COLORADO CLIMATE SUMMARY

WATER-YEAR SERIES

(October 1987–September 1988)

Nolan J. Doesken

Thomas B. McKee

Climatology Report No. 89-1

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by

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Fort Collins, CO 80523

March 1989

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ACKNOWLEDGMENTS

As always we would like to take this opportunity to thank the many cooperative weather observers in Colorado and their National Weather Service supervisors, Dave Clapper, Mike Asmus and Michael Elias, for making it possible to monitor the climate in all parts of Colorado at a very low cost. Again, our sincere thanks are in order.

The authors also wish to express their appreciation to Odilia Bliss for doing a fine job of preparing and processing each month's climate data and assembling this finished product. The work of John Kleist in automating much of the data analysis and in improving the appearance of each monthly report has been very helpful.

These summaries have been made possible by funding for the Colorado Climate Center from the CSU Agricultural Experiment Station through the College of Engineering.

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I. INTRODUCTION

The 1988 Water Year marked the 14th year of existence of the Colorado Climate Center (CCC) and the 11th year of closely monitoring the climate of this diverse and interesting state. The first monthly climate summary prepared by the CCC was written in early 1977 in the midst of an unprecedented severe winter drought. Since that time Colorado has experienced a myriad of extremes -- record winter cold, incredible snowstorms, disastrous hail storms and tornadoes, brief dry periods, and, more recently, some of the snowiest years in the past 60 years and one of the wettest consecutive periods in the state as a whole. Our monthly descriptions of Colorado climate have expanded to document and describe as much of this information as possible.

The monthly climate descriptions are intended to accomplish several purposes. They are a written historical record of what our climate has been which can hopefully always be used as a reference in the future. By tracking monthly departures of temperature and precipitation from long-term normals, these summaries have also become tools for operations, planning and policy-making related to agriculture, water resources, recreation, land use and energy. Finally these summaries are used to educate the people of Colorado about our unique climate and its impact on our lives and livelihoods.

In Colorado, the Water Year (October 1 through September 30) is the most appropriate period for monitoring climate. This 12-month period is directly correlated with the state's water storage--water usage cycle. In October snow usually begins to accumulate in the high mountains. As winter progresses, the snowpack normally continues to build. This snow is the frozen reservoir which supports the huge ski and winter recreation industry. As it melts in the subsequent spring and summer, it supplies much of the water for human consumption, for extensive irrigation, for industry, and to satisfy long-standing streamflow compacts with neighboring states. Irrigated agriculture still accounts for the vast majority of water used in Colorado. Therefore, demand for water peaks during the summer and tapers off as temperatures drop, crops are harvested, and autumn arrives. September marks an appropriate end to the water year.

Because of the crucial importance of water to Colorado, this publication emphasizes precipitation and water-year accumulated precipitation. Comparisons with long-term averages are made to help determine which parts of the state are wetter or drier than average. This makes it possible to document the availability of water resources and to assess potential drought situations.

A new report format was developed during the 1985 Water Year for displaying and describing the month by month climate and this format has been continued. The following paragraphs describe the information content of this report format.

Each month's summary begins with a brief one-paragraph description of observed general temperature and precipitation patterns. This is followed by a section called: "A Look Ahead" and "Colorado's Monthly Climate." This section is not a forecast in the normal sense but is a generalized statewide climatological description (based on past records) of what weather conditions can most typically be expected. This section is really designed as an educational tool for newcomers to Colorado and to those just learning about climate to help familiarize themselves with the nature of our climate--how it varies both in time and in space. It is also a potential planning tool for those individuals, businesses, researchers, and government agencies who are just starting to try to take climate into account in planning and scheduling activities.

Following the "Look Ahead" section is a special feature story on some aspect of Colorado's climate. Research results, new climate publications, and items of general public interest may appear in this section. Here is a list of this year's special features and the pages on which they are found.

The daily weather description, which has been a part of the monthly summary for several years, has been continued and includes a table of extremes of temperature, precipitation and snow. This narrative section gives the dates of major storms, heat waves and cold blasts and gives selected examples from across Colorado.

One page is dedicated each month to the precipitation pattern. A brief narrative description is followed by a list of the wettest and driest National Weather Service reporting stations. A detailed map showing precipitation amounts is contoured to show which areas were above and below average.

The next page of the summary includes a similar assessment of the water year accumulated precipitation. A brief narrative comparison is made between the current and the past year's precipitation. This is accompanied by a tabular comparison of the wettest and driest locations in the state and a contoured map analysis of the current year's accumulated precipitation compared to average.

Temperature data for the month and comparisons to average are described in a short paragraph. The monthly temperatures for approximately 55 selected locations are plotted on a map and are analyzed using contour lines of departures from the 1961-80 averages. Along with the air temperature data, a detailed analysis of Fort Collins daily soil temperatures at several depths is presented. Soil temperature is an important climatic element in agriculture, construction, and energy conservation. Unfortunately, detailed soil temperature data are not available throughout Colorado.

Heating degree day data for 36 Colorado cities is published each month in a data table similar to previous years. A description of heating degree days and their use is given in Section II of this report.

The next two page are tabular climate information for the month for selected Colorado stations. Stations are divided into 4 regions: the Eastern Plains, the Foothills/Adjacent Plains (includes the Front Range urban corridor), the Mountains and High Interior Valleys, and the Western Valleys (includes stations in western Colorado below 7,000 feet). Data presented for each station include the average high, low and mean temperature for the month and the departure from the 1961-1980 average, the highest and lowest temperature recorded during the month, the monthly total of heating, cooling and growing degree days (see Section II for definitions), the monthly total precipitation, the departure from the 1961-1980 average, the percent of the 1961-1980 average, and the total number of days with measurable precipitation.

Following the data tables is a comparative table of number of clear, partly cloudy and cloudy days and the percent of possible sunshine for 5 National Weather Service stations. This is followed by a graph of daily total solar radiation data measured at Fort Collins.

Specific daily temperature and precipitation data are not listed here. Daily data can be obtained in digital and/or hard copy form from the Colorado Climate Center and the National Climatic Data Center (Asheville, NC). Much of the daily data are published in the government document, Climatological Data.

Most temperature and precipitation data used in the monthly summaries were obtained from the National Weather Service cooperative observer network. Data from the major National Weather Service stations, such as Denver and Grand Junction, are also used extensively. A few volunteers who are not affiliated with the National Weather Service's networks are also included based on the Colorado Climate Center's judgement that the data are of good quality.

The averages which are used in this report for both temperature and precipitation were calculated using 1961-1980 data. Heating degree day normals were based on 1951-1980 data.

The written descriptions give a good general accounting of each month's weather, but the majority of information is contained on the maps and tables which accompany each report. The accuracy of all of these maps and tables is quite good. However, these reports were initially prepared soon after the end of each month, and preliminary information had to be used. Therefore, some of the precipitation, temperature, and heating, cooling and growing degree day values may differ slightly from what is later published by the National Climatic Data Center.

A new feature was added to the monthly climate summaries beginning in January 1988. A special program at University of Colorado at Boulder and Colorado State University called the Joint Center for Energy Management (JCEM) had been funded several months earlier to undertake various efforts to help conserve energy in Colorado. One project at the University of Colorado estabished a small network of automated weather stations across Colorado. One page of each monthly report is dedicated to briefly summarizing statewide weather conditions, including temperatures, humidity, solar energy, windspeed and direction. This summarized data (tables and compressed graphs) are provided to the Colorado Climate Center each month by Joint Center for Energy Management graduate students at the University of Colorado. An additional page features a special educational example where some aspect of climate is explored in terms of its effect on energy or energy use. These articles listed below are also authored by University of Colorado JCEM graduate students. This contribution will be continued for the duration of the project -- at least 2 years.

1) Joint Center for Energy Management Weather Data (Jan 88, pp. 48).
2) Applications of weather data to energy-related topics. (Feb 88, pp. 59)
3) How does the sun affect our energy use? (Mar 88, pp. 70)
4) What are degree-days, anyway? (April 88, pp. 81)
5) Wind energy. (May 88, pp. 92)
6) Solar geometry. (June 88, pp. 103)
7) The underground movement...? (July 88, pp. 114)
8) Saving energy by keeping score. (Aug 88, pp. 125)
9) Thermal energy storage in buildings. (Sep 88, pp. 136)

II. EXPLANATION OF DEGREE DAYS

Many climatic factors affect fuel consumption for heating and cooling. Wind, solar radiation and humidity all play a part, but temperature is by far the most important element. Very simply, the colder it gets; the more energy is needed to stay warm.

A simple index, given the name, heating degree days, was devised several years ago to relate air temperatures to energy consumption (for heating). The number of heating degrees for a given day is calculated by subtracting the mean daily temperature (the average of the daily high and low temperature) from 65°F. Sixty-five degrees is used as the base temperature because at that temperature a typical building will not require any heating to maintain comfortable indoor temperatures. That difference (65°F minus the mean daily temperature) is the number of heating degrees for that day. The daily values are accumulated throughout the heating season to give heating degree day totals. Different base temperatures can be used to calculate heating degree days, but 65° is the long-standing traditional base.

The heating degree day total for a month or for an entire heating season is approximately proportional to the quantity of fuel consumed for heating. Therefore, the colder it gets and the longer it stays cold, the more heating degree days are accumulated and the more energy is required to heat buildings to a comfortable temperature.

So why is this important? Very simply, if you know how much energy you have used for heating your home or business during a certain period of time, and if you also know the heating degree day total for the same period, you can then establish an energy consumption ratio. With that information you can then make reasonable estimates of your future energy consumption and costs. Also, you can easily check the success and calculate the savings resulting from energy conservation measures such as new insulation, storm windows or lowering the thermostat.

Cooling degree days are calculated in a similar fashion. Cooling degrees occur each day the daily mean temperature is above 65°F. They are accumulated each day throughout the cooling season and are roughly proportional to the amount of energy required to cool a building to a comfortable inside temperature. Cooling degree days are less useful than heating degree days, especially here in Colorado where air conditioning requirements are minimal in many parts of the state. However, they still offer a means of making general comparisons from site to site, year to year or month to month.

Growing degree days are a measure of temperature which has been found to correlate with the rate of development and maturation of crops. Several methods exist for computing growing degree days. In this report the "corn" growing degree day definition was used. The optimum growth occurs at 86°F and essentially no growth occurs at temperatures below 50°F. Therefore, when computing the daily mean temperature any minimum temperature below 50° is counted at 50° and any maximum above 86° is counted as 86°. Growing degree day totals are this adjusted mean temperature (°F) minus 50°F summed for each day.

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III. 1987 WATER-YEAR IN REVIEW

In previous years up through the 1984 water year summary several pages were written recapping the highlights of the year's climate and the impact it had on Colorado. This section now appears in abbreviated form as the special feature story that accompanies the September 1988 summary. This can be found on pages 130-131.

COLORADO CLIMATE

OCTOBER 1987

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

Volume 11 Number 1

October in Review:

October was a lovely autumn month. Storms were few, sunshine was plentiful, and extremes of cold temperature, strong winds and snow were nonexistent. Precipitation for the month was in the normal range over most of the northwestern half of Colorado while the southeast was very dry. Temperatures were warmer than average in western Colorado but were very close to average east.

A Look Ahead -- December 1987:

Last year Colorado experienced a remarkably "boring" December. Only one snowstorm and artic outbreak interrupted the otherwise mild and consistent weather. Don't expect a repeat performance in 1987.

In "typical" Decembers, a regular procession of storms is common as Pacific moisture is driven against the Rockies by westerly winds aloft. Clouds often cover the mountains and fill some of the Western Slope Valleys. Measurable snow falls on 10 to 15 days in the northern and central mountains. Snow occurs less frequently in the southern mountains, but when it comes it means business. For the mountains as a whole, December precipitation averages between 2 and 4" (30-60" of snow) with preferred areas like the mountains east of Steamboat Springs getting even more. East of the Continental Divide precipitation decreases abruptly and sunshine increases. The foothills average just 0.50" to 0.80" of moisture (8-20" snow) with normally less than 0.50" over most of the plains. Major blizzards are possible east of the mountains, but storms like Denver's Christmas Eve blizzard of 1982 are very rare.

