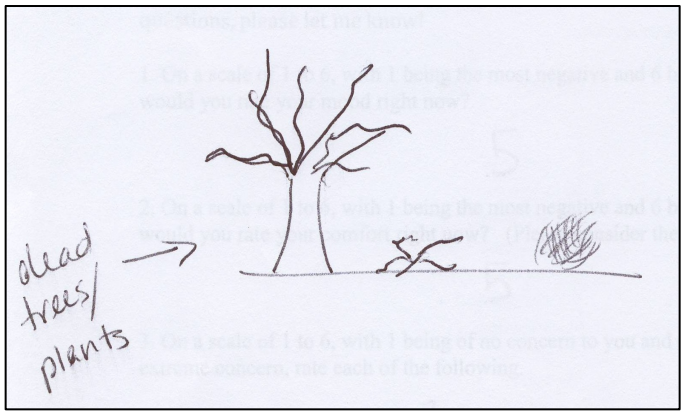

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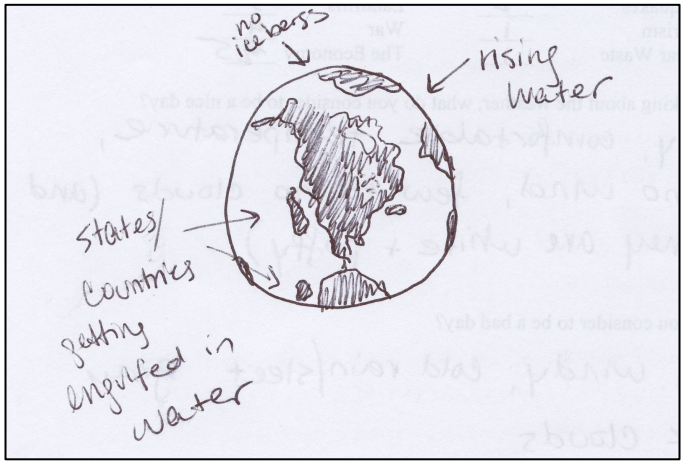

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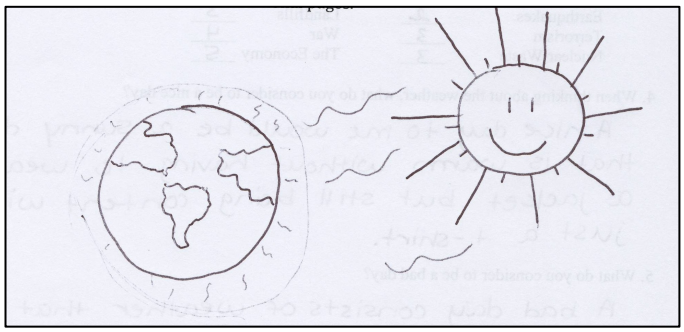

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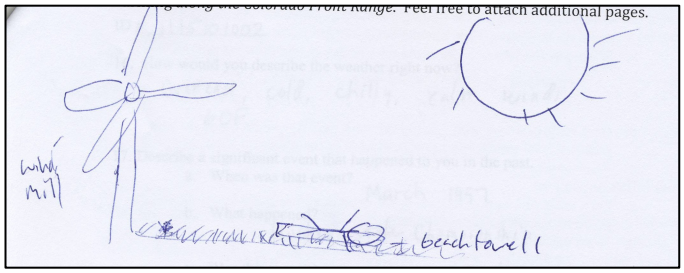
"Describe (or draw) the first image that comes to mind when thinking about global warming along the Colorado Front Range."



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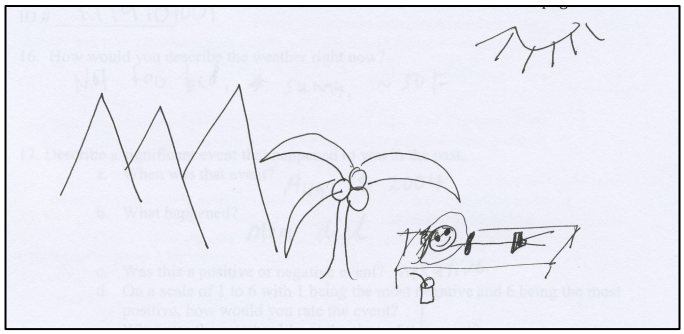

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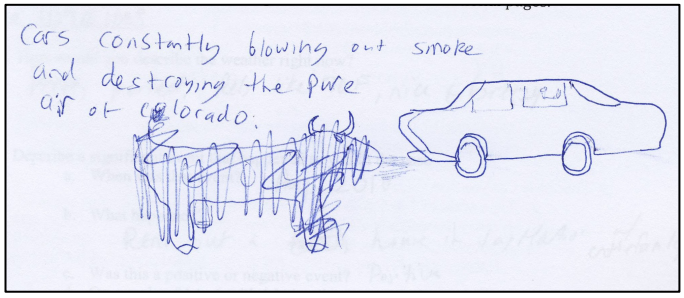

