THESIS

SOCIAL PERCEPTIONS VERSUS METEOROLOGICAL OBSERVATIONS OF SNOW AND WINTER ALONG THE FRONT RANGE

Submitted by

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ABSTRACT

SOCIAL PERCEPTIONS VERSUS METEOROLOGICAL OBSERVATIONS OF SNOW AND WINTER ALONG THE FRONT RANGE

This research aims to increase understanding of Front Range residents' perceptions of snow, winter and hydrologic events. This study also investigates how an individual's characteristics may shape perceptions of winter weather and climate. A survey was administered to determine if perceptions of previous winters align with observed meteorological data. The survey also investigated how individual characteristics influence perceptions of snow and winter weather. The survey was conducted primarily along the Front Range area of the state of Colorado in the United States of America. This is a highly populated semi-arid region that acts as an interface between the agricultural plains to the east that extend to the Mississippi River and the Rocky Mountains to the west. The climate is continental, and while many people recreate in the snowy areas of the mountains, most live where annual snowfall amounts are low. Precipitation, temperature, and wind speed datasets from selected weather stations were analyzed to determine correct survey responses. Survey analysis revealed that perceptions of previous winters do not necessarily align with observed meteorological data. The mean percentage of correct responses to all survey questions was 36.8%. Further analysis revealed that some individual characteristics (e.g. winter recreation, source of winter weather information) did influence correct responses to survey questions.

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CHAPTER 1: SOCIAL PERCEPTIONS VERSUS METERIOLOGICAL OBSERVATIONS OF SNOW AND WINTER ALONG THE FRONT RANGE

1.1 Introduction

The Front Range area of the state of Colorado in the United States of America is a highly populated semi-arid region that acts as an interface between the agricultural plains to the east that extend to the Mississippi River and the Rocky Mountains to the west. The climate is continental, and while many people recreate in the snowy areas of the mountains, most live where annual snowfall amounts are low. Across most of the Western United States (U.S.), between 60 and 75 percent of annual precipitation falls as snow while in the Northern Great Plains and other areas of the U.S., only 20 percent of the annual precipitation falls in forms of snow (Doesken and Judson, 1996). Although snow is a valuable natural resource, it is also the source of huge routine cost; in excess of $2 billion is spent annually in the U.S. for snow removal of streets and highways (Doesken and Judson, 1996). In the western United States, exceptional efforts are given to the management of snow, while little consideration is given to understanding society's perceptions and other social aspects of snow and winter.

Weather and climate perception is the process by which society seeks to understand their surrounding atmospheric conditions where they live so that they might be able to effectively respond and adapt (Stewart, 2007). Perception of weather and climate can be influenced by a number of variables such as, direct exposure to weather and climate, exposure from a variety of media sources, and cultural and social factors (Stewart, 2007). It is inherent that these types of exposures may vary from person to person giving variations of perceptions. One obvious influence on perceptions of snow and winter in Colorado may be the world class winter recreational opportunities; winter recreation has a definite cultural and social influence on many Front Range residents which may shape perception of snow and winter. Although there is substantial literature on how perceptions are formed and the importance of understanding perceptions related to issues such as "climate change", research involving how perceptions of snow and winter align with observed meteorological data is sparse and relatively non-existent for the Colorado Front Range. Existing research has attempted to align perceptions of weather with observed data and has shown that perceptions do not necessarily match observed meteorological data. Human perception of climate can be influenced by expectations, which may have little connection to the actual nature of climate as provided by the instrumental record (Rebetez, 1996). If significant variation between perception and observed data exist, it potentially represents a barrier to effective communication with diverse audiences (Akerlof and Maibach, 2011).

This research aims to increase understanding of Front Range residents' perception of snow, winter and hydrologic events and to determine if variation exists between perceptions of snow and winter and observed meteorological data. This study also investigates how individual characteristics may shape perceptions of winter weather and climate. Results will help to identify previously discussed barriers of communication which may assist in future discussions of social aspects of snow and winter weather in the Front Range. The scientific objectives of this paper are as follows:

1: Increase understanding of Front Range residents' perception of snow, winter and hydrologic events.

2: Determine how perceptions align with observed meteorological data.

3: Investigate how individual characteristics shape perceptions of winter weather and climate.

A questionnaire was developed, aimed to reveal Front Range residents' perceptions of the 2011-12 winter compared to previous winters (temperature, precipitation and wind speed) as well as their perceptions of overall trends in winter weather compared to observed data. A pilot study was first conducted to determine words that Front Range residents use to describe snow and winter weather. The results were used in development of vocabulary and question formatting needed to properly survey Front Range residents. Multiple weather stations were selected to represent the meteorological data needed to determine correct responses to the questionnaire. The Mann-Whitney-Wilcoxon test was used to statistically compare the meteorological data for the 2011-2012 winter to previous winters. A Mann-Kendall trend analysis was chosen to determine trends in winter weather variables. The analyzed meteorological data were used to determine the correct responses for each questionnaire item. After determining which response was correct, statistical analysis was used to determine if individual characteristics (e.g. winter recreational activities, years lived in Front Range) influenced the correct responses to the questionnaire.

For this paper, the following hypotheses were created:

1) There is no difference between perception of precipitation and observed precipitation data;

2) There is no difference between perception of temperature and observed temperature data;

3) There is no difference between perception of wind speed and observed wind speed data.

1.2 Study Area

The questionnaire was conducted in Fort Collins, Colorado. Fort Collins is located in Larimer County on the Cache la Poudre River along the Front Range of Northern Colorado at an elevation of 1,525 m above sea level. A small number of questionnaires that were not conducted in Fort Collins, CO were administered in other Colorado Front Range cities with similar climate.

The Fort Collins weather station (Table 1) was chosen to provide the meteorological data (temperature, precipitation and wind speed) to be used for alignment and comparative analysis with questions that pertain to Colorado Front Range winter weather and climate. Although there are many other weather stations along the Front Range, the Fort Collins Weather Station located on the Colorado State University campus, is one of few with good continuous datasets for all variables discussed in the survey (temperature, precipitation and wind). Since most of the participants currently live in Fort Collins, we feel that this weather station best represents the meteorological data needed for comparisons with perception of climate data concerning the Front Range portion of the questionnaire. Weather observations include: automated measurements of temperature, wind speed and direction, precipitation, pressure, solar radiation and soil temperature as well as manual measurements of precipitation, cloud and sky conditions, winds, temperature, humidity, visibility and other standard weather variables not used in our analysis. This weather station has been operating continuously since January 1, 1893.

The Aspen, Climax and Steamboat Springs weather stations (Table 1) are operated through the National Weather Service (NWS) Cooperative Observer Program (COOP) and were selected to represent the temperature and precipitation data for comparisons of perception to the mountain climate portion of the questionnaire. These stations were chosen since they are located in areas that are popular for winter recreation by Colorado Front Range residents, and they had a long continuous period of record. Front Range residents' perception of mountain winter weather may be developed by their visiting these popular sites for winter recreation, and/or the media's influence based on coverage of weather in these areas.

There are some SNOTEL (snow telemetry) sites operated by the Natural Resources Conservation Service (NRCS) located near popular areas for winter recreation. However, there have been changes in instrumentation at these stations that appear to adversely influence the trend analysis (Weber, 2013).

Since continuous wind speed data are not recorded at COOP and other meteorological observation stations, the C-1 station (Table 1) located at the Long Term Ecological Research (LTER) station at Niwot Ridge, Colorado (Niwot) was used to represent wind speed for comparison to questions pertaining to mountain wind. More stations are desired to summarize mountain wind speeds in the popular winter recreation areas; however, the available data in the area were from the Niwot C-1 site that is located in a subalpine Forest, 9.7 km east of the Continental Divide.

Table 1. Summary of the meteorology for the five stations used in the analysis, including the annual average maximum and minimum temperatures, total precipitation and snowfall, and wind speed, with location and period of record used. Note * that the wind data at Fort Collins were only available from 1996 through 2012.

station	annual average					station number	latitude [deg N]	longitude [deg W]	elev [m]	period of record used
	max temp [°C]	min temp [°C]	total precip [mm]	total snowfall [mm]	wind speed [m/s]					
Fort Collins	17	1	383	1196		53005	40.61	-105.13	1524	1980-2012*
Aspen 1SW	13	-4	491	3477	N/A	50372	39.18	-106.83	2456	1980-2012
Climax	6	-7	628	7120	N/A	51660	39.36	-106.18	3442	1980-2012
Steamboat Springs	13	-6	603	4232	N/A	57936	40.48	-106.82	2093	1980-2012
Niwot C-1	N/A	N/A	N/A	N/A		N/A	40.03	-105.53	3022	1988-2012

1.3 Methods

1.3.1 Questionnaire Construction

A pilot study titled *"How Do People Think and Talk About Snow and Winter?" (*Appendix I*)* was first performed as part of an exploratory survey. Exploratory surveys are used to collect preliminary information that is useful when the researcher would like to obtain a better understanding of topic and related issues and concerns that may be useful in developing a larger study (Vaske, 2008). Two open-ended questions were asked to participants:

1. *What words would you use to describe this winter season?*
2. *How does this winter compare to previous winters?*

Participants were then asked if they participated in winter recreational activities. If participants identified that they did participate in a winter recreational activity, they were asked on a scale from 1 to 10, where 1 equals novice and 10 equals expert, how they would they would rank themselves in this activity, as well as for a frequency (number of times per year they participate in this activity). Next, the participant was asked if they did anything related to water resource issues (e.g. professional/student/volunteer), where they sought information about winter weather, current weather conditions, date, time and demographic information. Results from the exploratory survey were analyzed using "classical content analysis" and "constant comparative analysis". Classical content analysis was used for identifying keywords in context (chunks or nodes) as well as word counts from the survey responses. Constant comparative analysis was also used, this begins with chunking the data similar to classical content analysis; the difference is that themes are created with constant comparative analysis instead of only counting the number each time a code is used. The results were used to help develop themes, ideas and vocabulary for the primary questionnaire.

The questionnaire titled, "How Do People Perceive Snow and Winter Weather?" was designed to evaluate perception of winter weather and climate as well as to provide perception data that could be compared with actual meteorological data (Appendix I). The questionnaire included nine questions asking the interviewee to: compare the 2011-2012 winter to the previous winter; compare the 2011-2012 winter to previous winters; and comment on their perception of any trends in winter weather variables including temperature, precipitation, and wind (for both the Front Range and the mountains). For these questions, a five-point scale was used for questionnaire items (e.g. very cold, cold, average, warm, and very warm). Following the first nine questions, were questions concerning winter recreation participation (rank and frequency), where the interviewee sought information about winter weather, date, time, current weather conditions, as well as demographic information. Questions 1-9 served as dependent variables while question concerning residence, winter recreational activities, where the participant sought information about winter weather and other demographics served as the independent variables. Questionnaire responses were input into SPSS statistical software to complete descriptive and statistical analyses.

1.3.2 Survey Sampling

A modified form of cluster survey sampling was used to administer face-to-face interviews for the questionnaire. Cluster sampling involves conducting a simple random sample of "clusters" or "groups" and then sampling people within the cluster (Fowler, 1993; Scheaffer et al., 1996; Vaske, 2008). Surveys were conducted throughout Fort Collins in areas including; open space parks, old-town Ft. Collins (downtown shopping and dining district) as well as on and around the Colorado State University campus. The pilot study was administered between March and June 2011 with a total of 50 respondents. The primary questionnaire was administered between August and November of 2012 with a total of 222 respondents. The questions were read to the interviewee by the interviewer. Because questions on the survey asked respondents to compare the 2011-2012 winter to previous winters, respondents' results who identified they were not residents in the Front Range for at least 3 years, were not included in the analysis. After removing data that did not meet this criteria, there were a total of 196 (n=196) completed questionnaires for analysis. The obtained alpha score for all questionnaire responses is 0.799 (Cronbach's alpha), which indicates that the scale has good reliability.