December temperatures are predictably cold in the mountains. Daytime temperatures are typically in the 20s in the high mountains with 30s in the surrounding valleys. Temperatures drop quickly at night and temperature inversions are very likely, especially in clear weather. Nighttime readings of 0°F or below are common in the higher mountain valleys while single digits are more common in the mountains. The lower valleys on the Western Slope are noticeably warmer, especially at night, but even areas like Grand Junction are often colder in December than cities east of the mountains. Occasional downslope winds help keep the Front Range cities warm. Daytime highs in the 40s and 50s are quite common east of the mountains with teens at night. But mild as this may sound, chinook winds can be very strong gusting to 100 mph or higher in preferred locations at the eastern base of the foothills. Between "chinooks," occasional artic blasts slide down the High Plains. Huge day-to-day temperature changes are thus possible east of the mountains, while changes west of the mountains are much less dramatic. The first subzero temperatures of the winter on the plains usually occur in late December.

As far as Christmas Day is concerned, almost anything is possible depending on where you are in Colorado. In the mountains a White Christmas is almost a certainty and the chances of more fresh snow falling on Christmas Day is about 50%. But at lower elevations, probabilities of being white drop off quickly. There is only a 20%-40% chance of having a White Christmas east of the mountains and snows of more than 1/2" on Christmas Day have been rare.

Drought or Powder -- What is ahead for this winter? Does anyone really know?

The phone here at the Colorado Climate Center has been "ringing off the wall" this fall with questions from the media and the general public about prospects for snow this winter. First, in late August and September, everyone seemed to think we were in for a severe and early winter. Then, after September and October brought delightful weather but with little or no snow, sentiments changed abruptly and many people became dreadfully frightened that a great snow drought was beginning. Mid-November snows have now calmed

(continued)

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

<u>Drought or Powder--What is ahead for this winter? Does anyone really know?</u> (continued)

our residents, at least temporarily. But with this intense interest in weather conditions that seems to exist in Colorado this fall, it seems that any slight departure from the elusive "normal" is going to raise a fuss.

How can we put this into a reasonable perspective? First, it is important to realize that at this time, despite incredible technological advances in atmospheric sciences, consistently accurate weather prediction more than a few days in advance is still beyond the capabilities of scientists in this field. (We will be publishing a feature in the next month or two on Long Range Forecasts (30 to 90 days) and how they are made.) You can find folks who can convince you that they can give you an accurate prediction for the next few months, but I would venture to say they are probably better salesmen than they are forecasters. Since scientists have so far failed to get the upper hand on long range forecasting, weather folklore, some of it passed on for centuries, is still frequently used to foretell the coming weather. You've probably noticed the same thing as I -- lorists seem most often to predict an early winter, or a severe one, or an early and severe one (as was the case this year). Forecasts for a mild winter are few. Yet, when we compare to average, we find that a goodly number of winters could be described as "mild." So there are obviously some problems with lore, too. Scientists have generally been kind to the lorists and have avoided detailed statistical evaluations of their forecast skills. Most likely, results of such tests would show that our beloved lorists also don't fare well with forecasts beyond the next two or three days.

It's beginning to sound like we're saying we don't really have any idea what the weather will be like in Colorado. I would like to go a step farther to say that I don't even think most of us remember from year to year what our winters are "normally" like. When cries of drought began to resound from across the state in early November we checked a few simple snow statistics from some of our high elevation stations in the Colorado mountains. While it is true that our mountains usually have had one or two respectable snowstorms by early November, significant widespread accumulations occur surprisingly infrequently. The following tables shows some of the characteristics of our mountain snow accumulation.

Probability (in percent) that the depth of snow on the ground will be less than or equal to the indicated value on this date shown.
Analysis based on 1951-1986 data.

Depth of Snow on Ground (inches)

Station and Elevation	NOVEMBER 1				DECEMBER 1				JANUARY 1			
	0"	5"	12"	24"	0"	5"	12"	24"	0"	5"	12"	24"
Berthoud Pass (11,314 feet)	13%	29%	75%	92%	∿0%	∿0%	8%	63%	∿0%	∿0%	∿1%	17%
Climax (11,350 feet)	32%	68%	89%	97%	∿0%	8%	35%	84%	∿0%	∿0%	3%	32%
Telluride (8,800 feet)	68%	86%	96%	∿99%	14%	43%	75%	∿97%	∿0%	11%	46%	83%
Winter Park (9,058 feet)	38%	78%	92%	96%	3%	14%	49%	92%	∿0%	∿0%	11%	54%

Only in our highest and northernmost mountains do we reliably have significant snow accumulation of 6" or greater by early November. At Berthoud Pass, for example, in 71% of the years there is at least 6" of snow on the ground by November 1. But even there, only one year in four has more than a foot on the ground. For most mountain areas below 11,000 feet (even higher in the San Juans) there is about an 80% chance that there will be 5" or less of snow on the ground by November 1. Only a handful of years have brought our mountains snow accumulations of more than a foot by early November. From this perspective, the fall of 1987 has been quite normal and the cries from our skiing communities have been inappropriate. Now it is true that during the past 3 falls we have had heavy early snows. Perhaps this is why this fall has seemed so dry. But with a longer historic base for comparison, we can see that these recent years were the unusual ones, while this year has been closer to normal.

Is lack of early snow an indicator of what is to come? Does having little mountain snow accumulation by early November predict a dry, open winter? Not at all. There is really little correlation between early snows and total winter snow accumulation. Yes, there are examples of very dry winters following falls that brought little snow, but there are also examples of heavy snow following dry falls. As recently as 1983 there had been scarcely any snow at all anywhere in the state by the beginning of the 2nd week of November. However, by the end of December, records had been shattered for the snowiest November and December ever seen.

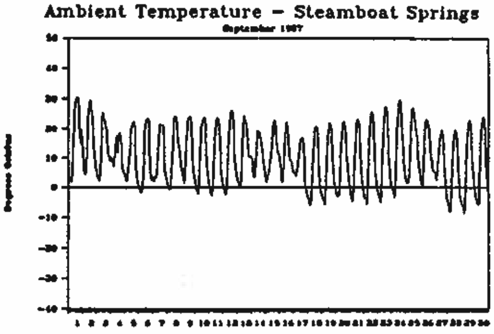
When is it appropriate to get concerned about lack of mountain snow accumulation? If it hasn't snowed much by Thanksgiving, then the ski areas really start to get nervous. Still, our statistics indicate that deep snow is not always present by December 1. Mountain snows, especially in the northern and central mountains, do tend to come more regularly beginning in mid-November, but to see more than 2 feet of snow on the ground by December 1 is unusual except in the highest and northernmost of our mountains. Even at Berthoud Pass only 1 year in 3 has more than 2 feet of snow by December 1. Down in Telluride, only about half the years have more than 5" of snow on the ground in town by that date. Only when we start moving through December without much mountain snow accumulation, particularly the last half of the month, do we have an indication of developing a problem. December typically contributes about 15-20% of the total winter snowpack in our mountains. January contributes an additional 20%. When our midwinter snows fail, which they did in 1976-77 and again in 1980-81 (and in 1986-87 in northern Colorado and from Colorado northward to southern Canada) then cries of "drought" may be well founded, and heavy spring snows may be unable to make up the deficit.

The Colorado Climate Center is currently involved in an interesting 3-year study investigating the variability of winter precipitation in the entire Rocky Mountain region. As a part of this study, Dave Changnon, a Ph.D. student, has been looking at statistical relationships between snowpack accumulation and the status and strength of the El Nino Southern Oscillation down in the tropics. I'm not going to get into the details of the El Nino at this time. There is plenty of literature elsewhere on that subject. Many scientists do feel it could affect our winter weather patterns here and could help improve the accuracy of long range forecasts. Changnon has compared the presence and strength of the El Nino to the subsequent winter snowpack in the Colorado mountains for the period since 1950. Current results do not indicate any relationship between El Ninos and early season snow accumulation. However, some associations do appear by later in the season. Strong El Ninos (there have been only 3 during this period) were associated with snowpack that was very close to average. Moderately strong El Ninos (there have been 3) were consistently dry years. Weak El Ninos (there have been 2) tended to be wetter than average. The remaining 27 years, judged to be "normal" or very weak El Nino years, made up the bulk of the distribution and still showed very large unexplained year to year variability. This analysis suggests that a relationship between the status of the El Nino and our winter weather could exist, but it certainly is not conclusive. There is currently a weak to very weak El Nino is in the tropical Pacific. Based on the above results, the best forecast would be for somewhat above average mountain snows from now until April 1. Unfortunately, we still aren't very confident in this approach to forecasting.

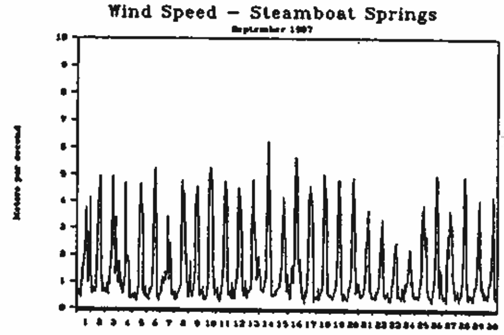
JCEM WTHRNET

There is a new source of detailed weather data that you should know about. WTHRNET (Wind, Temperature, Humidity and Radiation Network) is now operational. This network of 8 automated weather stations across Colorado is one of the several projects of the Colorado Joint Center for Energy Management (JCEM). JCEM was established in January 1987 by the Colorado Office of Energy Conservation and combines engineering, energy and communication expertise from both the University of Colorado and Colorado State University. We will be telling you more about this weather network in the months ahead and will hopefully be adding a special section in Colorado Climate to display summarized data each month. Here is a taste of what is to come.

Ambient Temperature – Steamboat Springs



Wind Speed – Steamboat Springs



OCTOBER 1987 DAILY WEATHER

Date	Event
1-11	Not a drop of rain or snow was observed over the western half of Colorado as a persistent high pressure ridge sat over the Western U.S. Temperatures were consistently warm west of the mountains. More weather changes occurred east of the mountains. Weak cold fronts crossed the plains on the 2nd and again on the 5th but on the 3rd and 4th very warm temperatures were noted. Most lower elevation areas were in the 80s both days with a few 90s down in the Arkansas Valley. The 96°F reading at Las Animas on the 4th was the hottest in the state for the month and was just 2 degrees short of the all time hottest October temperature. Temperatures were again quite warm on the 7th, but a stronger cold front crossed eastern Colorado late on the 8th and brought much colder temperature 9-11th. Cold east winds on the 10th brought clouds and very cold temperatures nearly everywhere east of the mountains. Incredible temperature differences were noted across the mountains on the 10th. While Denver struggled to reach 40°, Dillon was 61° and Rifle was 80°. The first widespread autumn freeze ended the growing season on the 10th and a few areas, including Denver, even experienced a few flakes of snow. The morning of the 11th brought the coldest temperatures of the month to most of eastern Colorado with lows mostly in the low 20s. The 5° temperature at Hohnholz Ranch up on the Laramie River was the coldest temperature in the state for October.
12-15	An upper level storm system drifted toward Colorado from California. Mild temperatures but with increasing clouds on the 12th. Moderate precipitation, mostly rain, was widespread on the 13th from the Front Range west to Utah. Colder temperatures with rain and high elevation snows continued on the 14th and diminished on the 15th. Moisture totals for the storm ranged from none in southeast Colorado to about 0.25" on the northeast plains. Along the Front Range only 0.03" fell at Pueblo and 0.09" at Fort Collins, but more than 1" fell at a number of locations south and west of Denver. Mountain and Western Slope precipitation was also extremely variable ranging from less than 0.20" in places like Eagle and Maybell up to 1.50 inches or more in parts of the San Juans.
16-22	Another week of dry and sunny weather but with cooler more seasonal temperatures. A cold front clipped NE Colorado on the 18th and triggered some local light rain and snow on the 19th.
23-25	Moist southwesterly winds aloft developed 23rd and spread light precipitation into Western Colorado on the 24th -- mostly rain. A fast moving upper air disturbance moved in from the northwest producing locally moderate precipitation late on the 24th into the 25th. Steamboat Springs measured 0.81" of rain from the storm and many locations exceeded 0.50". Due to warm temperatures with this system, snow accumulations were generally limited to areas above 10,000 to 11,000 feet. Only a few sprinkles spilled over east of the mountain barrier.
26-28	A return to dry and mild conditions with northwesterly winds aloft.
29-31	Another impulse of Pacific moisture from the southwest. Rains began in southwest Colorado on the 29th and spread northeastward on the 30th. Except for southeast Colorado, most of the state received some moisture. Heaviest amounts fell in the southwest, where Dolores reported 1" of rain and Mesa Verde had 0.98". Significant amounts also fell along portions of the northern Front Range. Snow accumulations were limited to areas above 9 or 10,000 feet. Skies cleared on the 31st and mild temperatures continued.