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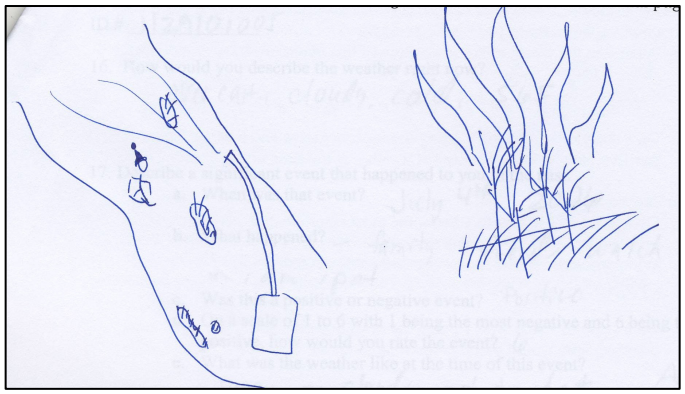

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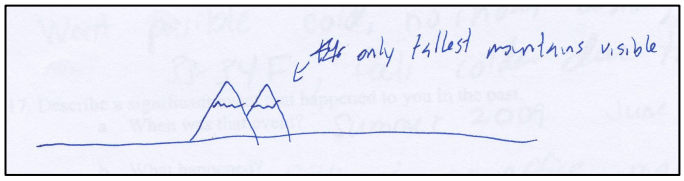

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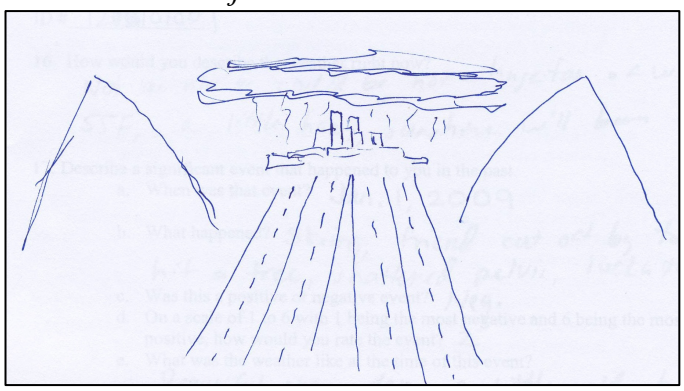

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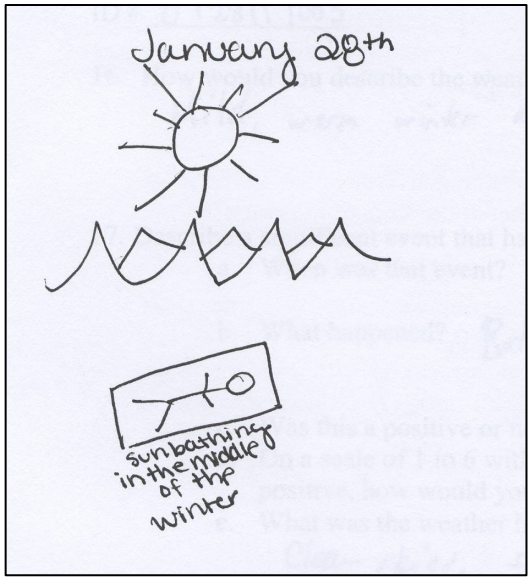

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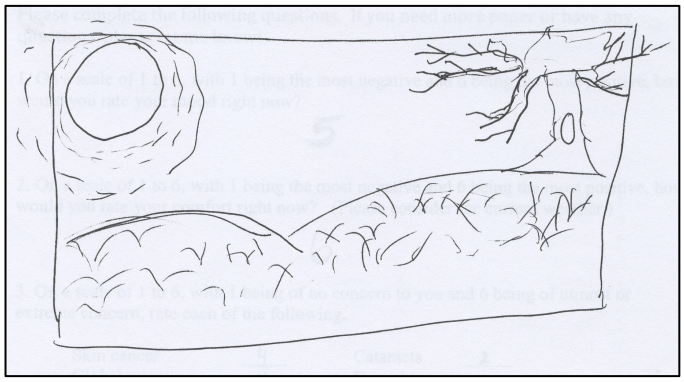