1.3.3 Perception Versus Meteorological Observation Analyses

Meteorological data from the selected weather stations were analyzed to compare with corresponding questionnaire results to see if perceptions aligned with the meteorological data. The first meteorological data to be analyzed concerned the comparison of the 2011-12 winter to the 2010-11 winter as well as the comparison of the 2011-12 winter to previous winters (comparisons variables include temperature, precipitation and wind). Data used to represent the previous winters were the current climate normals (1980-2010) for each station, this 30 year period is currently the preferred time frame for datasets estimating climate normals and trends ("Climate Normals", 2011). November through March datasets were used to represent winter months for all datasets. Due to the unavailability of 30-year continuous datasets for wind, the longest dataset available were used. Analysis for comparing the 2011-12 to the previous winter as well as comparing the 2011-2012 winter to climate normals (previous winters) includes a Mann-Whitney-Wilcoxon statistical analysis. Meteorological data was also needed to compare with the results of perception of trends in winter weather and climate. Concerning trends in the meteorological data, datasets for each station were analyzed using a Mann-Kendall trend test. Trend analyses for all stations were combined to determine overall trend for each parameter. Trend analysis was performed using the MAKESENS macro trend analysis worksheet (Salmi et al., 2002). When analyzing monthly data, if more than 3 days are missing, the month was removed. When analyzing annual data, if more than 15 days are missing, the month was removed. After completing statistical analysis and comparisons of all the meteorological data, it could be determined which questionnaire responses were considered the "correct" responses. Once correct responses were determined through the meteorological data analysis, the correct responses were used as test variables to determine if questionnaire responses were statistically different from the correct response. A t-test was used to test the following null hypotheses:

1. There is no difference between perception of precipitation and observed precipitation data.
    a. Winter-2012 vs. Winter 2011
        i) Front Range
        ii) Mountains
    b. Winter-2012 vs. Winter 1980-2010
        i) Front Range
        ii) Mountains
    c. Trend
2. There is no difference between perception of temperature and observed temperature data.
    d. Winter-2012 vs. Winter 2011
        i) Front Range

ii) Mountains

e. Winter-2012 vs. Winter 1980-2010

i) Front Range

ii) Mountains

f. Trend

3. There is no difference between perception of wind and observed wind data.

g. Winter-2012 vs. Winter 2011

i) Front Range

ii) Mountains

h. Winter-2012 vs. Winter 1980-2010
i) Front Range
ii) Mountains

i. Trend

1.3.4 Individual Characteristics Analysis

After determining which questionnaire responses were correct, statistical and comparative analyses were performed to determine if any of the independent variables influenced correct responses. Independent variables selected include: gender, number of years lived in the Front Range, participation in winter recreation (rank*frequency), and number of sources used for winter weather information.

a) Gender: The percentage of females and males that were correct for each question was first calculated. Next, the data for percentage of correct responses for males and females were analyzed to determine any statistically significant difference between groups. This analysis was used to identify any relationship between gender and correct questionnaire responses.

b) How many years lived in the Front Range: A crosstab multi-response analysis was performed between how long the respondent have lived in the Front Range and responses for questionnaire items; 1b, 2b, 3b, 4b, 5b, 6b, 7, 8, 9 (questions that correspond with past winters). Once this analysis was performed, the number of correct responses for all categories of years lived in Front Range was determined. Next, the percentage of correct responses for each category of years lived in the Front Range was calculated. Due to the large range of responses for years lived in the Front Range (0-48 years), this variable was broken into three groups, Group 1 (3-10 years) n=124, Group 2 (11-20 years) n=50, Group 3 (21-48 years) n=22. These groups were determined observing natural breaks in the data; grouping was also desired to increase statistical power of the analyses. Statistical analysis was performed on both the ungrouped as well as the grouped dataset for percentage of correct responses to determine if there is a correlation between years lived in the Front Range and correct questionnaire responses.

c) Winter Recreation: Survey participants were asked which if any winter recreational activities they participated in as well as the rank and frequency of this activity. Rank was scaled between 1 and 10 (1 being a novice and 10 being an expert) and frequency was simply the number of times per year they participated in that activity. Rank was multiplied by frequency (R*F) so that one number could be used to characterized participation in winter recreation (if a respondent participated in multiple activities the R*F values were summed for all activities). A crosstab multi-response analysis was performed between the

R*F variable and responses for questionnaire items; 2a, 2b, 4a, 4b, 6a, 6b, 7, 8, 9. Next, the number of correct responses for all values of R*F was used to calculate the percentage of correct responses for all values of R*F. Due to the large range of responses for R*F (0-1147), this variable was broken into four groups: Group 1-(R*F=0) n=75, Group 2 (R*F=1-15) n=41, Group 3-(R*F=16-50) n=35, and Group 4-(R*F=51-1147) n=43. These groups were determined observing natural breaks in the data; grouping was also desired to increase statistical power of the analyses. A Statistical analysis was performed on both the ungrouped as well as the grouped dataset of percentage of correct responses to determine if there is a correlation between R*F and correct survey responses.

d) Source of Weather Information: Survey participants were also asked to list the sources used for information about winter weather. These data were used to determine if sources of winter weather information influenced correct questionnaire responses. Analysis was performed to see if the number of sources used influenced correct responses. Because most respondents use between 1 and 3 sources, this variable was broken into three groups, Group 1 (one source) n=85, Group 2 (two sources) n=63, and group 3 (three or more sources) n=33. These groups were determined observing natural breaks in the data; grouping was also desired to increase statistical power of the analyses. First, a crosstab multi response analysis was performed between the number of sources used and all survey questions. Next, the number of correct responses for each group was used to calculate the percentage of correct responses. A Statistical analysis was performed on to determine if there is a correlation between the number of sources used for winter weather information and correct questionnaire responses.

1.4 Results

1.4.1 Pilot Study: How Do People Think and Talk About Snow and Winter?

The pilot study exploratory survey was administered between March and June of 2011 with a total of 50 respondents (n=50). Analysis of the questionnaire responses shows "cold" and "snow" were the terms mostly used for both questions asked. Constant comparative analysis of the second question, which asks respondents to compare the most recent winter to previous winters, was helpful in developing questions for the primary questionnaire. "Nodes" and themes extracted from this analysis (very cold, cold, average, warm, very warm etc.) were directly used to create the five-point response scale for the second survey. Also noted from this analysis was the separation between responses describing the "Front Range" and "Mountain" winter weather. Many respondents when asked to compare winters, compared winters for both the Front Range and the Mountain areas of Colorado. These separations of thoughts lead to items in the questionnaire concerning both the "Front Range" and the "Mountains" to make sure that respondents were thinking on a similar special scale when answering questions. Other themes noted from analysis include positive and negative connotations to words used to describe winter weather and snow. There were a total of 9 responses with clear positive connotations when asked to describe winter; of which all 9 respondents do participate in winter recreation activities. This supports the idea that social and cultural factors may influence the vocabulary used when discussing snow and winter weather, which may in turn influence perceptions of snow and winter weather. This pilot study was successful in developing vocabulary, themes and ideas for the questionnaire.

1.4.2 Perception Versus Meteorological Observation Analyses

Analyzing the Fort Collins 2011-12 winter precipitation data revealed that the 2011-12 winter had 86% more snow than 2010-11 and was 98% of the 30 year average (Figure 1). Temperature analysis for Fort Collins revealed that the 2011-12 winter temperatures was 1.28°C warmer than 2010-11 and was 1.50°C warmer than the 30 year average (Figure 2). Wind speed analysis for Fort Collins revealed that 2011-10 wind speeds were similar to 2010-11 and similar to the 15 year average (Figures 3-4).

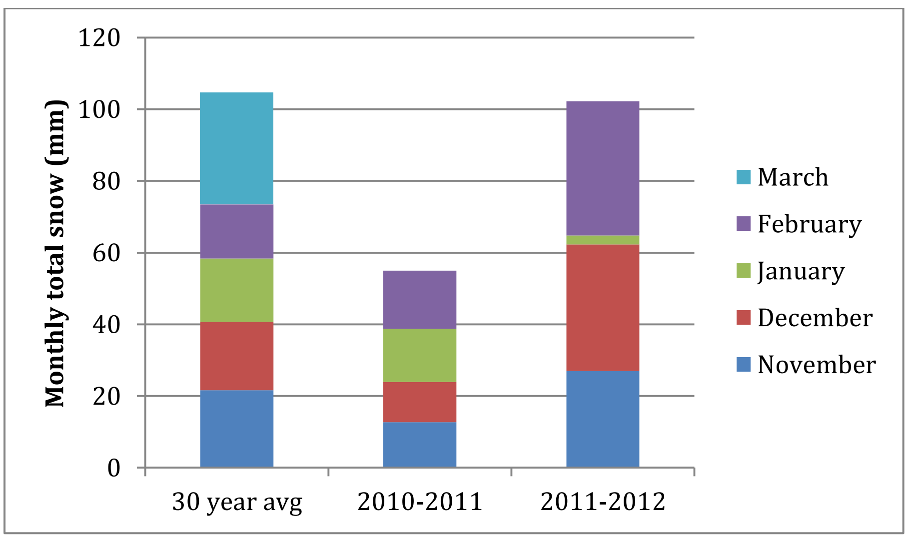

Figure 1. *Fort Collins Weather Station monthly snow totals*

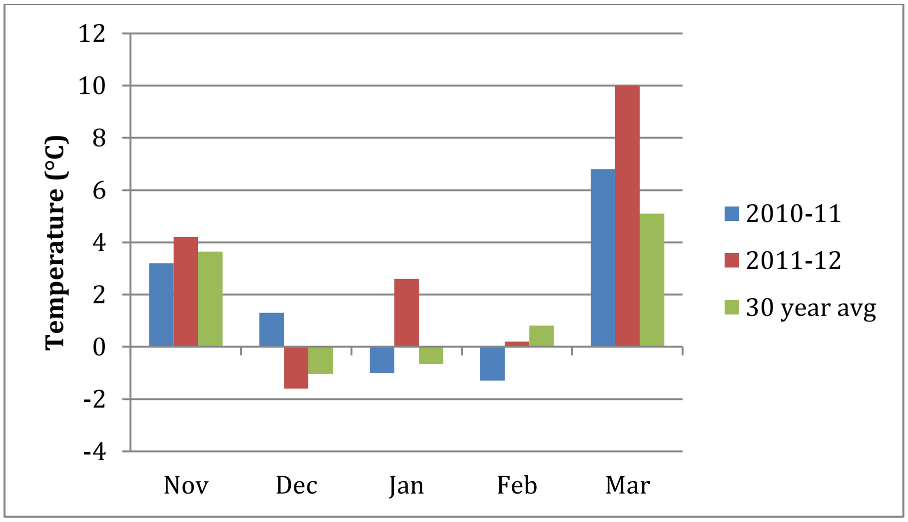

Figure 2. *Fort Collins Weather Station average monthly temperatures*

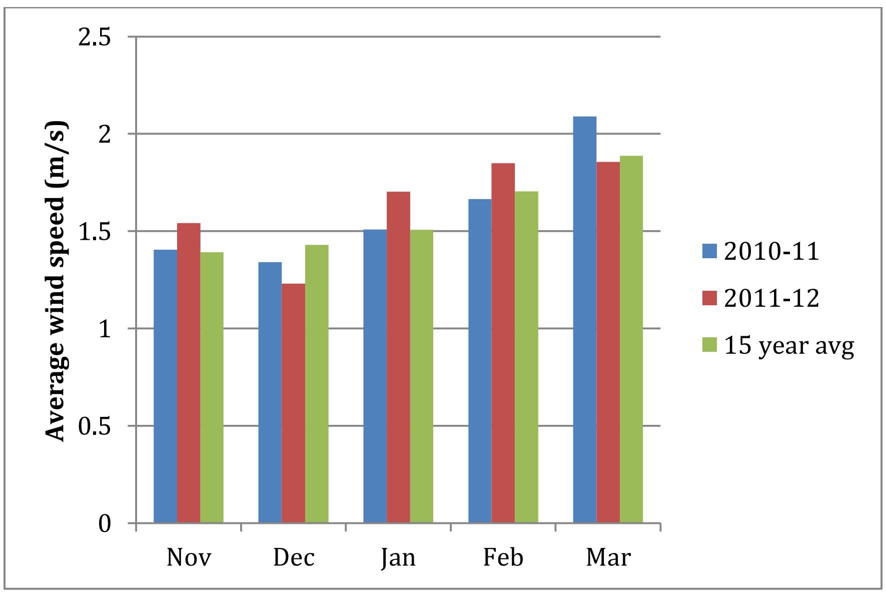

Figure 3. *Fort Collins Weather Station average monthly wind speed*

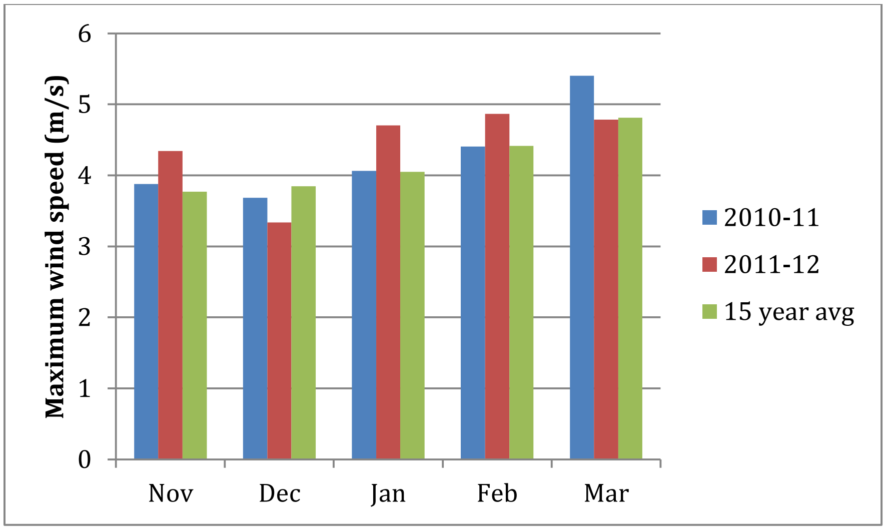

Figure 4. *Fort Collins Weather Station maximum monthly wind speed*

Analyzing the Aspen, Climax, and Steamboat Springs precipitation revealed that the 2011-12 winter (mountains) had 48% less snow than 2010-11 and was 71% of the 30 year average (Figures 5-7).