October 1987 Extremes

Highest Temperature	96°F	October 4	Las Animas
Lowest Temperature	5°F	October 11	Hohnholz Ranch
Greatest Total Precipitation	3.60"		Vallecito Dam
Least Total Precipitation	0		La Junta 1S and Stonington
Greatest Total Snowfall*	21"		Wolf Creek Pass 1E
Greatest Depth of Snow on Ground*	9"		Mount Evans Research Center

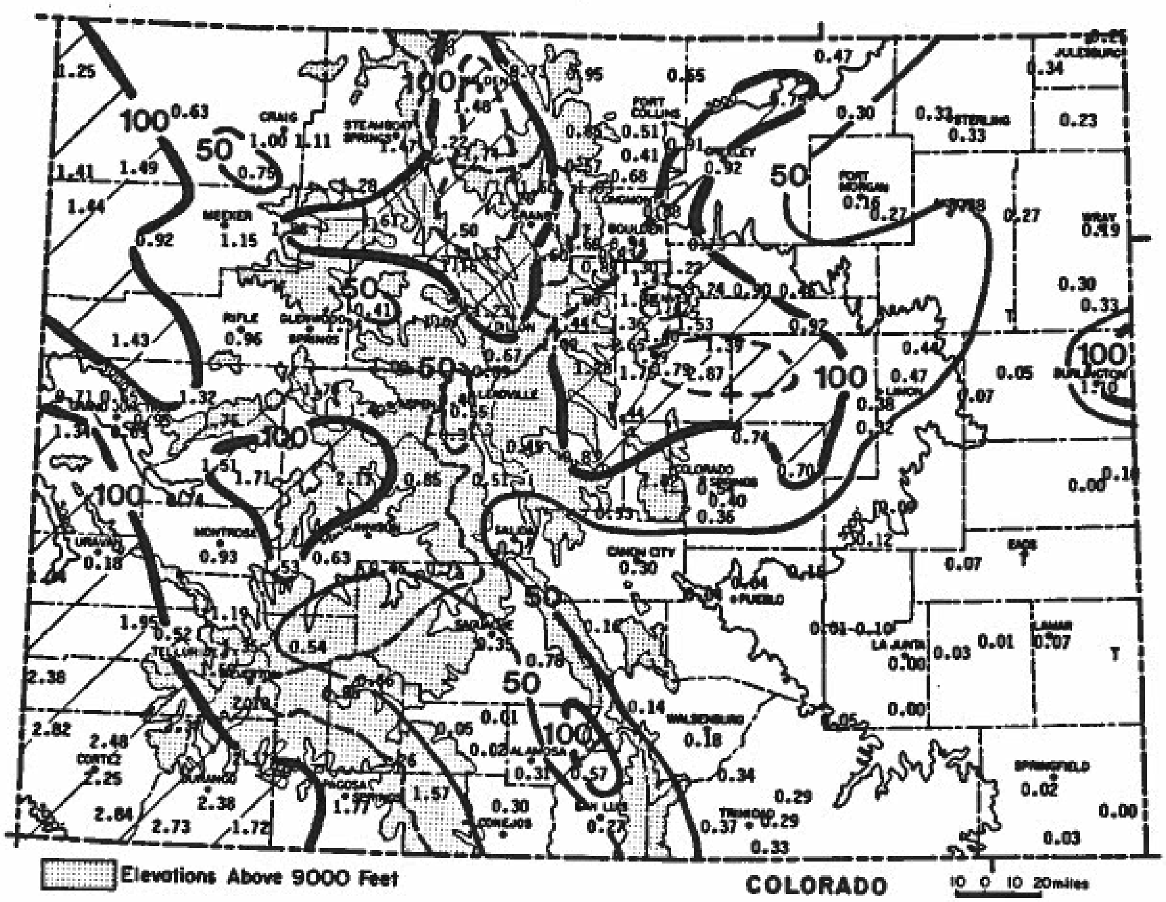
* data derived only from those stations with complete daily snowfall records.

OCTOBER 1987 PRECIPITATION

There was widespread perception among Colorado's populous that October was a very dry month. For the entire Arkansas Valley, most of the Rio Grande and portions of northeast Colorado this was indeed true. About 10% of all official reporting stations received less than 0.10" of moisture for the month. But many areas were near or above average. Most of southwest and extreme western Colorado was wetter than average as were areas in the central and northern mountains. Also much of the Platte River valley from Greeley upstream to Eleven Mile Reservoir was wetter than average.

It certainly wasn't the wettest start for a new water year, but we have had many that start drier. This was the driest first month (of the water year) since 1983.

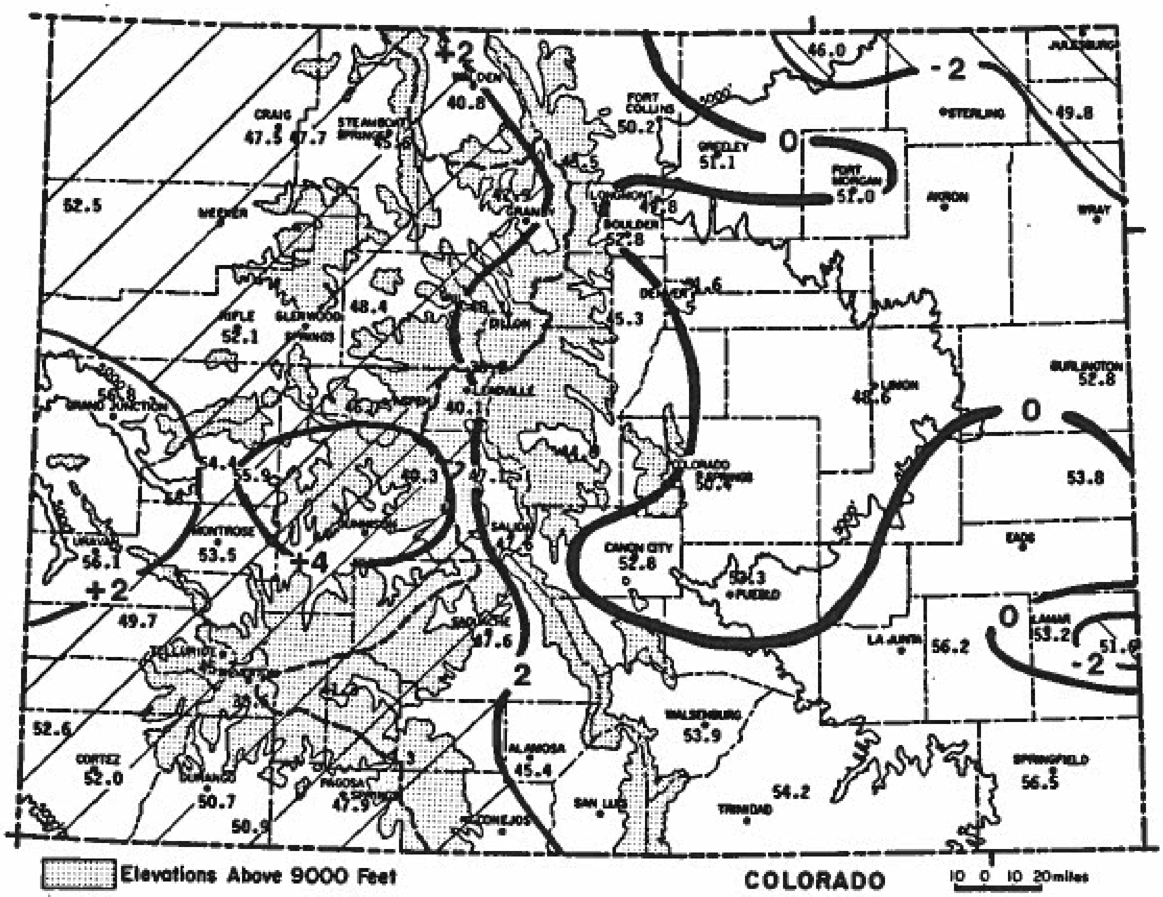
Greatest		Least	
Vallecito Dam	3.60"	La Junta 1S	0.00"
Rico	3.37"	Stonington	0.00"
Wolf Creek Pass 1E	3.26"	Cheyenne Wells	Trace
Castle Rock	2.87"	La Junta 20S	Trace
Mesa Verde Natl Park	2.84"	Eads	Trace
Yellow Jacket 2W	2.82"	Joes	Trace
		Holly	Trace



Precipitation amounts (inches) for October 1987 and contours of precipitation as a percent of the 1961-1980 average. The dashed line represents 150% of average.

OCTOBER 1987 TEMPERATURES AND DEGREE DAYS

October temperatures for the month as a whole were generally 2 to 4 degrees Fahrenheit warmer than average across all of western Colorado. The Taylor Park area was a local anomally with readings 7 degrees above average. East of the mountains readings were very close to average. Significantly cooler than average temperatures (2 to 3 degrees) were limited to the extreme northeast plains and the Arkansas Valley below Lamar.



October 1987 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

OCTOBER 1987 SOIL TEMPERATURES

Soil temperatures were a bit warmer than average for this time of year especially near the surface. They followed the normal downward trend for this time of year.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

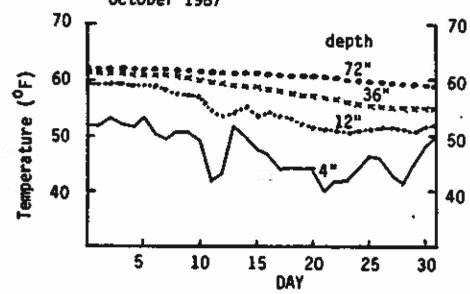


Table 1. Colorado Heating Degree Day Data through October 1987.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601									1127
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563									1182
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370									532
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549									1028
BURLINGTON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375									472
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374									508
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445									686
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396									591
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534									912
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354									473
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410									552
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763									1961
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435									681
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37		314	658	930	1283	1309	925	927	566	384	111	7444
	87-88	54	75	254	509									892
EVERGREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602									1122
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453									648
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430									581
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248									288

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677									1621
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424									579
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M									0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273									311
LEADVILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763									2080
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502									747
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87	M	0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464									668
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	M	7308
	87-88	M	M	M	M									0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349									513
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523									1079
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355									419
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391									549
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590									
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413									564
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603									1412
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330									439
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740									1731
WALSENBURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332									466

M = MISSING DATA

OCTOBER 1987 CLIMATIC DATA

Eastern Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
KAUFFMAN 4SSE	63.6	28.5	46.0	-3.2	85	19	581	0	237	0.47	-0.05	90.4	6
FORT MORGAN	68.7	33.2	51.0	-0.0	86	23	430	2	300	0.16	-0.41	28.1	2
HOLYOKE	66.6	33.0	49.8	-2.5	87	21	462	0	275	0.23	-0.50	31.5	4
BURLINGTON	67.4	38.2	52.8	-1.2	86	26	375	6	283	1.10	0.34	144.7	1
LIMON WSMO	65.1	32.0	48.6	-0.0	82	22	502	0	247	0.38	-0.22	63.3	4
CHEYENNE WELLS	71.5	36.1	53.8	0.5	88	24	342	6	341	0.00	-0.83	0.0	0
LAMAR	73.2	33.2	53.2	-1.8	94	24	359	2	361	0.07	-0.66	9.6	1
LAS ANIMAS	76.2	36.3	56.2	0.4	96	25	273	9	404	0.03	-0.60	4.8	1
HOLLY	73.7	29.5	51.6	-2.4	91	20	411	1	377	0.00	-0.80	0.0	0
SPRINGFIELD 7WSW	74.5	38.5	56.5	1.3	86	26	261	5	387	0.02	-0.68	2.9	1