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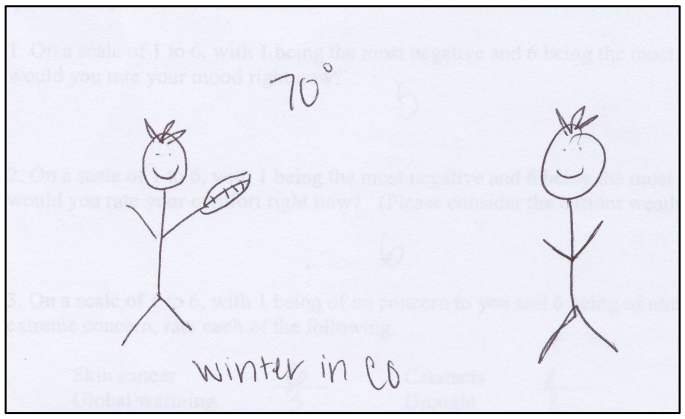

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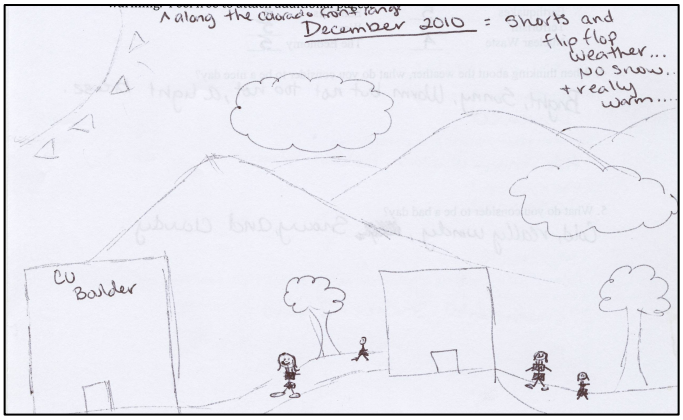

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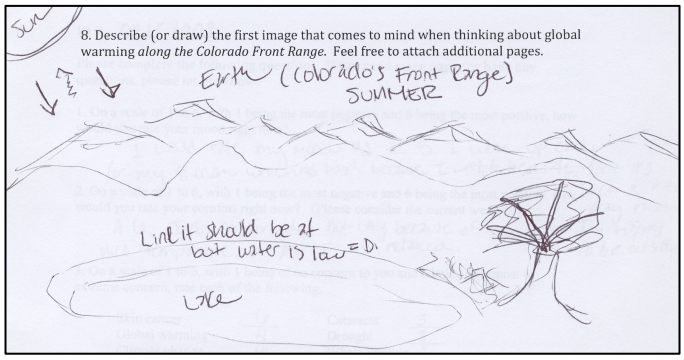

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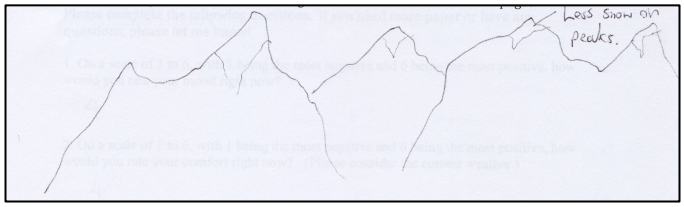

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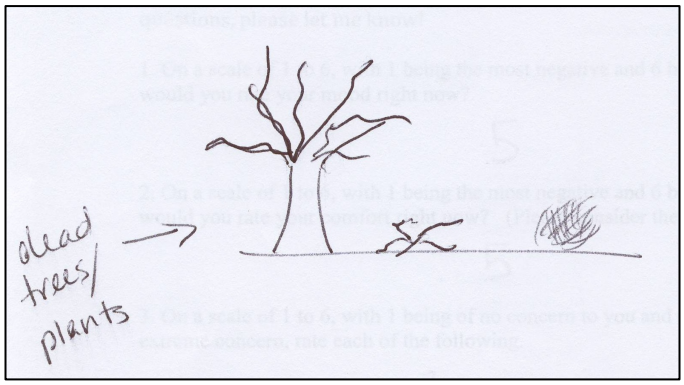

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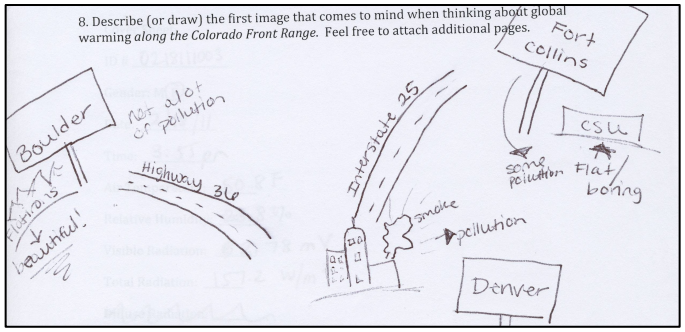

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