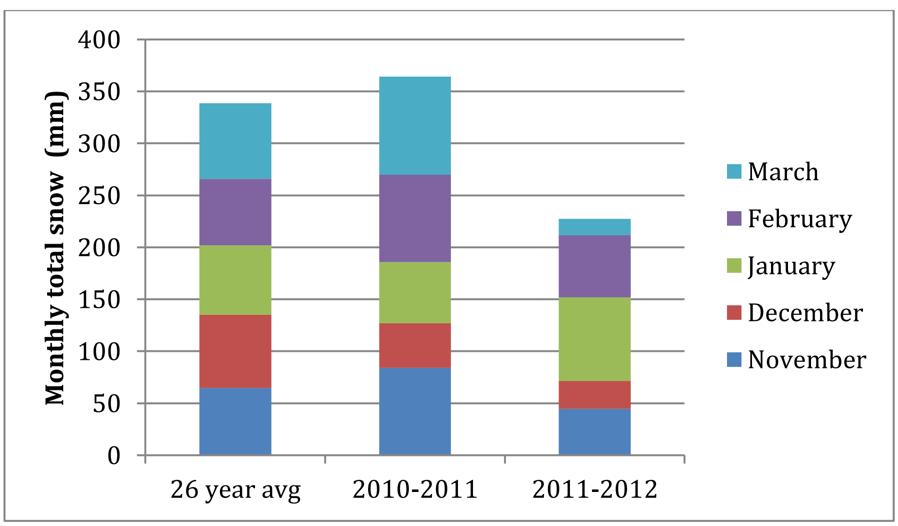

Figure 5. *Aspen Weather Station monthly snow totals*

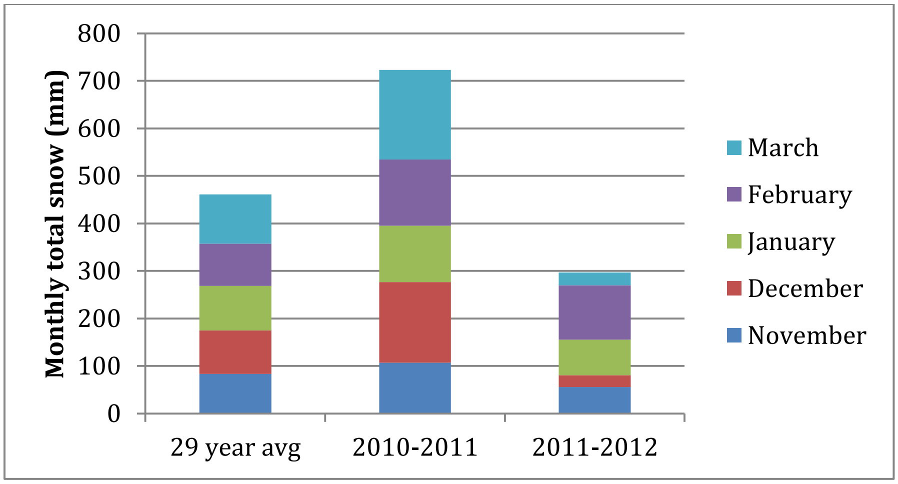

Figure 6. *Climax Weather Station monthly snow totals*

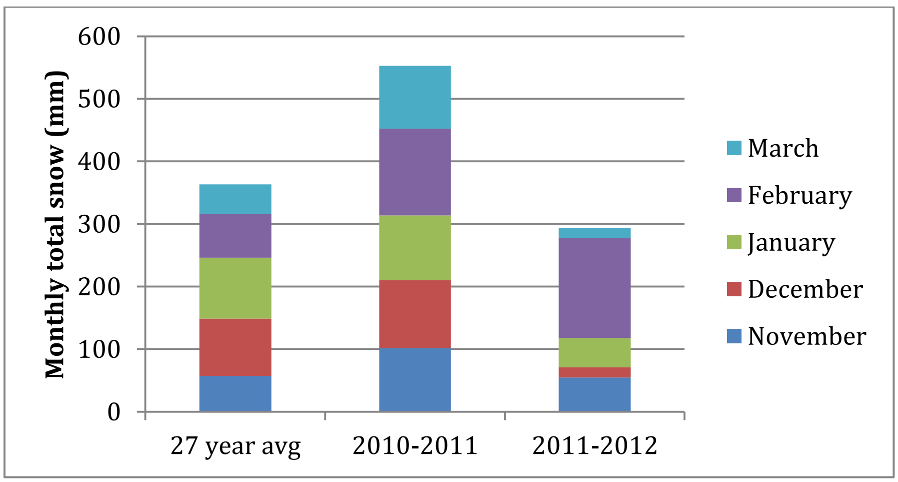

Figure 7. *Steamboat Weather Station monthly snow totals*

Analyzing the Aspen, Climax, and Steamboat Springs temperature data revealed that the 2011-12 winter (mountains) was 1.04°C warmer than 2010-11 and 0.79°C warmer than the 30 year average (Figures 8-10).

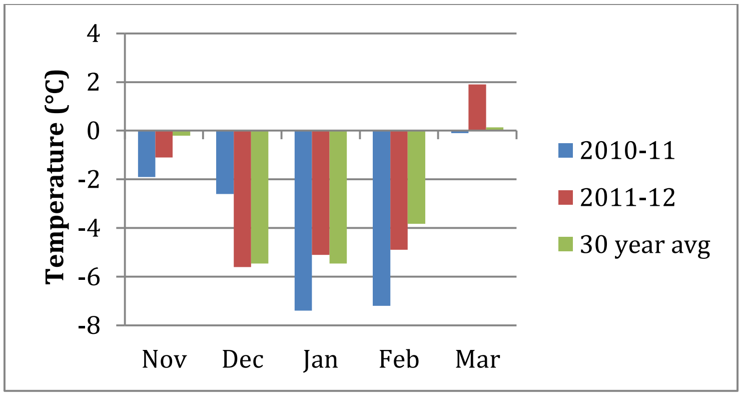

Figure 8. *Aspen Weather Station average monthly temperatures*

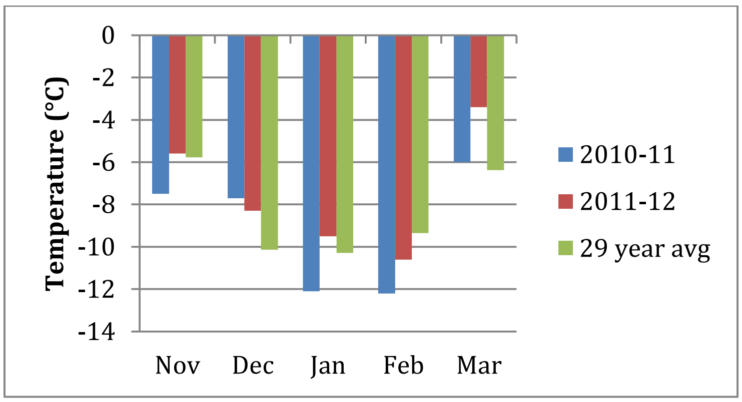

Figure 9. *Climax Weather Station average monthly temperatures*

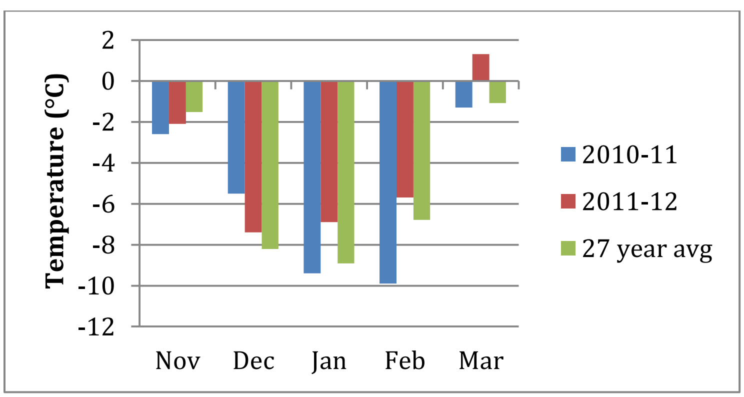

Figure 10. *Steamboat Weather Station average monthly temperatures*

Wind speed analysis for C1-Niwot revealed that 2011-10 wind speeds were similar to 2010-11 and similar to the 21 year average (Figure 11).

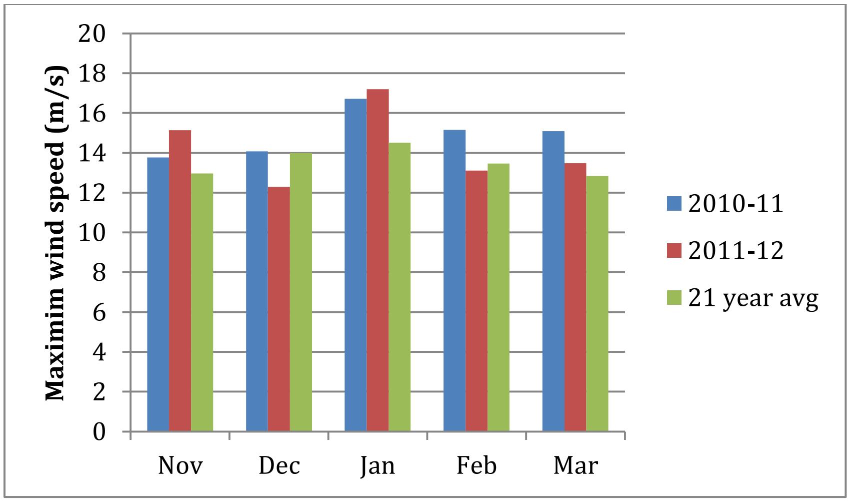

Figure 11. *C-1: Niwot Weather Station maximum monthly wind speed*

Trend analysis of winter precipitation for all stations revealed no statistically significant trends. Climax showed the largest rate of change in winter precipitation with a Q=400mm/100 yr (z=1.41) but was not statistically significant. Trend analysis of winter temperatures for all stations revealed that Fort Collins: Q=4.5°C/100 yr (z=2.00), and Aspen: Q=3.5°C/100 yr (z=1.57), show the largest rate of change in temperature. Fort Collins was the only station found to have statistically significant higher temperatures (p= 0.04). Trend analysis of wind data for Fort Collins and C1-Niwot revealed significantly higher max wind speeds at C1-Niwot (Q=20.6 m/s /100 yr, z=2.99, p=0.0028) and no significant trends in Fort Collins wind data .

Results from analysis of meteorological data were used to determine which responses were correct for each corresponding questionnaire item (Tables 2-5).

Table 2. Correct response concerning winter precipitation based on meteorological data analysis.

Questionnaire Item	Correct Answer	Meteorological Statistics "Why Correct"	Significance	Correct
1a. How much precipitation did the Front Range receive this past winter compared to the last winter?	Large/Very Large Amount	186%	Z= -0.838	3.10%
1b. How much precipitation did the Front Range receive this past winter compared to previous winters?	Average	98%	Z= -0.313	20.40%
2a. How much precipitation did the mountains received this past winter compared to the last winter?	Very Small Amount	52%	Aspen: Z= -1.567, Climax: Z= -2.402, Steamboat: Z= -1.567	29.10%
2b. How much precipitation did the mountains received this past winter compared to previous winters?	Very Small/Small Amount	71%	Aspen: Z= -1.567, Climax: Z= -1.567, Steamboat: Z= -1.358	66.80%

Table3. Correct response concerning winter temperatures based on meteorological data analysis.