Foothills/Adjacent Plain*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	65.3	35.1	50.2	0.2	82	23	453	0	250	0.51	-0.50	50.5	5
GREELEY UNC	67.9	34.3	51.1	0.4	86	22	424	0	293	0.92	-0.07	92.9	4
ESTES PARK	61.0	30.0	45.5	0.2	74	16	597	0	181	0.57	-0.21	73.1	4
LONGMONT 2ESE	66.7	32.8	49.8	-0.6	83	22	464	0	275	0.88	0.00	100.0	4
BOULDER	67.9	37.6	52.8	-0.7	84	26	370	1	286	0.94	-0.24	79.7	5
DENVER WSFO AP	66.9	36.4	51.6	-0.1	84	27	410	2	279	1.24	0.36	140.9	4
EVERGREEN	62.3	28.3	45.3	0.5	78	22	602	0	210	1.36	0.18	115.3	5
LAKE GEORGE 8SW	60.5	27.5	44.0	1.7	69	18	642	0	174	0.83	0.10	113.7	3
COLORADO SPRINGS	64.8	36.0	50.4	-0.2	80	23	445	0	240	0.54	-0.21	72.0	4
CANON CITY 2SE	69.0	36.5	52.8	-1.4	84	23	374	2	302	0.30	-0.57	34.5	2
PUEBLO WSO AP	71.8	34.8	53.3	-0.7	88	22	355	2	342	0.04	-0.54	6.9	2
WALSENBURG	71.5	36.4	53.9	0.8	84	23	332	0	344	0.18	-0.90	16.7	2
TRINIDAD FAA AP	72.0	36.3	54.2	0.6	85	25	330	0	346	0.29	-0.60	32.6	1

Mountains/Interior Valleys*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	59.2	22.5	40.8	2.1	75	9	740	0	154	1.48	0.66	180.5	5
LEADVILLE 2SW	54.8	25.4	40.1	3.1	66	16	763	0	96	0.55	-0.55	50.0	5
SALIDA	67.9	27.3	47.6	0.4	78	13	534	0	284	0.17	-0.85	16.7	2
BUENA VISTA	65.9	28.3	47.1	1.0	76	17	549	0	252	0.51	-0.27	65.4	4
SAGUACHE	64.9	30.3	47.6	2.8	74	20	533	0	238	0.35	-0.39	47.3	3
HERMIT 7ESE	61.7	20.9	41.3	2.8	73	9	727	0	189	0.95	-0.62	60.5	5
ALAMOSA WSO AP	67.2	23.5	45.4	1.7	77	9	601	0	275	0.31	-0.41	43.1	4
STEAMBOAT SPRINGS	64.9	26.4	45.6	3.7	78	15	590	0	240	1.47	-0.17	89.6	6
GRAND LAKE 6SSW	58.4	27.5	42.9	3.1	68	18	677	0	140	1.26	0.37	141.6	7
DILLON 1E	57.0	23.2	40.1	1.0	68	15	763	0	126	1.23	0.48	164.0	6
CLIMAX	45.6	24.9	35.2	1.2	56	15	917	0	21	0.89	-0.38	70.1	4
ASPEN 1SW	60.8	32.6	46.7	3.2	74	22	563	0	176	1.40	-0.31	81.9	6
TAYLOR PARK	55.7	24.9	40.3	7.3	66	15	759	0	103	0.85	-0.39	68.5	5
TELLURIDE	62.5	28.1	45.3	2.2	75	18	603	0	202	1.59	-0.63	71.6	7
PAGOSA SPRINGS	68.8	27.1	47.9	2.6	80	16	523	0	301	1.77	-0.22	88.9	6
SILVERTON	59.8	17.3	38.6	1.6	72	7	811	0	169	2.10	-0.17	92.5	6
WOLF CREEK PASS 1	52.9	25.6	39.3	2.8	64	17	788	0	77	3.26	-0.87	78.9	7

Western Valleys*

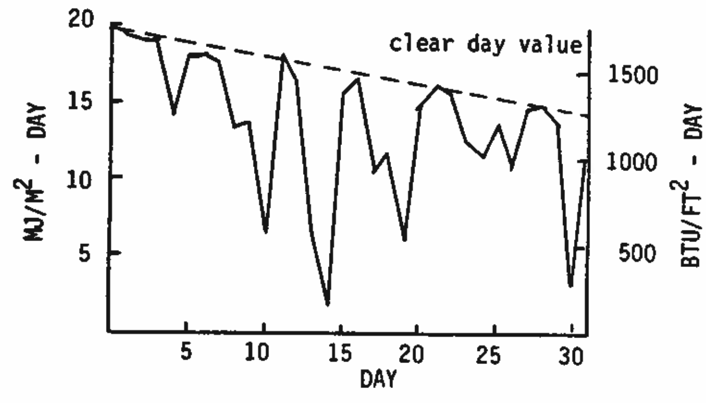
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	65.1	30.0	47.5	2.3	79	19	534	0	247	1.00	-0.30	76.9	6
HAYDEN	65.5	30.0	47.7	2.7	78	14	527	0	246	1.11	-0.23	82.8	5
RANGELY 1E	69.4	35.5	52.5	4.0	81	24	378	0	308	1.44	0.49	151.6	5
EAGLE FAA AP	68.2	28.5	48.4	3.6	81	16	509	0	288	0.41	-0.47	46.6	5
RIFLE	72.6	31.5	52.1	3.4	85	20	391	0	360	0.96	-0.19	83.5	7
GRAND JUNCTION WS	71.0	42.5	56.8	1.9	83	32	248	2	337	0.65	-0.26	71.4	8
CEDAREDGE	70.2	38.6	54.4	3.7	82	28	322	0	319	1.51	0.28	122.8	7
PAONIA 1SW	71.3	40.6	55.9	4.5	83	32	273	0	339	1.71	0.29	120.4	7
DELTA	74.5	32.2	53.3	1.6	86	22	354	0	386	0.74	-0.14	84.1	6
MONTROSE NO. 2	69.2	37.8	53.5	3.0	81	29	349	0	304	0.93	-0.20	82.3	8
URAVAN	74.8	37.3	56.1	1.5	88	28	271	0	388	1.48	0.08	105.7	9
NORWOOD	64.5	34.8	49.7	3.4	78	27	467	0	234	1.95	0.47	131.8	6
YELLOW JACKET 2W	65.4	39.8	52.6	2.5	80	24	378	0	248	2.82	0.87	144.6	7
CORTEZ	68.7	35.4	52.0	2.0	82	24	396	0	298	2.25	0.65	140.6	5
DURANGO	69.0	32.5	50.7	1.7	85	22	435	0	304	2.38	0.36	117.8	9
IGNACIO 1N	71.2	30.5	50.9	3.2	87	21	429	0	335	1.72	0.17	111.0	7

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

OCTOBER 1987 SUNSHINE AND SOLAR RADIATION

Station	Number of Days: clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	15	9	7	--	--
Denver	11	13	7	75%	73%
Fort Collins	13	12	6	--	--
Grand Junction	12	10	9	79%	74%
Pueblo	15	7	9	85%	79%

Fort Collins
Total Hemispheric Radiation
October 1987



COLORADO CLIMATE

NOVEMBER 1987

Colorado Climate Center
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Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 2

November in Review:

Lovely mild temperatures early in November gave way to more winter-like conditions later in the month. For the month as a whole, temperatures were slightly warmer than average. Precipitation was spotty, but the majority of the state ended up wetter than average.

A Look Ahead -- January 1988:

January, based on long-term average temperatures, is the coldest month of the year. In addition, mountain snows are normally frequent and heavy. In recent years, though, we've had it pretty easy here in Colorado. We've had some snows and a few cold waves, but if you've only lived in Colorado a couple of years, you really don't know what January can be like. We have to go back almost 10 years to 1979 to find a really frigid, stormy first month.

To give you some idea of what to expect on an "average" January day, daytime temperatures rise into the 30s and 40s from the Eastern Plains into the foothills. Thirties are normal in the western valleys and 20s are most typical for the mountains. For lows we see temperatures in the lower teens over most areas east of the mountains. In and near the mountains the local topography has a big effect on nighttime temperatures. Average lows range from the lower 20s in a few locations near the base of the eastern foothills to near 0°F high in the mountains. The coldest locations are the broad, high mountain valleys on the west side of high mountain ranges. In these areas, temperatures are often well below zero.

Just describing averages doesn't really do justice to January, especially for the areas east of the mountains. In truth, there is a great deal of day-to-day variations. Downslope westerly winds, which can blow at speeds well above 60 mph in preferred locations, can help raise temperatures into the 50s, 60s and sometimes even the low 70s. But there is also an excellent chance that one or more "Arctic outbreaks" will drop temperatures well below zero. In the lower elevations of the state, temperatures drop below 0°F on about 5 days. Be prepared for these abrupt changes and extremes.

January precipitation patterns reveal the incredible impact the mountains have on our climate. In the mountains and on the Western Slope, January is frequently the snowiest month of the year, while east of the mountains it is one of the driest months. On the Western Slope precipitation totals are normally 0.50"-1.00" (8-20" snowfall). Most mountain areas receive 2" to 4" of moisture (30 to 60" of snow). The eastern foothills usually expect 0.30" to 1.00" (6-25" snowfall), while the Eastern Plains and San Luis Valley typically receives only 0.20" to 0.50" (5-12" snow). January snows are normally dry and fluffy. Large storms east of the mountains, like the one that buried Colorado Springs last year, occur infrequently. But it only takes a small amount of snow to make travel treacherous, especially in the large Front Range cities.

Where do those long-range forecasts come from?

The public is always interested in knowing (or at least talking about) what the weather is going to be like weeks or even months in advance. For many, it's much more than recreational conversation. For many businesses, from farming to retailing, the weather has a lot to do with profits. Here at the Colorado Climate Center we monitor climatic conditions and anticipate the future by recognizing and describing what is most likely to occur at any time of year (based on past records). This is not the same as specifically predicting an exceptionally cold or wet month.

(continued on last page)

NOVEMBER 1987 DAILY WEATHER

Date	Event
1-2	Unseasonably mild. Holly hit 85°F on the 2nd, the hottest in the state for the month. An upper air disturbance crossed the state producing scattered but locally heavy precipitation, especially in the SW. Pagosa Springs got 1.27" of rain from the storm while up at Wolf Creek Pass 16" of wet snow fell.
3-7	Dry and unseasonably warm 3-5th. Aspen enjoyed a 64° temperature on the 5th while Denver basked in 70° sunshine and Rifle hit 73°. Clouds increased late on the 5th and rains (high elevation snows) spread over the state 6-7th as a large upper level low pressure system drifted across the state. Significant precipitation fell across portions of western and northeastern Colorado with most of it again falling as rain except in the higher mountains. Rico totalled 1.98" of moisture from the storm including 15" of wet snow.
8-13	Clearing and chilly 8-9th. Another upper air disturbance 10-11th brought a little snow to northwestern Colorado. Then partly cloudy, dry and quite mild statewide 12-13th.
14-15	A rapidly developing storm took aim on Colorado. Rains on the 14th turned to snow on the 15th accompanied by very strong winds. For many low elevation locations it was the first measurable snowfall of the season. On the 15th a plane crash in Denver killed a number of passengers as the plane attempted to take off during the height of the storm. Precipitation was surprisingly spotty from the storm, but some locally great amounts were noted. Climax reported 1.42" of moisture (16" snow) and Wheat Ridge measured 1.69" (9.5" snow). But Mount Evans, with 1.87" of precipitation (34" snow), took the prize.
16-18	Clearing and cold. Hohnholz Ranch woke to a -18° temperature on the 16th. A reinforcing cold air mass slid south across the state on the 17th triggering snowshowers. Most mountain areas got 1 to 6" of snow, and there was even some accumulation east of the mountains. Springfield picked up 2" and the Walsenburg area reported 4". Very cold on the 18th. Crested Butte dipped to -22°F.
19-20	Dry period as a high pressure ridge straddled the Rockies. Much warmer. Warm, brisk downslope winds developed on the 21st, and temperatures returned to the 60s east of the mountains. Pueblo recorded a toasty 73° reading.
22-25	Partly cloudy and cool. A few light snowshowers in the northern mountains on the 22nd. More snow on the 24th in the northern and central mountains and across parts of the northeast plains as an upper level disturbance crossed Colorado. Almost 4" of snow at Steamboat Springs and 3" out on the plains at Sedgwick and Holyoke.
26-27	A significant storm system developed early on Thanksgiving day southwest of Colorado. Limited moisture supplies kept snowfall totals fairly light, but the storm was still strong enough to disrupt holiday travel. Heaviest snows were in the southern mountains, parts of the San Luis Valley and much of eastern Colorado. Denver, Colorado Springs and Pueblo each got 5". More than a foot of snow fell in parts of the San Juans. Clearing but colder on the 27th.
28-30	Mostly sunny but cold. Many subzero temperatures in the mountains with lows in the teens out on the plains. Daytime highs mostly reached into the 30s and low 40s with 20s in the mountains. Antero Reservoir dropped to -22°F on the 28th to tie for the state's coldest reading.

November 1987 Extremes

Highest Temperature	85°F	November 2	Holly
Lowest Temperature	-22°F	November 18	Crested Butte
		November 28	Antero Reservoir
Greatest Total Precipitation	5.36"		Wolf Creek Pass 1E
Least Total Precipitation	0.19"		Stonington
Greatest Total Snowfall*	73"		Wolf Creek Pass 1E
Greatest Snowdepth*	43"	November 18	Mount Evans Research Center

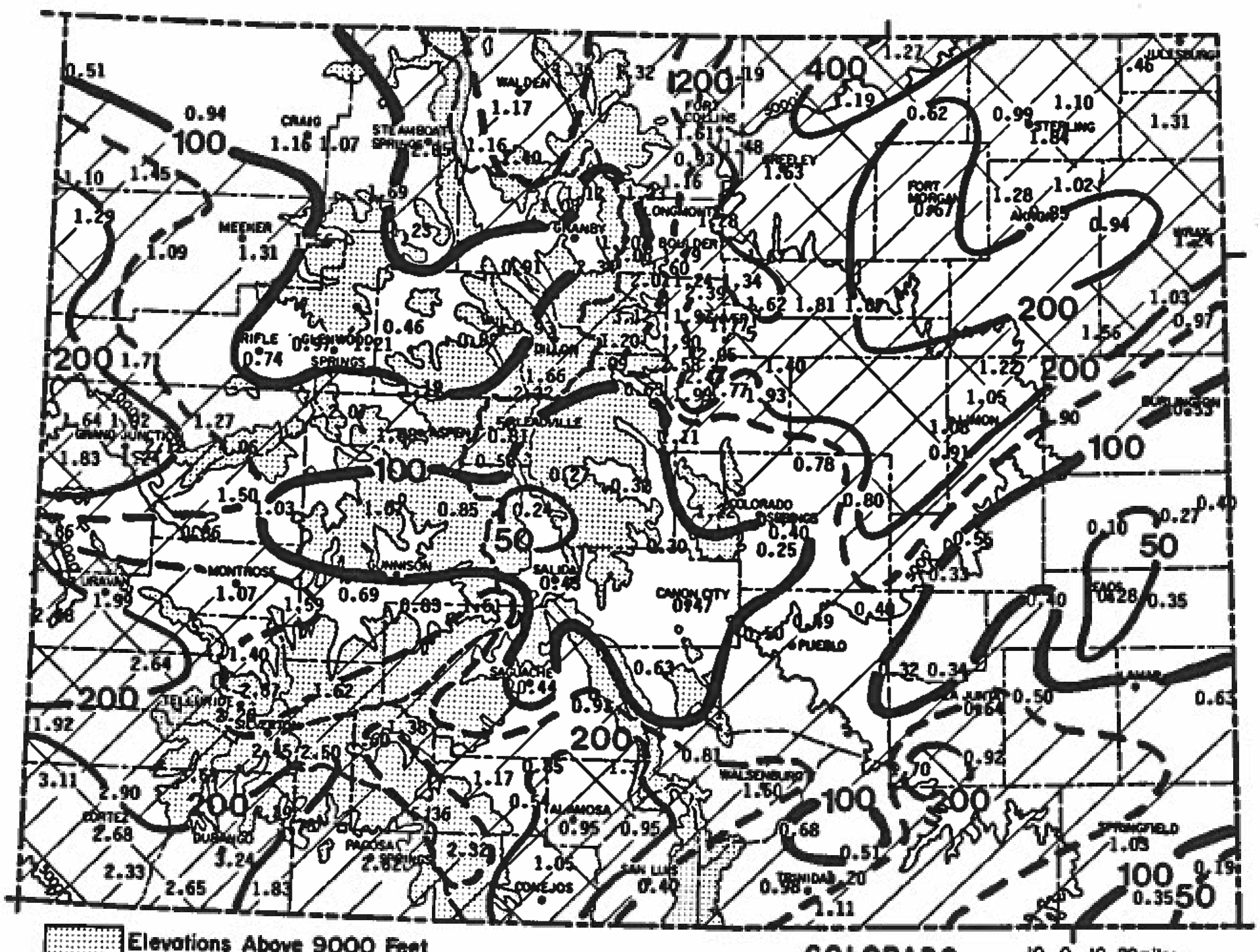
* data derived only from those stations with complete daily snowfall records.

NOVEMBER 1987 PRECIPITATION

The majority of Colorado received more than the average November precipitation. More than double the average moisture fell in the valleys of extreme western Colorado, in parts of the San Luis Valley and over much of northeast Colorado from Denver and Fort Collins east to Limon and Sterling. The 1.92" total at Grand Junction was the 2nd wettest November this century second only to November 1983. But not all areas were wet. Snowfall was well below average in the Eagle-Vail area, in a portion of central Colorado from Crested Butte and Buena Vista to Canon City and across portions of the southeast plains.

Despite reasonably good precipitation, snowpack accumulation lagged behind average. This was true because warm temperatures accompanied several of the storms. Except above 10,000 feet, some of the moisture fell as rain and some of the snow that did fall melted. As temperatures got colder later in the month, relatively little snow fell in the mountains.

Greatest		Least	
Wolf Creek Pass 1E	5.36"	Stonington	0.19"
Lemon Dam	4.39"	Buena Vista	0.24"
Bonham Reservoir	4.06"	Fort Carson	0.25"
Vallecito Dam	3.78"	Cheyenne Wells	0.27"
Rico	3.61"	Antero Reservoir	0.27"



Precipitation amounts (inches) for November 1987 and contours of precipitation as a percent of the 1961-1980 average. The dashed line represents 150% of average.

1988 WATER YEAR PRECIPITATION

For the first two months of the 1988 water year precipitation has been above average over most of the northeastern quarter of the state, the Western Slope and most of the San Juan Mountains. Significant areas with less than average precipitation extend from northwestern Colorado through the central mountains to almost the entire Arkansas drainage. Less than half the average moisture has fallen over most of the immediate Arkansas Valley from near Buena Vista downstream to the Kansas border.

Comparison to Last Year

The 1988 water year has gotten off to a much drier start than last year over most of the mountains and southeastern plains. Only in extreme western areas and in parts of northeast Colorado are this year's precipitation totals comparable to or greater than last year.

1988 Water Year to Date through November

Wettest (as % of average)

Castle Rock	265%	4.80"
Denver (Metro)	227%	3.19"
Briggsdale	200%	1.94"

Driest (as % of average)

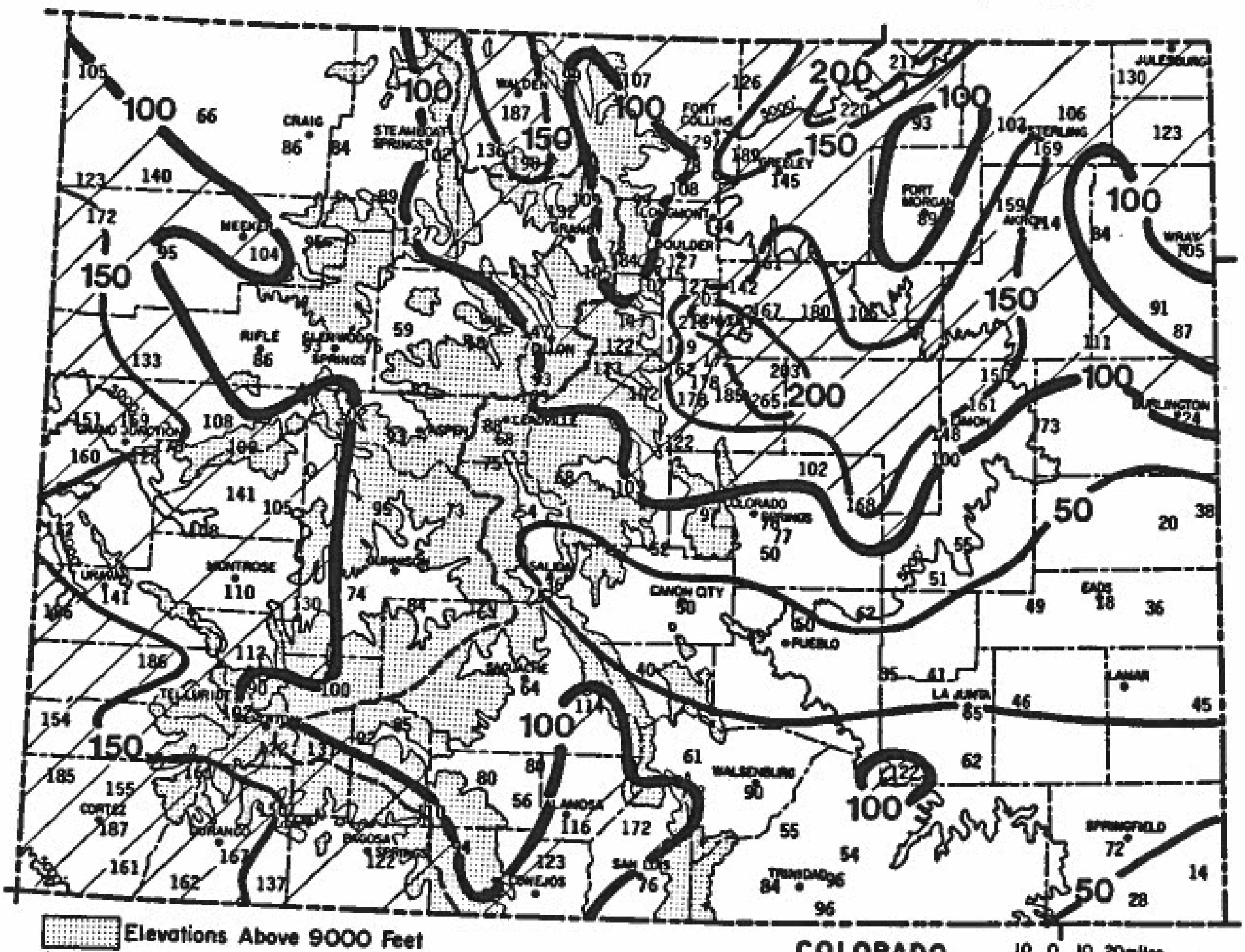
Stonington	14%	0.19"
Eads	18%	0.28"
Cheyenne Wells	20%	0.27"

Wettest (total precipitation)

Wolf Creek Pass 1E	8.62"	110%
Vallecito Dam	7.38"	164%
Rico	6.98"	161%

Driest (total precipitation)