Questionnaire Item	Correct Answer	Meteorological Statistics "Why Correct"	Significance	Correct
3a. What was the temperature like this past winter in the Front Range compared to the last winter?	Warm/Very Warm	(+)1.28 degrees C	Z=-0.313	51.50%
3b. What was the temperature like this past winter in the Front Range compared to previous winters?	Warm/Very Warm	(+)1.50 degrees C	Z=-0.313	2.00%
4a. What was the temperature like this past winter in the mountains compared to the last winter?	Warm	(+)1.04 degrees C	Aspen: Z= -0.522, Climax: Z= -0.731, Steamboat: Z= -0.522	33.70%
4b. What was the temperature like this past winter in the mountains compared to previous winters?	Warm	(+)0.79 degrees C	Aspen: Z= -0.105, Climax: Z= -0.522, Steamboat: Z= -0.522	38.80%

Table 4. Correct response concerning winter wind based on meteorological data analysis.

Questionnaire Item	Correct Answer	Meteorological Statistics "Why Correct"	Significance	Correct
5a. How windy was it this past winter in the Front Range compared to the last winter?	Average	102%	Average Wind Speed: Z=-0.522. Max Wind Speed: Z= -0.522	35.20%
5b. How windy was it this past winter in the Front Range compared to previous winters?	Average	104%	Average Wind Speed: Z=-0.313. Max Wind Speed: Z= -0.731	41.80%
6a. How windy was it this past winter in the mountains compared to the last winter?	Average	95%	Max Wind Speed: Z= -0.940	33.20%
6b. How windy was it this past winter in the mountains compared to previous winters?	Average	105%	Max Wind Speed: Z= -0.522	32.10%

Table 5. Correct response concerning winter meteorological trends based on meteorological data analysis.

Questionnaire Item	Correct Answer	Station Statistics "Why Correct"	Significance	Correct
7. What trend do you see in precipitation since you were younger?	Similar	Fort Collins: Q= -0.515, Aspen: Q=0.491, Climax: Q=4.004, Steamboat: Q=-0.739	Fort Collins: Z= -0.75, Aspen: Z= 0.09, Climax: Z= 1.41, Steamboat: Z= -0.739	23.50%
8. What trend do you see in temperature since you were younger?	Similar/More	Fort Collins: Q= 0.045, Aspen: Q=0.035, Climax: Q=0.007, Steamboat: Q=-0.014	Fort Collins: Z= 2.00, Aspen: Z= 1.57, Climax: Z= 0.32, Steamboat: Z= -0.23	78.60%
9. What trend do you see in wind since you were younger?	Similar/More	Fort Collins Average: Q= -0.054, Fort Collins Max: Q=0.174, Niwot Max: Q=0.206	Fort Collins Average: Z= -0.69, Fort Collins Max: Z= 0.40, Niwot Max: Z= 2.99	62.80%

Items 2b, 3a, 8, and 9, were the only questions where at least 50% of the respondents had the correct responses. Items 1a (3% correct) and 3b (2% correct) were the questions with the least amount of correct responses. Items 2b (67% correct) and 8 (79% correct) were the questions with the most correct responses. The mean percentage for correct responses to all questionnaire items was 37%. The t-test analyses revealed that questionnaire responses did not match observed data for any questions concerning precipitation and temperature. For questions concerning wind: 5a, 5b, and 6b, were the only responses that did match observed data. Table 6 lists the hypotheses results.

Table 6. Null hypotheses results (see abstract for entire t-test analyses results)

Questionnaire Items	**Null hypotheses: there is no difference between responses and correct response**
Precipitation	*Null Hypothesis (reject p<0.05)*
1a. How much precipitation did the Front Range receive this past winter compared to the last winter?	Reject*
1b. How much precipitation did the Front Range receive this past winter compared to previous winters?	Reject*
2a. How much precipitation did the mountains received this past winter compared to the last winter?	Reject*
2b. How much precipitation did the mountains received this past winter compared to previous winters?	Reject*
7. What trend do you see in precipitation since you were younger?	Reject*
Temperature	*Null Hypothesis (reject p<0.05)*
3a. What was the temperature like this past winter in the Front Range compared to the last winter?	Reject*
3b. What was the temperature like this past winter in the Front Range compared to previous winters?	Reject*
4a. What was the temperature like this past winter in the mountains compared to the last winter?	Reject*
4b. What was the temperature like this past winter in the mountains compared to previous winters?	Reject*
8. What trend do you see in temperature since you were younger?	Reject*
Wind	*Null Hypothesis (reject p<0.05)*
5a. How windy was it this past winter in the Front Range compared to the last winter?	Retain
5b. How windy was it this past winter in the Front Range compared to previous winters?	Retain
6a. How windy was it this past winter in the mountains compared to the last winter?	Reject*
6b. How windy was it this past winter in the mountains compared to previous winters?	Retain
9. What trend do you see in wind since you were younger?	Reject*

The following results describe the relationship between questionnaire items 1-9 and gender, years lived in the Front Range, winter recreation participation, and source of winter weather information.

a) Gender: For this sample population there were 95 females and 101 males. Analysis shows that females were correct more than males overall (Figure 12).

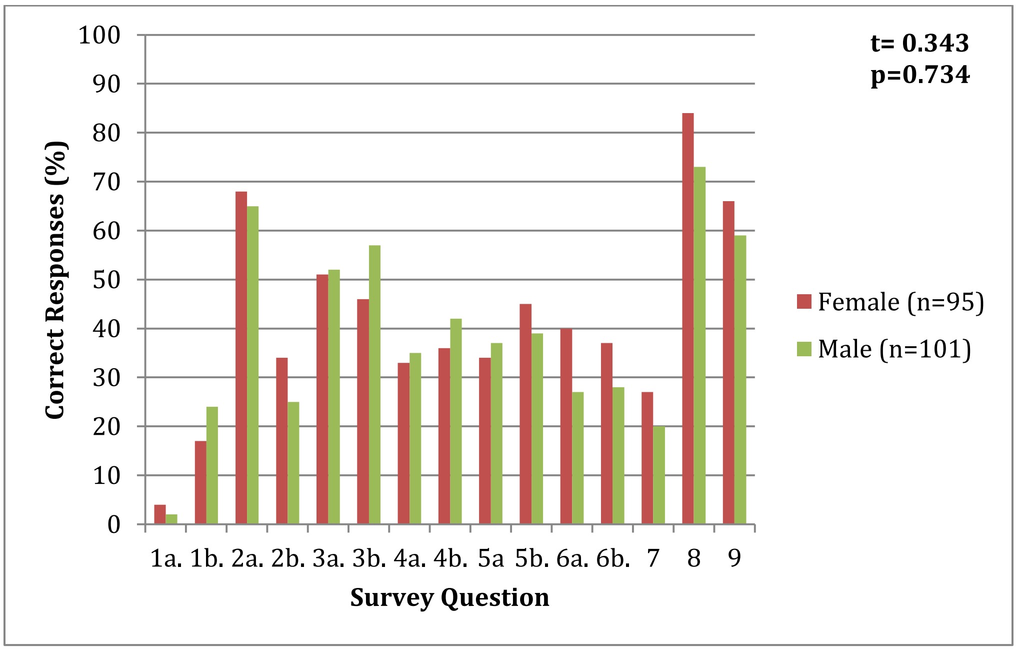

Figure 12. *Percentage of correct responses for females and males*

Female's percentage of correct responses has a mean=41.46 and males percentage of correct responses has a mean =39.00. Women were at least 10% more correct than males for items 6a and question 8. A t-test analysis of the data shows that there is not a statistically significant difference between males (M=39.00, SD=20.15) and females (M=41.47, SD=20.15) with relation to correct survey responses, t (28)=0.343, p=0.734.

b) How many years lived in the Front Range: For this sample population, the range of responses for how many years lived in the Fort Collins ranged from 0 to 48 years (those who have lived in Fort Collins less than 3 years and did not live in Front Range areas previously were excluded). Analysis shows that the percentage of correct responses does not increase with increased years lived in the Front Range (Figure 13).

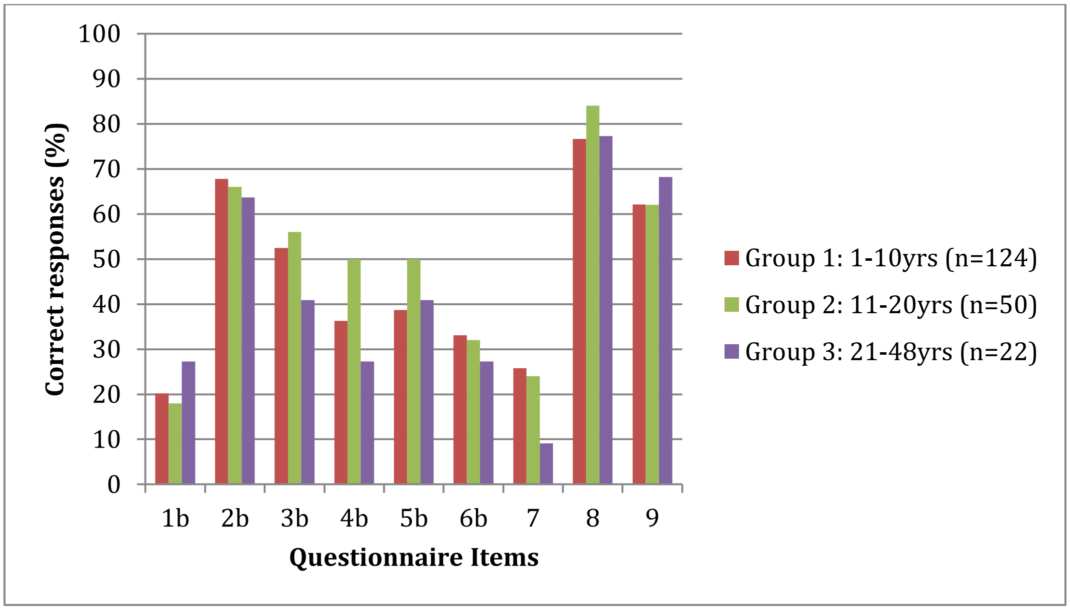

Figure 13. *Percentage of correct responses based on number of years in Front Range*

Group 1 (3-10 years with n=124) has a mean of 46%. Group 2 (11-20 years with n=50) has a mean of 49%. Group 3 (21-48 years with n=22) has a mean of 41%. Statistical analysis of both the grouped data as well as raw data showed no statistically significant positive correlation between the numbers of years lived in the Front Range and the percentage of correct survey responses (Table 7).

Table 7. Correlation analysis between number of years lived in Front Range and correct responses.

	Years in Front Range		Years in Front Range (Groups)	
Questionnaire Items	**Pearson Correlation**	**Significance**	**Pearson Correlation**	**Significance**
1a.	N/A	N/A	N/A	N/A
1b.	0	0.999	0.024	0.899
2a.	N/A	N/A	N/A	N/A
2b.	-0.181	0.33	-0.033	0.862
3a.	N/A	N/A	N/A	N/A
3b.	-0.051	0.786	-0.09	0.63
4a.	N/A	N/A	N/A	N/A
4b.	-0.2	0.28	-0.188	0.312
5a.	N/A	N/A	N/A	N/A
5b.	0.057	0.763	-0.008	0.966
6a.	N/A	N/A	N/A	N/A
6b.	-0.083	0.659	-0.081	0.663
7	-0.33	0.07	-0.406	0.023
8	-0.029	0.876	-0.001	0.996
9	0.12	0.52	0.102	0.585

c) Participation in winter recreation: The first analysis transformed the winter recreation variable R*F into either did participate or did not participate (R*F>0=did participate). For this sample population there were 75 respondents who did not participate in winter recreational activities and 119 respondents who did. Analysis shows those who participate had a higher mean percentage of correct responses for items 2a, 2b, 4a, 4b, 6a, 6b, 7, 8, 9; items corresponding to mountain winters (Figure 14).

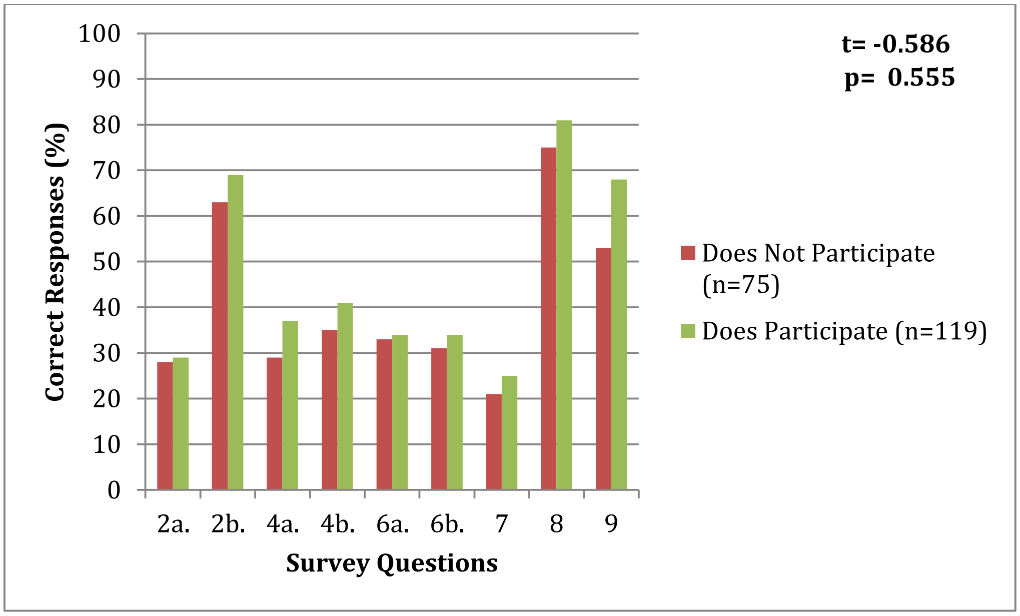

Figure 14. *Percentage of correct responses based on participation in winter recreation activities*

Those who participate in winter recreational activities percentage of correct responses have a mean of 46% and those who do not participate percentage of correct responses has a mean of 40%. A t-test analysis of the data shows that there is not a statistically significant difference between those who do not participate (M=40.44 , SD=18.091) and those who participate (M=45.78 , SD=20.468) with relation to correct survey responses, t (19)= -0.586, p=0.555.

The second analysis used the R*F values to determine if there was a correlation between participation in winter recreation and items 2a., 2b., 4a., 4b., 6a., 6b., 7, 8, 9; items corresponding to mountain winters (Figure 15).

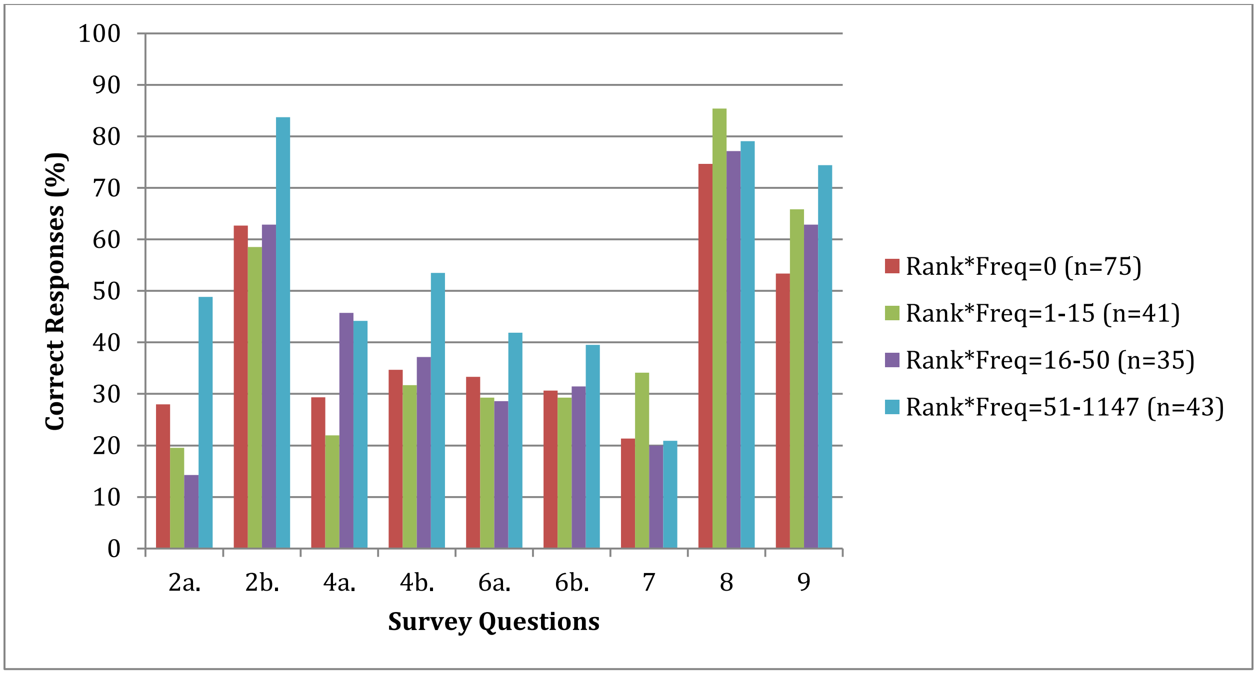

Figure 15*. Percentage of correct responses based on winter recreation rank*frequency values*

The group with the highest percentage of correct responses was Group 4 (51-1147) has a mean of 53%. Group 2 (1-15) has the second highest percentage of correct responses has a mean of 41%, closely followed by Group 1 (does not participate) has a mean of 40%. The group with the lowest percentage of correct scores was Group 3 (16-50) has a mean of 34%. Statistical analysis revealed that items 2b, and 6, both show a positive relationship between R*F and the percentage of correct responses. Item 2b, has the strongest relationship between variables (Pearson Correlation=0.348, p=0.006) (Table 8).

Table 8. Correlation analysis between winter recreation (rank*frequency) and correct responses.

	Rank*Frequency		Rank*Frequency (Groups)	
Survey Questions	**Pearson Correlation**	**Significance**	**Pearson Correlation**	**Significance**
1a	N/A	N/A	N/A	N/A
1b	N/A	N/A	N/A	N/A
2a	0.210	0.101	0.337	0.007
2b	0.348	0.006	0.378	0.002
3a	N/A	N/A	N/A	N/A
3b	N/A	N/A	N/A	N/A
4a	-0.034	0.792	0.192	0.136
4b	0.073	0.574	0.252	0.048
5a	N/A	N/A	N/A	N/A
5b	N/A	N/A	N/A	N/A
6a	0.210	0.101	0.125	0.333
6b	0.284	0.025	0.157	0.224
7	0.201	0.117	-0.131	0.309
8	0.166	0.197	0.015	0.907
9	0.159	0.216	-0.018	0.890

d) Source of information: This analysis determined if the amount of sources for winter weather information correlates with the percentage of correct responses (Figure 16).

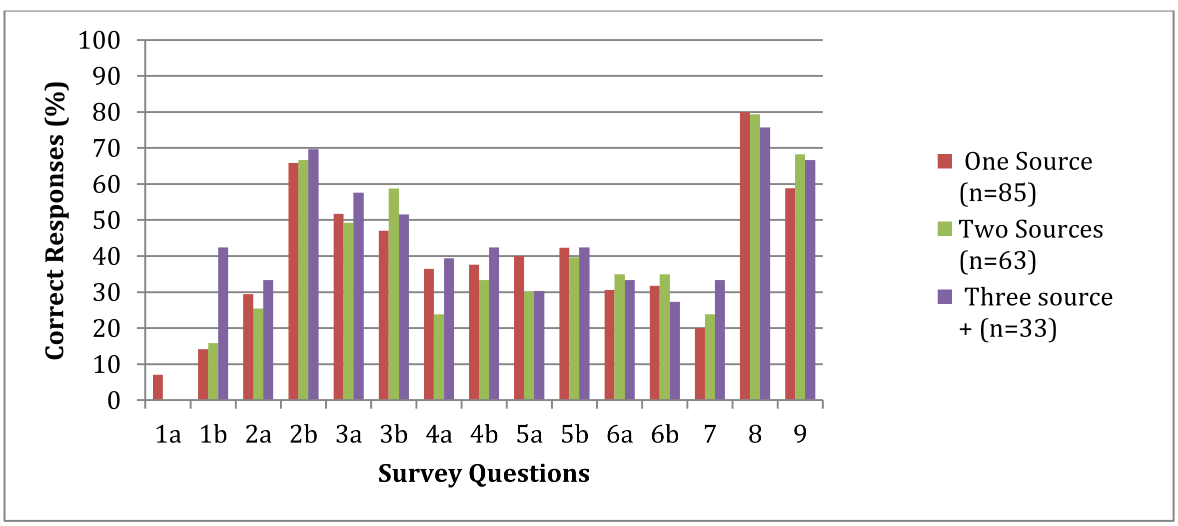

Figure 16. *Percentage of correct responses based on the how many sources are used for winter weather information*

Group 3 (three or more sources with n=33) has the highest percentage of correct responses with a mean of 43%. Group 1 (one source with n=85) has the second highest percentage of correct responses with a mean of 40%. The group with the lowest percentage of correct responses was Group 2 (two sources with n=63) with a mean of 39%. Statistical analysis revealed that questions 1b, 2a, 2b, 3a, 3b, 4b, 6a, 7, and 9, all show a moderate to strong positive relationship between the number of sources used for winter weather information and percentage of correct responses but no statistically significant correlations were found (Table 9).

Table 9. Correlation analysis between the number of winter weather information sources used and correct responses.

	Number of Winter Weather Information Sources	
Survey Questions	**Pearson Correlation**	**Significance**
1a	-0.866	0.333
1b	0.893	0.298
2a	0.496	0.670
2b	0.946	0.211
3a	0.674	0.529
3b	0.376	0.755
4a	0.175	0.888
4b	0.530	0.644
5a	-0.860	0.341
5b	0.008	0.995
6a	0.625	0.570
6b	-0.589	0.599
7	0.971	0.154
8	-0.927	0.245
9	0.777	0.434

1.5 Discussion

1.5.1 What words do Front Range residents use to describe snow and winter weather?

Analysis of the pilot study revealed many similarities to Toupin's (2001) research results. Similarities include "snow" and "cold" as words most used to describe winter. Also similar, some respondents use words with positive connotations while other respondents use words with negative connotations to describe the same winter. Analysis also revealed that 100% of the respondents, who used words with positive connotations to describe winter, participate in winter recreational activities. These results reinforce Toupin's conclusion that demographic and environmental factors can influence perception of winter weather and words used to describe these perceptions.

1.5.2 How do Front Range residents' perceptions of snow, winter weather and hydrologic events compare to actual meteorological data?

Analysis of the questionnaire with respect to correct responses revealed that the majority of respondent's perception of winter weather and climate did not correspond with the observed meteorological data. Items 2b, 3a, 8, and 9, were the only questions in which at least 50% of participants (n=196) listed the correct response. Items 1a, and 3b, are both questions concerning the Front Range (where all participants currently live) in which less than 4% of participants answered correctly. Similar to Knez and Thorsson (2006), Tronrud & Petzold (1998), and Meze-Hausken's (2004) earlier research, perceptions of weather and climate do not necessarily match observed meteorological data. Item 1a *(How much precipitation did the Front Range receive this past winter compared to the last winter?*) was expected to be a question with a high percentage of correct answers due to 2011-12 having almost twice the amount of snow (186%) as 2010-11, but was the question with the second least amount of correct responses. Although why exactly perceptions were so different than observed data is not clear, one explanation is that Front Range residents may be forming their perception of winter weather and snow by what is happening in the mountains and assuming the same for the Front Range. This would be a poor assumption since the mountains experienced record snowfall in 2010-11 while the Front Range experienced well below average snowfall in 2010-11.

1.5.3 Meteorological Data

While station selection was carefully determined to best represent areas corresponding with survey questions (Front Range and mountains), using weather stations which truly only represent their exact location spatially to extrapolate and summarize climatic variables over large areas may create discrepancies between observed meteorological data and what survey respondents may have observed. Unavoidably, all weather stations are subject to issues with extrapolation due to spatial variability as well as data continuity issues caused by variability among instrument type, location, collections method and period of record (Legates and Deliberty, 1993). Thirty year datasets similar to those used to calculate climate normal for precipitation and temperature would have been desired for wind as well but are unavailable. Continuous long term datasets for wind speed are nonexistent for areas corresponding with survey questions so the longest available datasets were used.

1.5.4 Do individual characteristics (e.g. participation in winter recreational activities, source of winter weather information, years lived in Front Range) shape perceptions of winter weather and climate?