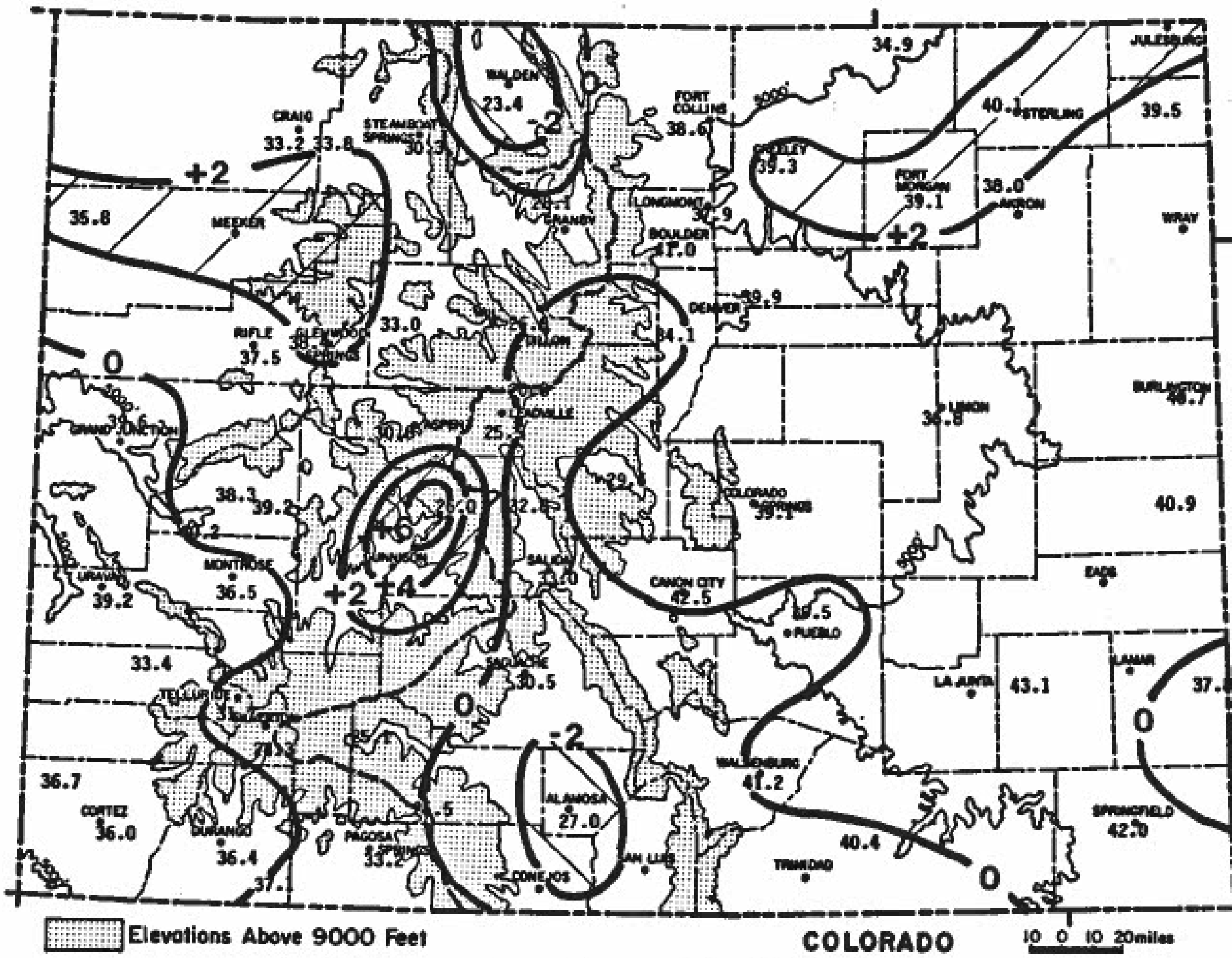
Stonington	0.19"	14%
Cheyenne Wells	0.27"	20%
Eads	0.28"	18%



Precipitation for October 1987 through November 1987 as a percent of the 1961-1980 average.

NOVEMBER 1987 TEMPERATURES AND DEGREE DAYS

November got off to a warm start and a cold finish. For the month as a whole temperatures ended up a little warmer than average over most of the mountains and Eastern Plains. The warmest areas compared to average were found in the South Platte valley downstream from Greeley and in the Gunnison-Taylor Park area. Colder than average conditions were found from Dillon southward to Alamosa, in North Park (Walden) and in the southwestern valleys. For most of the state, temperatures were within two degrees of the long-term average.



November 1987 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

NOVEMBER 1987 SOIL TEMPERATURES

Near surface soil temperatures remained unusually warm early in the month but then dropped to seasonal levels by the end of November.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

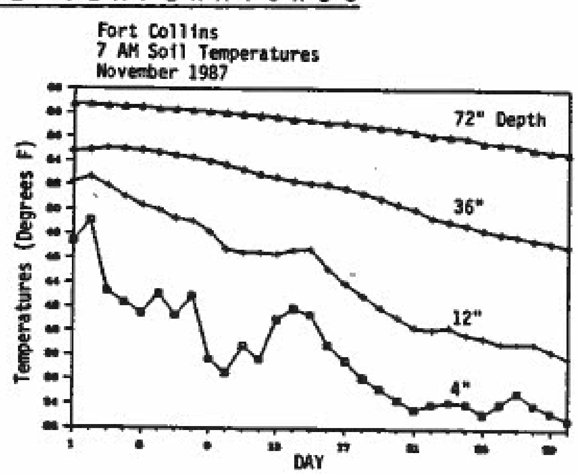


Table 1. Colorado Heating Degree Day Data through November 1987.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130								2257
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024								2206
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713								1245
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955								1983
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724								1196
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668								1176
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767								1453
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860								1451
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950								1862
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737								1210
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745								1297
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145								3106
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851								1532
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37		314	658	930	1283	1309	925	927	566	384	111	7444
	87-88	54	75	254	509	950								1842
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922								2044
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784								1432
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773								1354
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754								1042
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098								2719
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762								1341
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M								0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653								964
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180								3260
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840								1587
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87		0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805								1473
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	M	7308
	87-88	M	M	M	M	M								0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849								1362
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947								2026
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754								1173
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819								1368
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033								
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742								1306
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992								2404
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730								1169
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242								2973
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707								1173

M = MISSING DATA

NOVEMBER 1987 CLIMATIC DATA

Eastern Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	48.0	21.9	34.9	-1.0	67	5	894	0	65	1.27	0.99	453.6	9
STERLING	54.2	26.1	40.1	4.1	73	13	742	0	110	0.99	0.55	225.0	7
FORT MORGAN	52.4	25.7	39.1	2.4	71	11	773	0	101	0.67	0.31	186.1	6
AKRON FAA AP	49.6	26.4	38.0	1.3	70	10	801	0	77	1.28	0.82	278.3	7
HOLYOKE	51.9	27.0	39.5	1.5	73	13	758	0	103	1.31	0.79	251.9	4
BURLINGTON	51.5	29.9	40.7	1.0	70	14	724	0	99	0.53	-0.02	96.4	3
LIMON WSMO	50.2	23.4	36.8	0.8	68	11	840	0	90	1.08	0.70	284.2	5
CHEYENNE WELLS	54.2	27.5	40.9	1.8	72	11	718	0	121	0.27	-0.22	55.1	2
LAS ANIMAS	59.8	26.4	43.1	2.1	82	11	653	1	175	0.50	0.00	100.0	5
HOLLY	56.6	19.0	37.8	-1.5	85	2	810	0	155	0.63	0.06	110.5	3
SPRINGFIELD 7WSW	56.1	28.0	42.0	0.3	80	10	680	0	138	1.03	0.28	137.3	5

Foothills/Adjacent Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	50.8	26.4	38.6	1.3	64	10	784	0	75	1.61	0.98	255.6	6
GREELEY UNC	51.7	26.9	39.3	2.4	69	10	762	0	83	1.63	0.87	214.5	6
LONGMONT 2ESE	51.7	24.2	37.9	0.8	66	7	805	0	94	1.28	0.67	209.8	7
BOULDER	53.0	29.0	41.0	0.2	69	14	713	0	101	1.79	0.83	186.5	9
DENVER WSFO AP	52.1	27.7	39.9	1.1	70	12	745	0	93	1.62	0.79	195.2	7
EVERGREEN	49.2	19.1	34.1	-0.1	67	1	922	0	67	1.90	0.90	190.0	4
LAKE GEORGE 8SW	43.3	15.9	29.6	1.3	59	-4	1055	0	28	0.32	-0.06	84.2	6
COLORADO SPRINGS	51.8	26.5	39.1	1.5	70	11	767	0	99	0.44	-0.09	83.0	3
CANON CITY 2SE	56.6	28.3	42.5	0.2	73	8	668	0	144	0.47	-0.19	71.2	4
PUEBLO WSO AP	57.2	21.9	39.5	-1.0	74	4	754	0	147	0.49	0.02	104.3	2
WALSENBURG	54.6	27.8	41.2	0.1	72	5	707	0	119	1.58	0.69	177.5	5
TRINIDAD FAA AP	55.9	24.9	40.4	-0.6	73	10	730	0	137	0.51	-0.08	86.4	4

Mountains/Interior Valleys*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	38.6	8.2	23.4	-2.9	59	-18	1242	0	16	1.17	0.58	198.3	7
LEADVILLE 2SW	39.4	11.5	25.5	0.5	54	-12	1180	0	5	0.81	-0.09	90.0	10
SALIDA	49.6	16.4	33.0	-3.5	66	-4	954	0	68	0.43	-0.19	69.4	3
BUENA VISTA	49.5	16.2	32.8	-1.0	63	-6	955	0	65	0.24	-0.35	40.7	3
SAGUACHE	45.3	15.6	30.5	-0.8	60	-7	1031	0	30	0.44	-0.05	89.8	4
HERMIT 7ESE	41.9	8.3	25.1	0.5	61	-12	1189	0	12	1.60	0.42	135.6	4
ALAMOSA WSO AP	45.4	8.7	27.0	-2.7	61	-16	1130	0	39	0.95	0.59	263.9	6
STEAMBOAT SPRINGS	43.1	17.5	30.3	1.4	65	-2	1033	0	33	2.05	0.24	113.3	10
GRAND LAKE 6SSW	38.9	17.4	28.1	0.4	56	3	1098	0	9	1.08	0.21	124.1	10
DILLON 1E	40.6	12.5	26.6	-0.1	58	-8	1145	0	15	0.93	0.22	131.0	9
CLIMAX	33.3	8.4	20.8	-1.0	48	-11	1320	0	0	2.22	0.49	128.3	11
ASPEN 1SW	43.6	17.9	30.8	0.8	64	0	1024	0	19	1.68	0.08	105.0	11
TAYLOR PARK	38.1	13.9	26.0	6.8	54	-6	1163	0	6	0.85	-0.22	79.4	6
TELLURIDE	46.2	17.2	31.7	0.5	62	-5	992	0	27	2.26	0.71	145.8	11
PAGOSA SPRINGS	50.1	16.4	33.2	0.3	65	-1	947	0	58	2.62	1.02	163.7	8
SILVERTON	42.9	5.8	24.3	0.6	57	-17	1215	0	11	2.45	1.00	169.0	9
WOLF CREEK PASS 1	42.1	8.8	25.5	-0.6	54	-7	1180	0	2	5.36	1.66	144.9	7

Western Valleys*

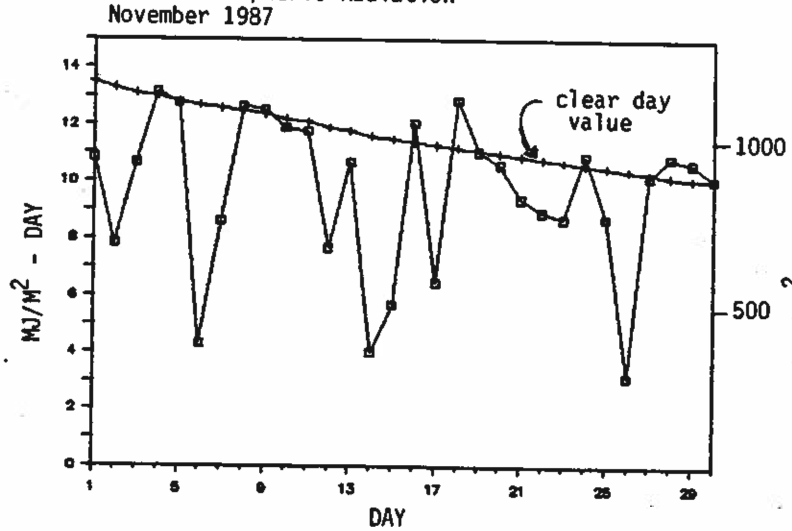
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	45.1	21.2	33.2	1.7	67	5	950	0	42	1.16	-0.04	96.7	8
HAYDEN	46.0	21.7	33.8	2.0	68	5	926	0	36	1.07	-0.17	86.3	9
RANGELY 1E	46.6	25.1	35.8	2.2	62	11	866	0	41	1.29	0.66	204.8	6
EAGLE FAA AP	47.2	18.9	33.0	1.5	64	-2	950	0	43	0.46	-0.13	78.0	8
GLENWOOD SPRINGS	50.4	26.4	38.4	3.0	70	7	790	0	63	0.97	-0.03	97.0	7
RIFLE	51.8	23.0	37.4	0.7	73	10	819	0	76	0.74	-0.07	91.4	5
GRAND JUNCTION WS	49.5	29.7	39.6	-0.6	68	17	754	0	62	1.92	1.31	314.8	8
CEDAREDGE	50.1	26.4	38.3	0.4	70	12	794	0	67	1.50	0.60	166.7	8
PAONIA 1SW	51.3	27.0	39.2	0.5	74	12	766	0	78	1.03	-0.14	88.0	7
DELTA	55.8	24.6	40.2	1.7	72	13	737	0	104	0.86	0.26	143.3	5
MONTROSE NO. 2	48.5	24.6	36.5	-1.0	67	11	849	0	52	1.07	0.39	157.4	7
URAVAN	52.3	26.2	39.2	-1.8	68	13	766	0	74	1.99	0.93	187.7	9
NORWOOD	46.4	20.5	33.4	-0.3	65	3	939	0	34	2.64	1.66	269.4	6
YELLOW JACKET 2W	47.3	26.1	36.7	-0.6	63	10	840	0	30	3.11	1.87	250.8	9
CORTEZ	50.6	21.5	36.0	-2.2	65	7	860	0	56	2.68	1.65	260.2	9
DURANGO	50.1	22.7	36.4	-1.0	66	11	851	0	51	3.24	1.91	243.6	9
IGNACIO 1N	52.4	21.8	37.1	1.4	66	9	828	0	78	1.83	0.80	177.7	8

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

NOVEMBER 1987 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	8	15	7	--	--
Denver	8	11	11	74%	65%
Fort Collins	10	12	8	--	--
Grand Junction	9	7	14	66%	63%
Pueblo	12	10	8	73%	74%

Fort Collins
Total Hemispheric Radiation
November 1987



Where do those long-range forecasts come from? continued

There is a small group called the Prediction Branch within the Climate Analysis Center (CAC) of the National Weather Service (NWS) back in Washington D.C. which has been providing 30- and 90-day forecasts to the public since 1949 and 1959, respectively. These are the forecasts that appear in the papers and on TV near the beginning of each month that show which parts of the country are expected to be wetter (drier) and/or warmer (colder) than normal. The 30-day forecast is issued at the beginning of each month and again in mid month; 90-day forecasts are only issued at the beginning of each month. Last month we promised to give you more information on how long range forecasts are made. This is our attempt to do that. One of the long-range forecasters, Anthony Barnston, is a frequent reader of our monthly report. He has been kind enough to provide us with a brief description of their forecast techniques. It will be hard to grasp all of the forecast details from this extremely abbreviated description. Hopefully it will give you enough information to help you gain some appreciation for the process.