Analysis of the questionnaire revealed that differences between perception and observed meteorological data may be attributed to individual characteristics that shape perceptions of winter weather and climate. Individual characteristics that did not influence correct responses to survey questions are gender, and years lived in the Front Range. Although gender was not expected to influence correct responses to survey questions, it was expected that years lived in the Front Range would influence correct responses to questions concerning past winters, this was not observed. Individual characteristics that did influence correct responses to survey questions are participation in winter recreational activities, and the amount of sources used to obtain information on winter weather and climate. Direct exposure to winter weather and climate associated with winter recreational activities could explain why this individual characteristic influences correct responses. The amount of sources used to gain information about winter weather and climate is not associated with direct exposure to winter weather and climate but is associated with the organization of information used to form perceptions. Perception is described as the organization, identification, and interpretation of sensory information in order to represent and understand the environment (Schacter, 2011). Perception of weather and climate can be influenced by a number of variables such as, direct exposure to weather and climate, exposure from a variety of media sources, and cultural and social factors (Stewart, 2007). This study not only reinforce previous studies results in which individual characteristics that influence perception of weather and climate are identified but also which individual characteristics may influence perceptions that aligns with observed metrological data (the "correct" perception). Due to the questionnaires being administered over a short period of time; in which little to no variation in weather variables was observed during the administration, it could not be determined how current weather effects perception of winter weather and snow . Further research should extend the sampling period so that it can be determined if current weather conditions effect perception of snow and winter.

1.6 Conclusions

Analysis of the pilot study was successful in determining what words Front Range residents use to describe winter weather and climate. While words such as "cold" and "snow" are most commonly used, Front Range residents also used words with different connotations to describe the same winter. Analysis of the questionnaire was successful in determining that perceptions of winter weather and climate do not necessarily align with observed meteorological data, and some individual characteristics do influence perception. Although results from this study conclude that some individual characteristics may influence perceptions to align with observed data, for some questions, almost all respondents' perceptions were incorrect regardless of individual characteristics.

Extensive research focusing on words used to describe winter weather and climate as well as perceptions of winter weather and climate does not yet exist. Research that does exist highlights the complexities associated with forming perceptions and the variations of perception between individuals. Further research addressing why such large percentages of Front Range residents have misleading perceptions of winter weather and climate may be useful in improving communication of water resource related issues and concerns. As Colorado's Front Range population continues to grow, and water resources are stretched thinner, communication about water resources will become ever more important.

1.7 References

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APPENDIX A: LITERATURE REVIEW

A-1 Winter Weather, Climate and Its Perception

"*The anticipation of snow, followed by preparation for it, the actual experience of it, recovery from its effects, and finally the memory of snow after the spring melt, make snow consciousness a part of everyday life*" (Mergen, 1997). Across most of the Western United States (U.S.), between 60 and 75 percent of annual precipitation falls as snow while in the Northern Great Plains and other areas of the U.S. only 20% of the annual precipitation falls in forms of snow (Doesken and Judson, 1996). Snow is an invaluable resource that influences the national economy providing life-giving water, yet a growing majority of the U.S. population now lives in areas that receive very little snowfall, such as the Southern California, Las Vegas, Phoenix and the Colorado Front Range (Doesken and Judson, 1996). Although snow is a valuable natural resource, it is also the source of huge routine cost; annually in excess of $2 billion is spent in the U.S. for snow removal of streets and highways (Doesken and Judson, 1996). Catastrophic winter storms are less expected, and between 1949 and 2003, 202 such storms occurred (each causing more than $1 million in damages) totaling $35.2 billion (2003 dollars) in losses and were responsible for the deaths of 30 to 40 persons each year (Changnon, 2007). Although these examples highlight the importance as well as the dilemmas associated with snow, society generally has a lack of appreciation of the importance of snow to everyday life (DeWalle and Rango, 2008).

Due to snow being such a dynamic resource, the perceptions of snow and winter may be just as dynamic and understanding what factors influence these perceptions may help with the transfer of information about winter weather to the public. The lack of connection with snow previously mentioned may influence why there are different connotations to words used to describe winter weather as well as why people may have different perceptions of winter weather and climate. Perception is described as the organization, identification, and interpretation of sensory information in order to represent and understand the environment (Schacter 2011). Due to perception being developed by such a complex mixture of information and processing of information, it could be argued that perception can be very dynamic and may vary person to person.

A-2 Words Used to Describe Snow and Winter Weather

When asked about snow and winter, people sometimes respond with "*it's a bad winter*" or "*it's a good winter*." A "bad" winter has a very different meaning to different people. Words associated with winter, such as cold and snowy, can have different connotations to different people experiencing the same weather. Exposure to subsequent atmospheric conditions as well as weather forecasts may assist society in developing a range of descriptive terms and narratives that are useful for perceiving current climate conditions (Stewart, 2007). A 1996 study by Toupin (2001) surveyed the public in two towns in the St. Lawrence Valley, Quebec (Canada). One of the survey questions asked was, "*how would you define winter?*"; the term mostly used was "cold" (42% in Trois-Rivières representing an urban area, 30% in Champlain representing a rural area) and "snow" (28% in Champlain, 23% in Trois-Rivières) (Table 1.1) (Toupin, 2001). Additional words used to describe winter are presented in Table 1.1. In Trois-Rivières, people tend to describe winter in a negative way (dreary,long, miserable, painful) and became increasingly negative with age (r=0.63) (Toupin, 2001), while some people in Champlain describe winter in a positive way (nice, beautiful, love it) and the perception of winter became less negative with age (r=0.23) (Toupin, 2001). Positive aspects of winter including the participation in winter sports were always more noticeable in Champlain (Toupin, 2001). Toupin's (2001) results reinforce that demographic and environmental factors can influence perception of winter weather and the words that we use to describe these perceptions.

Table A-1. Summary of the most frequent terms defining winter (*from* Toupin, 2001).

term(s)	*Champlain n=40*		*Trois Rivières n=113*	
	n	**%**	**n**	**%**
Cold	12	30	47	42
Snow	11	28	26	23
Dreary, long, miserable	1	3	16	14
nice, beautiful, love it	5	13	5	4
game, sport	4	10	5	4
Peaceful	3	8	3	3
White	3	8	5	4
Clothes	1	3	6	5
Rest	2	5	2	2
cold and **snow**	1	3	6	5

Understanding words used to describe changes in climatic characteristics such as "global warming or climate change" and why these words have different connotations to various sectors of society, has become an increasingly important topic. All aspects of human dimensions of global climate change have become an important topic (Jacobson et al. 1990; Jaeger et al., 1993; Rebetez, 1996; Stern et al., 1992). The transfer of scientific information on climate to the public poses many issues to scientist (Kearney, 1994). Unlike most other environmental issues, the terms used to describe increasing atmospheric concentrations of anthropogenic greenhouse gases are many, with multiple and even conflicting meanings (Akerlof and Maibach, 2011). For the better part of the past decade, social scientists, marketers and political strategists have understood that the words commonly used to describe planetary changes resulting from increasing greenhouse gases, specifically global warming, climate change, and global climate change, each have different connotations to the public (Akerlof and Maibach, 2011). The very definition of climate change varies between the two foremost expert groups in this field, the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) treaty (Akerlof and Maibach, 2011). If significant variation of connotations associated with "climate change" exists, it potentially represents a barrier to effective communication with diverse audiences, and to the validity of measurement in public opinion polls and other social science research that employ these terms to evaluate beliefs, attitudes, and affective and behavioral responses (Akerlof and Maibach, 2011).

A-3 Factors that shape societies' perceptions of winter weather and the accurateness of these perceptions when aligned with meteorological data

Weather and climate perception is the process by which society seeks to understand their surrounding atmospheric conditions where they live so that they might be able to effectively respond and adapt (Stewart, 2007). Perception of weather and climate can be influenced by a number of variables such as, direct exposure to weather and climate, exposure from a variety of media sources, and cultural and social factors (Stewart, 2007). Human perception of climate can be strongly influenced by expectations, which may have little connection to the actual nature of climate as provided by the instrumental record (Rebetez, 1996). A 2006 study examined the influence that environmental attitude (urban versus open-air person), and culture (Swedish versus Japanese) had on participants' thermal, emotional and perceptual assessment of an open square with physiological equivalent temperature (comfortable interval of 18-23°C) (Knez and Thorsson, 2006). Results verified that environmental and social factors do influence perception of weather and climate. Japanese participants estimated the weather as warmer than did the Swedish participants and, Japanese consistently felt less thermally comfortable on site, although participants in both countries perceived similar comfortable outdoor conditions (Knez and Thorsson, 2006). "This indicates that thermal, emotional and perceptual assessments of a physical place may be intertwined with psychological schema-based and socio-cultural processes, rather than fixed by general thermal indices developed in line with physiological heat balance models" (Knez and Thorsson, 2006).

Surveys conducted in 1999 and 2002 in northern Ethiopia resulted in a paper titled "Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia" (Meze-Hausken, 2004) and relates closely with the research conducted in this thesis. Most of the population of northern Ethiopia survives on subsistence farming (Meze-Hausken, 2004), due to the intimate relationships farmers have with land and water resources, farmers possess local knowledge or memory of changes in climate (Fassnacht *et al.*, 2011). Meze-Hausken (2004) compares results from interviews and discussions in focus groups in northern Ethiopia during 1999 and 2002 and compares these results with historical rainfall data from four rainfall stations in northern Ethiopia. Although the different groups interviewed could not agree on a perceived time or a perceived reason, all groups agreed that there has been a decline in rainfall in northern Ethiopia (Meze-Hausken, 2004). After analyzing 40 years of rainfall data from the four rainfall stations, the 1980s, remembered by most because of the large-scale famine conditions, were on average the wettest years during the last 40 years, whereas the 1970s had the lowest amount of summer rainfall (Meze-Hausken, 2004). The 1960s had the wettest spring rainfalls, followed by poor early rains in the spring during the next decade (Meze-Hausken, 2004). The mass curve (graph of accumulated standardized rainfall plotted chronologically used to investigate long-term trends) for Mekelle, one of the four rainfall stations, shows for both spring and summer rainfall a relatively even incremental growth (Meze-Hausken, 2004). These results clearly show that the perceptions of change in the amount of rainfall overtime in northern Ethiopia do not align with the meteorological data. What may explain the gap in perception of rainfall and actual rainfall data? One explanation for this gap is, the amount of rainfall, and the amount of water that is tangible to any given person do not always correlate and can change due to social and environmental factors. It can be assumed that, while the supply of rainfall has not decreases during recent decades, demand for it has increased (Meze-Hausken, 2004). Ethiopia's population has grown from 24 million to 65 million between 1960 and 2000 and is one of the major factors in increased demand for water (Meze-Hausken, 2004). Weather cycles are often idealized and simplistic, giving a feeling of reliability and predictability (Stehr, 1997). Any deviation from this expected outcome creates insecurity and it is reasonable to assume that a year in which food production drops to a level that threatens a family's welfare could be classified as a drought, regardless of the amount of rainfall (Meze-Hausken, 2004). Drought may serve for the northern Ethiopian people as a synonym for starvation, which may or may not be directly related to the amount of rainfall (Meze-Hausken, 2004). The implications of this research re-enforces that analysis of subjective observations about weather and climate requires a deeper investigation of the social economic, environmental and cultural drivers experienced by the affected people (Meze-Hausken, 2004).

Another relevant study conducted by D.E. Petzold, a University of Wisconsin-River Falls professor, investigated the accuracy of elderly resident's perception of past winters in NW Wisconsin. A survey was administered to elderly residents to document their perception of past winters (Tronrud and Petzold, 1998). Next, climate data from NW Wisconsin were summarized to determine the accuracy of the perceived severity (Petzold). Results concluded that memories of the most severe winter weather are associated with childhood (Tronrud and Petzold, 1998)Only one respondent chose the 1970s as the coldest decade, which was correct (Tronrud and Petzold, 1998)A majority of respondents chose the 1930's as being the coldest decade, which it was not (Tronrud and Petzold, 1998). Petzold attributes the majority of the respondents choosing the 1930's as the coldest decade because the most severe winters of their lives were associated with walking to school. Over 35 percent of subjects chose 1950's as the snowiest decade, when in fact it was the least snowiest (Tronrud and Petzold, 1998). Petzold attributes this to the 1950-51 winter being exceptionally snowy across the Midwest. This study also highlights that there may be a variety of influences that shape perception of winter weather and that perception may not align with observed meteorological data.

A-4 Analysis Methods

A-4-1 Human Dimensions Survey Analysis

The questionnaire is a recognized tool within social science research for acquiring information on participant social characteristics, behaviors, standards of behavior or attitudes and beliefs and reasons for action with respect to the topic (Bird, 2009; Bulmer, 2004). "*In general, survey research involves three major sequential tasks*" (Vaske, 2008). First, the researcher must specify hypotheses or questions that will be investigated in the study. Hypothesis and research questions help guide decisions regarding the kinds of questions that should be included in the survey (Vaske, 2008). Second, the methodology for the survey is outlined and a delivery method for administering the surveys must be chosen. There are many types of delivery methods including mail, phone, electronic, face-to-face and mixed mode surveys delivery (Vaske, 2008). None of the methods is inherently superior, but selecting a survey method requires consideration of issues including length, completion time, accuracy of answers, complexity and the availability of sample contact information etc. (Vaske, 2008). A summary of the 25 general guidelines for writing good survey questions presented by Vaske (2008) is given in Appendix A. Once a delivery method is decided on, the construction of the questions can begin. Good question design is essential in order to generate the data conductive to goals of the research once the hypotheses or research questions have been developed (Bird, 2009).

After the construction of the questionnaire, survey implementation and sampling techniques can be evaluated. Survey research involves administering questionnaires to a sample of respondents selected from a larger population (Vaske, 2008). The sample of respondents should represent the population to the best of the researcher's ability. When conducting a survey to a sample from a larger population, there will always be some sampling error because sample statistics are rarely equal to the population parameters (Vaske, 2008). Sampling approaches for questionnaires include but are not limited to, systematic sampling; simple random sampling stratified random sampling, cluster sampling and multistage sampling. For the purposes of this research, cluster sampling was selected to administer the surveys. Cluster sampling involves conducting a simple random sample of "clusters" or "groups" and then sampling people within the clusters (Vaske, 2008). It is assumed that there are geographic areas or clusters where a greater probability exists for sampling desired individuals (Vaske, 2008). If clusters can be identified, cost and time to complete data collection can be less than other sampling methods (Vaske, 2008).

After the surveys have all been administered, the survey information must be analyzed. Data analysis normally begins by examining the basic frequencies and distributional characteristics of the variables: central tendency, dispersion and shape (Vaske, 2008). Depending on the type of variable to analyzes, and how the variable is coded, the appropriate analysis strategy can be determined. The following is a table from "Survey Research and Analysis: Applications in parks, recreation and human dimensions" and is a guide to help select the appropriate analysis strategy for survey research.

Table A-2. Guidelines for Selecting an Appropriate Analysis Strategy (from Vaske, 2008).

Type of Variable		**Type of Variable**			
Independent Variable	Dependent Variable	Independent Variable	Dependent Variable	Analysis Strategy	Test Statistic
Dichotomous Categorical	Dichotomous Categorical	1	1	Chi-square	X^2
Dichotomous	Continuous	1	1	t-test (groups)	t
	Continuous	Cases	2	t-test (paired)	t
Dichotomous Categorical	Continuous	1	1	1-way ANOVA	F
Dichotomous Categorical	Continuous	2+	1	n-way ANOVA	F
Dichotomous Categorical	Continuous	2+	2+	MANOVA	F

	Continuous	Cases	2+	Repeated measures ANOVA	F
Continuous	Continuous	1	1	Correlation	F
Continuous	Continuous	1+	1	Regression	F
Dichotomous Continuous	Continuous	1+	1	Dummy variable regression	F
Dichotomous Continuous	Dichotomous	1+	1	Logistic regression	X^2
Dichotomous Continuous	Dichotomous Categorical	1+	1	Discriminant	F
Dichotomous Categorical	Dichotomous Categorical	1+	1+	Log linear	X^2

Once all research is complete, research articles should have sufficient methodological detail as well as the questionnaire provided to permit reproduction of or comparison with similar research (Bird, 2009).

A-4-2 Trend analysis of meteorological data and current research of climate trends in Colorado

Estimation, detection and prediction of trends pertaining to climate change has been heavily researched and discussed in recent years ("The Climate Guide: Trend Analysis", 2013). A trend (the rate at which a given variable changes over a time period) may be linear or non-linear, however; trends generally are synonymous with a linear slope for a line best fit to a time series ("The Climate Guide: Trend Analysis", 2013). Least squares or regression methods are most commonly used when estimating slope ("The Climate Guide: Trend Analysis", 2013). Statistical significance is usually assessed using a simple Student's *t*-test, Mann-Kendall test or bootstrapping ("The Climate Guide: Trend Analysis", 2013). Whichever test is used, the user should understand the underlying assumptions of the statistical method and the technique used to estimate a trend ("The Climate Guide: Trend Analysis", 2013). One challenge with performing trend analysis on climate data sets can be the lack of continuous data for certain regions or climatic variables. The National Oceanic and Atmospheric Administration (NOAA) recently updated the climate normals to 1981-2010. Climate Normals are the last three-decade averages of climatological variables and although it is not always possible to obtain a time series of this length at many meteorological measurement stations, this 30 years period is currently the preferred time frame for datasets estimating climate normal's and trends ("Climate Normals", 2011).

The Colorado Water Conservation Board has published a report titled: "Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation". This report is a synthesis of observed trends, modeling, and projections of temperature, precipitation, snowmelt, and runoff for Colorado. The document states that in Colorado, temperatures have increased by approximately 1°C between 1977 and 2006 (Ray *et al*., 2008). Some models project Colorado will warm by 1.4°C by 2025 and 2.2°C by 2050, relative to the 1950-99 baselines (Ray *et al*., 2008). In all regions of Colorado, no consistent trends in annual precipitation have been identified (Ray *et al*., 2008). Spatial variability of precipitation is high which can make detecting trends difficult (Ray *et al*., 2008). Precipitation and temperature trends are well documented but there is no information on trends in wind datasets reported in this report. One recent study has focused on trends in Colorado wind datasets. Fuller combined North American Regional Reanalysis (NARR) with two alpine sites (Niwot Ridge, CO and Glacier Lakes Ecological Experiments Station, Wyoming) to assess dataset agreements as well as long-term trends in wind data (Fuller, 2012). Trend analysis of wind speed datasets (annual, seasonal and daily) showed only slight trends with minimal significance and trends were not significantly different between the NARR and the station datasets (Fuller, 2012).

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APPENDIX B: SUPPLEMENATRY DATA

B-1 Pre-questionaire

How Do People Think and Talk About Snow and Winter? Prompt Sheet

INTERVIEWER: Speak <u>only</u> the italicized sections to the individual you are interviewing. Further information for you and prompts are indicated with [*]. Take notes of information that does not fit neatly into the survey using the column on the right side of the survey.

REQUEST: *Hi, my name is ___________________. I'm a student at Colorado State University and I'm conducting a brief survey about winter weather and snow. It should only take about 4-5 minutes. Would you be willing to participate?*

INTRODUCTION: *When asked about snow and winter, people sometimes respond with "it's a bad winter" or "it's a good winter". What is meant by a bad winter can have very different meanings to different people. These views can be opposing thoughts about what has or is occurring. This short survey aims to determine the terminology that people use and the specific meaning behind general words used to describe snow and winter (including winter weather*

1. *What words would you use to describe this winter season?*

2. *How does this winter compare to previous winters?* [*] If they do not answer why, prompt why. If they do not mention temperature, ask about temperature changes.

3. *We'd like to know a little bit about your* ***water-based uses****.*
   [*] For each activity identified, ask the following questions:

   1) *On a scale of 1 to 10, where 1 equals novice and 10 equals expert, how would you rank yourself for this activity?*

   2) *Approximately how many times a year do you participate in this activity?*

   a. Recreation
      i. *What Winter Recreational Activities do you participate in?*
         __ skiing (alpine) ::: ::: ::: ::: (Rank: _______; Frequency:_______)

         __ skiing (tele) ::: ::: ::: ::: (Rank: _______; Frequency:_______)

         __ skiing (nordic) ::: ::: ::: ::: (Rank: _______; Frequency:_______)

         __ snowboarding ::: ::: ::: ::: (Rank: _______; Frequency:_______)

__ snowshoeing ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ ice fishing ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ resort activities ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ snowmobile (recreation) ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ snowmobile (backcountry access) ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ backcountry ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ ice climbing ::: ::: ::: ::: (Rank: ______; Frequency:______)

ii. *What Spring/Summer/Fall Water-based Recreational Activities do you participate in?*

__ kayaking/rafting ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ angling (fly fishing) ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ fishing ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ boating (non-motor) ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ boating (motor) ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ water skiing ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ wakeboarding ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ tubing ::: ::: ::: ::: (Rank: ______; Frequency:______)

b. *Do you do anything else related to water or have you been exposed to water based issues?*

i. Job/Professional

__ agriculture (crops)

__ agriculture (ranching)

__ water management

__ other: ______________________________

__ other: ______________________________

4. *Where do you seek information about winter weather and/or snow?*
__ Internet (prompt which sites)

__ CAIC __ NWS __ <weather.com>
__ <wunderground.com>

__ CDOT __ weather channel __
<powderbuzz.com>

__ local news (list station/paper if mentioned: _____________________________________)

__ national news (list station/paper if mentioned: __________________________________)

__ resort websites list which ones: ____

__ other people's knowledge (list relation if mentioned:_______________________________)

__ other: ____

__ other: ____

5. *Finally, we'd like to know a little bit about you.*

a. *Do you currently live in Colorado? If so, how long?* ___________________________

    i. (If <10 years) *Where did you live before?* ___________________________

b. *How old are you?* ____________________________

---

[*] Record the following information:

Date ________________ Time __________ Location ______________________

Gender of Interviewee: ☐ Male ☐Female

Weather – cloud cover: __ No (clear) __ Some __ Complete

– snowing: __ No __ Yes

– temperature: ~ __ degrees (F / C)

B-2 Questionnaire

How Do People Perceive Snow and Winter Weather? *Prompt Sheet*

INTERVIEWER: Speak only the italicized sections to the individual you are interviewing. Further information for you and prompts are indicated with [*]. Take notes of information that does not fit neatly into the survey using the column on the right side of the survey.

REQUEST: *Hi, my name is ___________________. I'm a student at Colorado State University and I'm conducting a brief survey about winter weather and snow. It should take less than 5 minutes. Would you be willing to participate?* [*] If yes: *This short survey aims to determine how the public perceives winter weather (most recent winter/ previous winters) and to see how current weather conditions and peoples outdoor activities help to contribute to their perception.*

Climate Variable	**Perceived Amount of Change**					
1. *How much precipitation did the Front Range receive this past winter compared to the last winter/previous winters?*	1. Very small amount	2. Small amount	3.Average	4. Large amount	5. Very large amount	6. don't know
	1. Very small amount	2. Small amount	3.Average	4. Large amount	5. Very large amount	6. don't know
2. *How much precipitation did the mountains received this past winter compared to the last winter/previous winters?*	1. Very small amount	2. Small amount	3.Average	4. Large amount	5. Very large amount	6. don't know
	1. Very small amount	2. Small amount	3.Average	4. Large amount		6. don't know
3. *What was the temperature like this past winter in the Front Range compared to the last winter/previous winters?*	1. Very cold	2. Cold	3.Average	4. Warm	5. Very warm	6. don't know
	1. Very cold	2. Cold	3.Average	4. Warm	5. Very warm	6. don't know

4. What was the temperature like this past winter in the mountains compared to the last winter/previous winters?	1. Very cold 1. Very cold	2. Cold 2. Cold	3.Average 3.Average	4. Warm 4. Warm	5. Very warm 5. Very warm	6. don't know 6. don't know
5. How windy was it this past winter in the Front Range compared to the last winter/previous winters?	1. Very light winds 1. Very light winds	2. Light winds 2. Light winds	3.Average 3.Average	4. Windy 4. Windy	5. Very windy 5. Very windy	6. don't know 6. don't know
6. How windy was it this past winter in the mountains compared to the last winter/previous winters?	1. Very light winds 1. Very light winds	2. Light winds 2. Light winds	3.Average 3.Average	4. Windy 4. Windy	5. Very windy 5. Very windy	6. don't know 6. don't know
7. What trend do you see in precipitation since you were younger?	1. Much less	2. Less	3. Similar	4. More	5. Much more	6. don't know
8. What trend do you see in temperature since you were younger?	1. Much less	2. Less	3. Similar	4. More	5. Much more	6. don't know
9. What trend do you see in wind since you were younger?	1. Much less windy	2. less windy	3. Similar	4. More windy	5. Much more windy	6. don't know
10. ... how far back is younger when you think back	5 years	10 years	20 years	30 years	40 years	other

11*. We'd like to know a little bit about you.*

c. *Where do you currently live?* ________________________

d. *For how many years?* __________

i. [If < 10 years in the same location] *where did you leave before that* ________________________

12. *What Winter Recreational Activities do you participate in:* [*] For each activity identified, ask the following questions:

a) *On a scale of 1 to 10, where 1 equals novice and 10 equals expert, how would you rank yourself for this activity?*[*]Rank

b) *Approximately how many times a year do you participate in this activity?* [*]Frequency