The 30-day forecast is prepared by one individual. The responsibility is rotated from month to month among 3 forecasters. The basis for each 30-day forecast is the anticipated mean departure from the normal air motions at a height of approximately 10,000 feet above sea level (700 millibars). Forecasts are based on a number of analyses, both objective and subjective. First, atmospheric patterns and changes over the past few months are examined. Then, results of the computer generated 3-5 day forecasts and 6-10 day forecasts are included. Next, detailed objective statistics on persistence (the tendency for existing atmospheric patterns to continue) are computed to help determine which features of the atmospheric circulation are most likely to continue and which will most likely change during the forecast period. These results are combined and checked for internal consistency. A 700 millibar predicted mean flow pattern is constructed consistent with the strongest (most confident) features derived from the previous analyses. From this flow pattern, surface temperature and precipitation patterns are inferred either by a correlation model or by "specification" in which historic records are examined to show what surface weather patterns accompanied similar upper level wind motions during previous years. The individual forecaster uses his best judgment to produce a final forecast using a probability format.

The 90-day "seasonal" forecasts uses different data inputs, no numerical forecasts, and is the result of consensus among 3 to 4 forecasters. Statistics on persistence are the major inputs to the seasonal forecast. Observed conditions from the past month, the past 3 seasons and the past 2 years of the season being forecast are carefully analyzed to determine which features are most likely to persist throughout the forecast period. The other major input is called the analog method. Years are found whose weather patterns are most similar or most opposite to what is currently occurring by examining features such as the height of the 700 millibar pressure surface, sea surface temperatures in selected tropical and extratropical locations in the Atlantic and Pacific, U.S. surface temperatures and sea level pressure in the eastern tropical Pacific. These criteria often capture the phase of the El Nino/Southern Oscillation cycle. Other inputs of lesser significance are then considered such as soil moisture and snow cover over the central U.S. Finally, forecaster judgement is applied to create an internally consistent forecast given the assortment of dependent and independent facts and tools.

Accuracy of long range forecasts is not especially good, but has been improving gradually in recent years. Forecasts are most accurate for the winter and summer seasons -- least accurate for the spring and fall. Accuracy of precipitation forecasts is only about half as good as temperature forecast. Monthly forecasts are a little better than seasonal forecasts. Monthly winter temperature forecasts, which are the most accurate of the long range forecasts, have an accuracy for the nation as a whole of about 16% (0% is equal to pure chance, 100% is a perfect forecast). Forecast accuracy tends to be greatest for the southeast U.S. and the Pacific coast. the least accuracy is found -- you guessed it, in the vicinity of the Rocky Mountains.

In addition to the Prediction Branch of the CAC, there are a small number of Experimental Forecast Centers throughout the country. Two examples are the Scripps Oceanographic Institute in California and NASA Goddard laboratories in Maryland. Research results from these experimental centers and other atmospheric research organizations, such as Colorado State University and the National Center for Atmospheric Research, are constantly being reviewed and, when appropriate, incorporated into the operational forecasting schemes.

Anyone can subscribe to the monthly and seasonal forecast service provided by NWS-CAC by writing to: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Request the Monthly and Seasonal Weather Outlook. The cost per annual subscription to receive 12 monthly issues and 12 mid-month updates is $19. These reports contain verification information as well as the forecast and are mailed in a timely manner.

COLORADO CLIMATE

DECEMBER 1987

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 3

December in Review:

Almost all of Colorado enjoyed a crisp, cold and snowcovered Christmas. Except for the central mountains and most of the southwestern mountains and valleys, Colorado experienced a snowier than average month. Along with the snow came colder than average temperatures, and above average cloudcover, especially east of the Continental Divide.

Colorado's February Climate:

Last year was a most unusual February. More precipitation fell on the Eastern Plains than was observed in most of the northern and central mountains. It is unlikely that such a pattern will repeat.

Historically, February is an extremely dry month east of the mountains averaging only about 0.25" (3-8" snow). Precipitation increases to 0.50-1.00" in the eastern foothills (8-20" snow) and rises to 2.00-4.00" in the higher mountains (30-60" snow). In Colorado's western valleys, precipitation ranges from about 0.50" to 1.50" (8-30" snow). The likelihood of major snowstorms from the Front Range out onto the plains is low until the last few days of the month, but large storms are not uncommon in the mountains.

The whole state begins to warm-up from January's midwinter chill as days begin to grow visibly longer. In the mountains the warm-up is barely noticeable -- generally only 1-4 degrees Fahrenheit. But in some western valleys and out on our plains, the warm-up can be dramatic. At Lamar and Grand Junction, February temperatures average close to 10 degrees higher than in January. Southeast Colorado has even experienced a few highs in the 80s. But don't let this lull you into thinking spring is here. Subzero temperatures continue routinely throughout the month up in the mountains and are still a good possibility at lower elevations during the first 10 days of February. Many of Colorado's coldest temperatures have occurred in early February including Fort Morgan's -41°F reading on Feb. 1, 1951 and the Colorado all-time record of -61°F set at Maybell on Feb. 1, 1985.

Colorado Snow Removal Problems -- A Climatological Perspective

Where I grew up back in the Midwest, snow removal was never much of a problem. Most of the time it didn't snow enough to matter. When a big storm finally would come our way, it was a mighty good excuse to stay at home. As a kid, we hoped no one would ever clear the streets so we could have long holidays from school. Unfortunately, it usually didn't take more than a few hours after a storm ended before the local farmers would get their blades attached to their tractors and head for town to help dig out their elderly relatives. It was such a disappointment to see those tractors -- for me, anyway.

That same approach to snow removal is undoubtedly still alive and well here in Colorado. But in the larger cities there are too many people, too many cars, too many miles of streets and not a whole lot of people with their own tractors and snow plows. All it takes is one enthusiastic and largely unpredicted snowstorm to hit a major metropolitan area (such as Denver's post-Christmas storm of 1987) and the wrath of seemingly millions of urbanites comes down on their elected government officials. It's all pretty funny, I suppose, until you loose 2 hubcaps, inadvertently realign your wheels, smack into your neighbor's parked car, and spend the rest of the winter nursing your Aunt Sarah's broken hip that she got from falling on the ice. The fact is, our urban areas nationwide -- not just Denver -- are extremely vulnerable to heavy snows. Heavy snow disrupts the urban economy and lifestyle, and folks don't adjust well at all to the disruption. People out in the country chuckle and poke fun at their urban relatives. But the problem is real.

(continued on last page)

DECEMBER 1987 DAILY WEATHER

The jet stream was quite strong during December and spent much of the month directly over Colorado. This kept weather systems moving rapidly and weather changes occurring quickly.

Date	Event
1-2	Mostly dry with moderating temperatures. A few mountain snow showers on the 2nd and strong winds along the northern Front Range.
3-6	Unseasonably warm statewide with 40s and 50s in the mountains with some 60s and even 70s out on the plains. Both Walsh and Springfield hit 75° on the 4th -- the hottest in the state. Clouds spread over the state 4-5th and several cities in western Colorado received significant rain on the 5th. Paonia totalled 0.58" from the storm.
7-11	Three disturbances crossed Colorado in rapid succession with gusty winds and scattered mountain snows with each system. A low pressure area developed with the first system late on the 7th and produced a period of rain and wet snow on the northeast plains. Several stations reported at least 0.25" of precipitation, but close to 1.00" of moisture fell in a small area from Brush to Akron. Mild throughout the period but sharply warmer on the 10th with some 60s and 70s reported again on the plains. Windy and turning colder on the 11th.
12-15	Arctic air began a gradual invasion of Colorado on the 12th bringing an end to mild autumn weather. A major storm developed to our southwest and buried El Paso, Texas, with unprecedented snow on the 13th. Most of Colorado was spared much moisture, but temperatures dipped to near zero on the plains and well below 0° in the mountains 14-16th. Some areas of southern Colorado and the Front Range received significant snowfall 13-14th. Ten inches of snow fell at Mesa Verde, and Walsenburg received 18".
16-21	Moderating temperatures but still chilly. Increasing clouds 16-17 as a large storm drifted eastward from California. The storm weakened as it passed south of the state 18-19th but most of the mountains and Western Slope received some snow. Close to a foot of snow fell in parts of the San Juan mountains. Air pollution problems developed along the Front Range, but brisk westerly winds 20-21st cleared the air.
22-28	A major storm developed impressively northwest of Colorado on the 22nd and dropped southward. Snow became heavy in northwest counties and along the northern Front Range on the 23rd. Hayden measured 17" from the storm, Rangely 13" and Fort Collins 8". By the 24th the storm was over extreme southern Arizona but snow continued over our southern mountains. On Christmas Day snow began falling in southeastern Colorado. As much as 6" of snow covered parts of the Arkansas Valley. Then on the 26th, the storm strengthened again unexpectedly and snow increased over northeastern Colorado late in the day. Heavy snow then focused on the Denver area on the 27th with totals ranging from 12" to about 2-3 feet at the base of the foothills. Out on the plains snowfall amounts were mostly between 4 and 12 inches. The storm finally moved east of Colorado on the 28th leaving the entire state blanketed with new snow. Temperatures were also quite cold during the period. Northern Colorado woke to a frigid Christmas morning. Greeley hit -9°F on the 25th. Hohnholz Ranch (Laramie River) was -37° for the coldest report in the state.
29-31	Some mountain flurries but generally dry and seasonal. A surge of Artic air reached the state on the 30th. The year ended with cold sunshine but subzero nighttime temperatures across most areas.