__ skiing (Alpine/Tele-AT-Rondonee/Nordic) ::: ::: (Rank: ___/___/___; Frequency: ___/___/___)

__ snowboarding ::: ::: (Rank: ______; Frequency:______)

__ snowshoeing ::: ::: (Rank: ______; Frequency:______)

__ ice climbing ::: ::: (Rank: ______; Frequency:______)

__ ice fishing ::: ::: (Rank: ______; Frequency:______)

__ snowmobile (recreational/ backcountry access) ::: ::: (Rank: ___/___; Frequency:___/___)

__ resort activities ::: ::: ::: ::: (Rank: ______; Frequency:______)

__ backcountry ::: ::: (Rank: ______; Frequency:______)

__ ice skating ::: ::: (Rank: ______; Frequency:______)

__ sledding ::: ::: (Rank: ______; Frequency:______)

__ other:______________________ ::: ::: (Rank: ___/___/___; Frequency: ___/___/___)

13. *Where do you seek information about winter weather and/or snow?*

___ Internet (prompt *which sites*)

__ CAIC __ NWS __ <weather.com> __ <wunderground.com> __ CDOT __ weather channel __ <powderbuzz.com>

__ other _____________________ __ other _______________________ __other_____________________

___ TV (prompt *which stations/networks*)

__ local news ________________ __national news ___________________________________

__ weather channel

___ Resort websites list which ones: ____

___ Newspapers (prompt *which ones*): ____

___ Other people's knowledge (list relation if mentioned):______________________) *Why do you consider that person a source of information?*
____

__ other: ____

__ other: ____

[*] Take note of the following, but do not ask:

Gender of Interviewee: ☐ Male ☐ Female

Weather

– snow on the ground: __ No __ Some __ Complete Snow Cover

– cloud cover: __ No (clear) __ Some __ Complete

– Precipitation: __ No __ Snow __ Rain

– temperature: ~ ____ degrees (F / C)

Interviewer Name: ______________________________________

Date ____________________ Time ____________________ Location ____________________

APPENDIX C: QUESTIONNAIRE RESPONSES

Survey Question	Survey Answers	Survey Answers	Survey Answers	Survey Answers	Survey Answers	Survey Answers
1a. How much precipitation did the Front Range receive this past winter compared to the last winter?	1. Very small amount=23.0%	2. Small amount=47.4%	3. Average=20.4%	4. Large amount=2.6%	5. Very Large Amount=0.5%	6. Don't know=6.1%
1b. How much precipitation did the Front Range receive this past winter compared to previous winters?	1. Very small amount=21.9%	2. Small amount=43.4%	3. Average=20.4%	4. Large amount=4.6%	5. Very Large amount=0.5%	6. Don't know=9.2%
2a. How much precipitation did the mountains received this past winter compared to the last winter?	1. Very small amount=29.1%	2. Small amount=37.2%	3. Average=23%	4. Large amount=2.0%	5. Very large amount=1.0%	6. Don't know=7.7%
2b. How much precipitation did the mountains received this past winter compared to previous winters?	1. Very small amount=26.5%	2. Small amount=40.3%	3. Average=19.4%	4. Large amount=2.0%	5. Very Large amount=0.0%	6. Don't know=11.7%
3a. What was the temperature like this past winter in the Front Range compared to the last winter?	1. Very cold=2.0%	2. Cold=13.3%	3. Average=21.6%	4. Warm=41.8%	5. Very warm=9.7%	6. Don't know=5.6%

Survey Question	Survey Answers	Survey Answers	Survey Answers	Survey Answers	Survey Answers	Survey Answers
3b. What was the temperature like this past winter in the Front Range compared to previous winters?	1. Very cold=26.5%	2. Cold=40.3%	3. Average=19.4%	4. Warm=2.0%	5. Very warm=0.0%	6. Don't know=11.7%
4a. What was the temperature like this past winter in the mountains compared to the last winter?	1. Very cold=2.0%	2. Cold=5.6%	3. Average=31.6%	4. Warm=33.7%	5. Very warm=12.8%	6. Don't know=14.3%
4b. What was the temperature like this past winter in the mountains compared to previous winters?	1. Very cold=2.0%	2. Cold=7.1%	3. Average=25.5%	4. Warm=38.8%	5. Very warm=12.2%	6.Don't know=14.3%
5a. How windy was it this past winter in the Front Range compared to the last winter?	1. Very light winds=1.5%	2. Light winds=16.3%	3. Average=35.2%	4. Windy=21.9%	5. Very windy=4.1%	6. Don't know=20.9%

Survey Question	Survey Answers	Survey Answers	Survey Answers	Survey Answers	Survey Answers	Survey Answers
5b. How windy was it this past winter in the Front Range compared to previous winters?	1. Very light winds=2.0%	2. Light winds=11.7%	3. Average=41.8%	4. Windy=14.3%	5. Very windy=2.0%	6. Don't know=28.1%
6a. How windy was it this past winter in the mountains compared to the last winter?	1. Very light winds=1.0%	2. Light winds=6.1%	3. Average=33.2%	4. Windy=12.2%	5. Very windy=4.6%	6. Don't know=42.9%
6b. How windy was it this past winter in the mountains compared to previous winters?	1. Very light winds=1.0%	2. Light winds=5.6%	3. Average=32.1%	4. Windy=10.7%	5. Very windy=2.0%	6. Don't know=48.5%
7. What trend do you see in precipitation since you were younger?	1. Much less=14.3%	2. Less=50.5%	3. Similar=23.5%	4. More=5.1%	5. Much more=1.0%	6. Don't know=5.6%
8. What trend do you see in temperature since you were younger?	1. Much colder=0.0%	2. Colder=5.1%	3. Similar=24.0%	4. Warmer=54.6%	5. Much warmer=11.7%	6. Don't know=4.6%
9. What trend do you see in wind since you were younger?	1. Much less windy=0.5%	2. Less windy=10.2%	3. Similar=43.4%	4. More windy=19.4%	5. Much more windy=1.0%	6. Don't know=25.5%

APPENDIX D: SUMMARY OF QUESTIONNAIRE RESULTS

Table D-1. Percentage of correct responses with respect to gender, data used for t-test.

	Female (n=95)	Male (n=101)
Survey Questions	**Correct %**	**Correct %**
1a	4	2
1b	17	24
2a	68	65
2b	34	25
3a	51	52
3b	46	57
4a	33	35
4b	36	42
5a	34	37
5b	45	39
6a	40	27
6b	37	28
7	27	20
8	84	73

9	66	59

Table D-2. Percentage of correct responses with respect to years lived in Front Range, data used for correlation analysis.

	Group 1: 1-10yrs (n=124)	Group 2: 11-20yrs (n=50)	Group 3: 21-48yrs (n=22)
Questions	**Correct %**	**Correct %**	**Correct %**
1b	20.2	18.0	27.3
2b	67.7	66.0	63.6
3b	52.4	56.0	40.9
4b	36.3	50.0	27.3
5b	38.7	50.0	40.9
6b	33.1	32.0	27.3
7	25.8	24.0	9.1
8	76.6	84.0	77.3
9	62.1	62.0	68.2

Table D-3. Percentage of correct responses with respect to participation in winter recreational activities, data used for t-test.

Question	Does Not Participate (n=75) Correct %	Does Participate (n=119) Correct %
2a	28	29
2b	63	69
4a	29	37
4b	35	41
6a	33	34
6b	31	34
7	21	25
8	75	81
9	53	68

Table D-4. Percentage of correct responses with respect to rank*frequency values, data used for correlation analysis.

Rank*Freq (all sports)	n	Groups	2a. (correct %)	2b. (correct %)	4a. (correct %)	4b. (correct %)	6a. (correct %)	6b. (correct %)	7 (correct %)	8 (correct %)	9 (correct %)
0	75	1	30	64	29	35	32	30	21	75	48
1	6	2	50	67	33	17	17	17	17	67	67
2	3	2	0	33	67	33	33	33	0	100	33
3	4	2	0	75	0	0	75	75	25	100	75
4	3	2	33	33	33	67	33	33	67	67	67
5	2	2	0	50	0	50	0	0	50	100	50
6	5	2	20	60	40	80	40	20	20	80	60
8	3	2	33	0	33	33	33	33	33	100	100
9	4	2	0	75	25	25	25	25	100	100	50
12	6	2	17	67	0	17	17	33	33	100	67
14	2	2	0	100	0	0	50	50	0	0	50
15	3	2	33	67	0	33	0	0	33	100	67
16	2	3	0	0	50	50	50	100	50	100	50
19	1	3	0	0	0	0	0	0	0	100	0
20	2	3	100	100	50	50	50	50	50	50	100
21	1	3	0	0	0	0	0	0	0	100	0
22	2	3	50	0	0	0	50	50	50	50	50
23	1	3	0	100	100	100	0	0	0	100	100
24	3	3	0	67	67	33	0	0	33	100	33
25	5	3	0	100	20	20	40	60	20	80	60

Rank*Freq (all sports)	n	Groups	2a. (correct %)	2b. (correct %)	4a. (correct %)	4b. (correct %)	6a. (correct %)	6b. (correct %)	7 (correct %)	8 (correct %)	9 (correct %)
27	1	3	0	0	100	100	0	0	0	100	0
30	2	3	0	50	50	50	50	50	50	100	50
32	3	3	0	67	33	33	0	33	0	67	33
35	1	3	0	0	0	0	100	0	0	100	100
36	1	3	0	100	100	0	100	0	0	0	0
39	1	3	0	100	0	0	0	0	0	0	0
40	2	3	0	100	50	50	0	50	0	50	50
42	1	3	0	100	100	100	0	0	0	0	100
49	4	3	50	100	75	75	25	25	25	100	75
50	2	3	0	0	50	0	50	0	0	100	0
56	2	4	100	100	50	100	0	0	0	100	0
60	1	4	100	100	100	100	100	100	0	100	0
62	1	4	100	100	0	0	0	0	0	0	0
70	2	4	0	100	50	50	0	0	50	100	0
72	2	4	50	50	50	50	50	0	0	50	100
80	6	4	50	50	33	17	67	50	50	67	83
89	1	4	0	100	100	100	0	0	0	100	100
90	1	4	0	100	0	0	0	0	0	100	0
94	1	4	100	100	100	100	100	100	0	100	100
105	1	4	0	0	100	100	0	0	0	100	100

Rank*Freq (all sports)	n	Groups	2a. (correct %)	2b. (correct %)	4a. (correct %)	4b. (correct %)	6a. (correct %)	6b. (correct %)	7 (correct %)	8 (correct %)	9 (correct %)
120	2	4	0	50	50	50	50	50	0	100	100
140	3	4	67	100	33	67	33	33	0	67	67
145	1	4	100	100	100	0	0	0	0	0	0
150	1	4	100	100	0	100	0	0	0	100	100
160	1	4	100	100	0	100	100	100	0	100	100
180	1	4	0	100	0	0	100	100	0	100	100
200	1	4	0	100	100	100	0	0	100	100	0
240	1	4	100	100	0	100	100	100	0	0	0
248	1	4	100	100	100	100	0	0	0	0	0
258	1	4	0	0	0	0	0	100	100	100	100
260	1	4	0	100	100	100	100	0	0	0	0
280	1	4	0	100	100	100	0	0	0	100	0
306	1	4	0	100	0	0	100	100	0	100	100
332	1	4	100	100	0	0	100	100	100	100	100
350	1	4	0	100	100	100	0	0	0	100	0
425	1	4	100	100	0	100	0	100	0	100	100
475	1	4	100	100	0	0	0	0	0	100	100
563	1	4	0	100	0	0	100	100	0	100	0
675	1	4	100	100	100	0	0	0	0	100	0
905	1	4	0	100	100	100	0	0	100	100	100
1000	1	4	0	100	0	100	100	100	0	100	100

Rank*Freq (all sports)	n	Groups	2a. (correct %)	2b. (correct %)	4a. (correct %)	4b. (correct %)	6a. (correct %)	6b. (correct %)	7 (correct %)	8 (correct %)	9 (correct %)
1147	1	4	100	100	0	0	100	100	100	100	100

Table D-5. Percentage of correct responses with respect to the number of sources used to obtain information about winter weather and climate, data used for correlation analysis

Question	One Source: n=85 (% correct)	Two Sources: n=63 (% correct)	Three source (+): n=33 (% correct)
1a	7.1	0.0	0.0
1b	14.1	15.9	42.4
2a	29.4	25.4	33.3
2b	65.9	66.7	69.7
3a	51.8	49.2	57.6
3b	47.1	58.7	51.5
4a	36.5	23.8	39.4
4b	37.6	33.3	42.4
5a	40.0	30.2	30.3
5b	42.4	39.7	42.4
6a	30.6	34.9	33.3
6b	31.8	34.9	27.3
7	20.0	23.8	33.3
8	80.0	79.4	75.8
9	58.8	68.3	66.7