December 1987 Extremes

Highest Temperature	75°F	December 4	Springfield 7WSW Walsh
Lowest Temperature	-37°F	December 25	Hohnholz Ranch
Greatest Total Precipitation	3.25"		Silver Lake
Least Total Precipitation	0.19"		Brown's Park Refuge
Greatest Total Snowfall*	68"		Mount Evans Research Center
Greatest Snowdepth	79"	December 28	Mount Evans Research Center

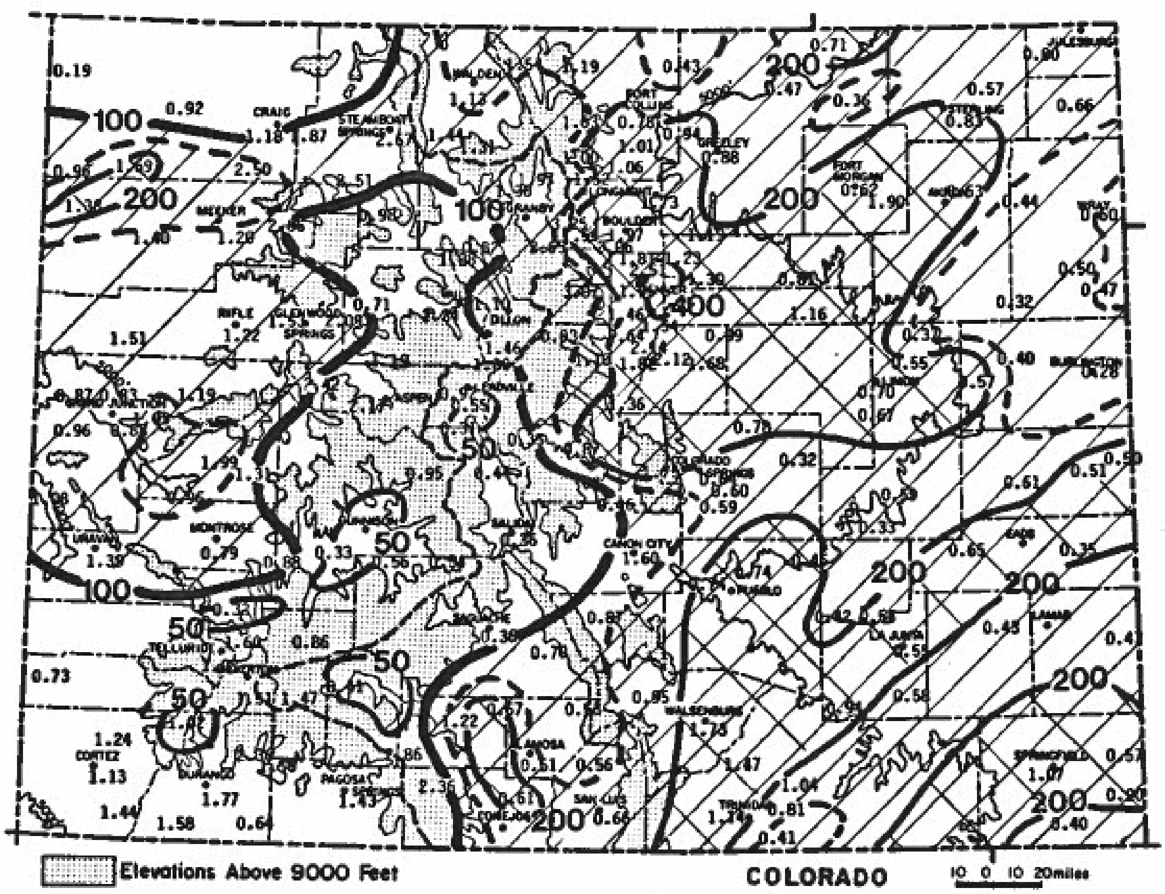
* data derived only from those stations with complete daily snowfall records.

DECEMBER 1987 PRECIPITATION

The storms in late December covered eastern Colorado with much above average precipitation for the month. More than double the normal meager precipitation was observed in many areas. By far the snowiest region, compared to average, was a strip from Loveland to Castle Rock where 3 to 5 times the average precipitation fell. Near to above average precipitation also fell in west central and northwest Colorado. But even with the strong westerly flow aloft and frequent disturbances, most of Colorado's mountain areas were drier than normal. While, in general, the central and southern mountains received about 80% of average, a number of areas were significantly drier. Half or less of the average December precipitation fell near Rico, Ridgway, Gunnison, Creede, and Leadville.

Greatest	
Silver Lake	3.25"
Mount Evans Research Center	3.07"
Wolf Creek Pass 1E	2.86"
Steamboat Springs	2.67"
Winter Park	2.65"

Least	
Brown's Park Refuge	0.19"
Burlington	0.28"
Twin Lakes Reservoir	0.31"
Rush 4N	0.32"
Joes	0.32"
Ridgway	0.32"



Precipitation amounts (inches) for December 1987 and contours of precipitation as a percent of the 1961-1980 average. The dashed line represents 150% of average.

1988 WATER YEAR PRECIPITATION

Three months into the 1988 water year, precipitation has been above average over most of northeastern Colorado, and also the westernmost and southernmost counties of the state. The Denver area is wettest, compared to average, with several stations reporting more than double their average precipitation. Drier than average conditions run in a band from the northwest corner of the state through the central mountains and then down the Arkansas Valley to Kansas. The driest areas in this band have received only 60% of the average October-December moisture.

Comparison to Last Year

The northern mountains are a bit wetter than they were at this time last year. The Western Slope and northeastern plains are about the same. But in the southwestern mountains and the Arkansas Valley, conditions this year are drier than they were a year ago.

1988 Water Year to Date through December

Wettest (as % of average)

Wheatridge	272%	6.33"
Castle Rock	271%	6.48"
Akron FAA	260%	3.53"

Driest (as % of average)

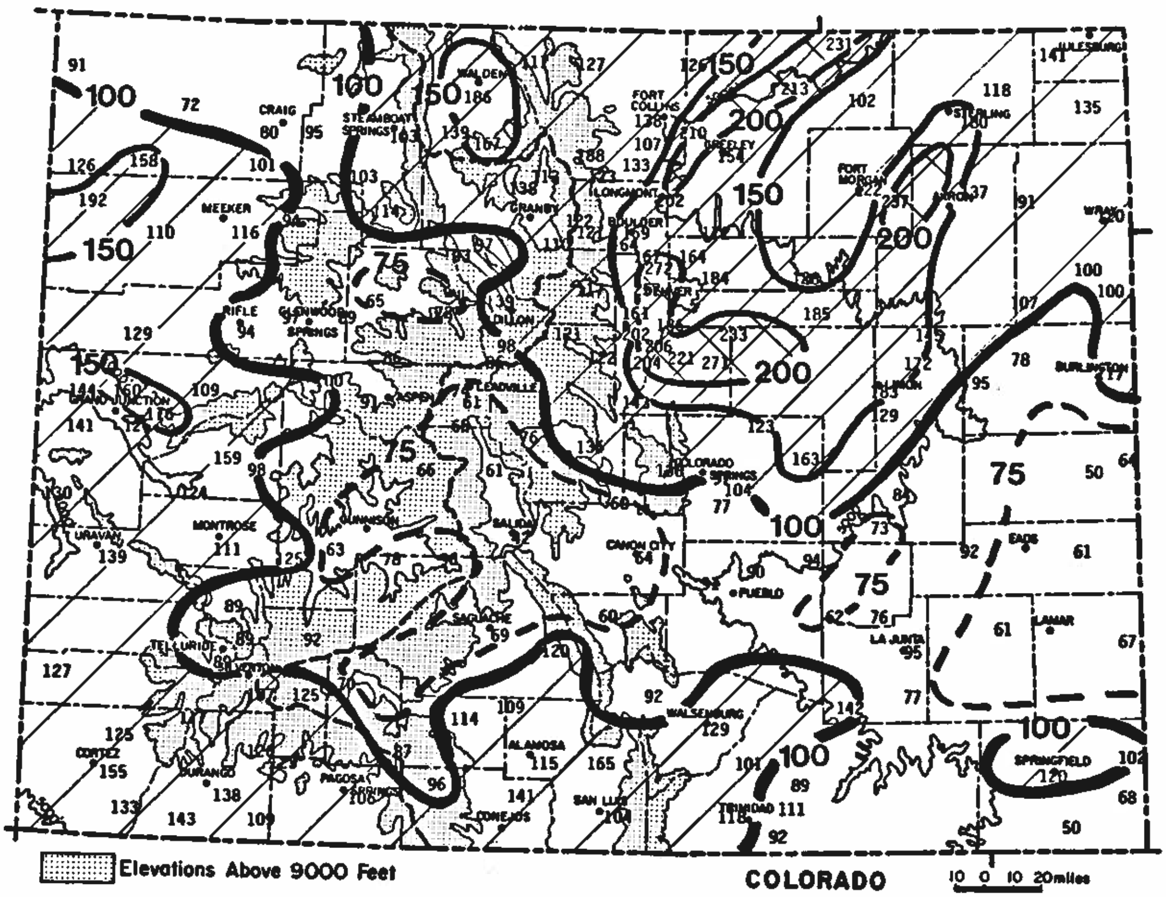
Salida	42%	0.96"
Cheyenne Wells	50%	0.78"
Campo 7S	50%	0.78"

Wettest (total precipitation)

Wolf Creek Pass 1E	11.48"	87%
Lemon Dam	9.12"	126%
Vallecito Dam	8.88"	123%

Driest (total precipitation)

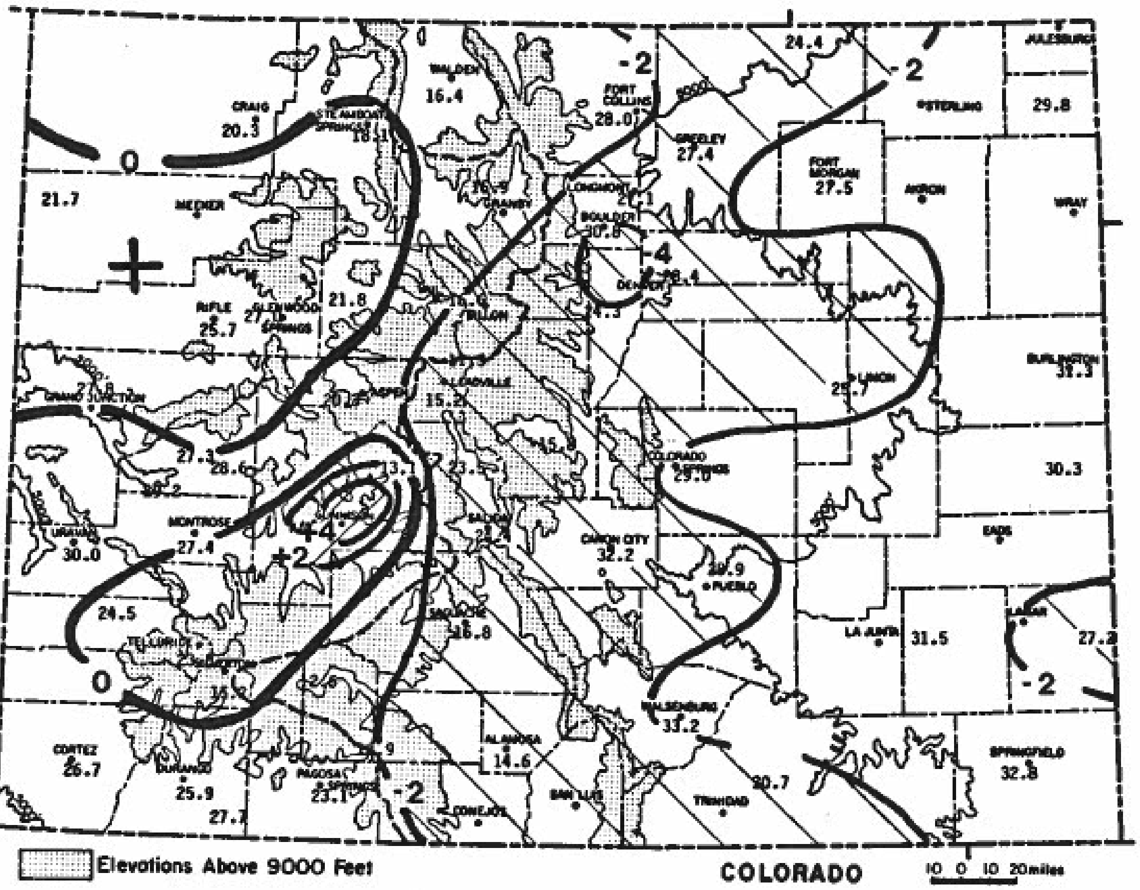
Brandon	0.70"	61%
Fowler	0.75"	62%
Cheyenne Wells	0.78"	50%
Campo 7S	0.78"	50%



Precipitation for October 1987 through December 1987 as a percent of the 1961-1980 average.

DECEMBER 1987 TEMPERATURES AND DEGREE DAYS

The first 10 days of December were much warmer than average but the last 21 days more than made up the difference. Except for a few warmer locations in western Colorado, most of the state ended up 1 to 3 degrees Fahrenheit colder than average for the month as a whole. The Denver-Boulder area was the coldest, compared to average, with readings about 4 degrees below the 1961-80 average.



December 1987 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

DECEMBER 1987 SOIL TEMPERATURES

The onset of snowcover is evident in the December soil temperatures. Snowcover actually warms the near-surface soil temperatures by providing insulation from the cold air above. Snow also suppresses any rapid fluctuations in temperature.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

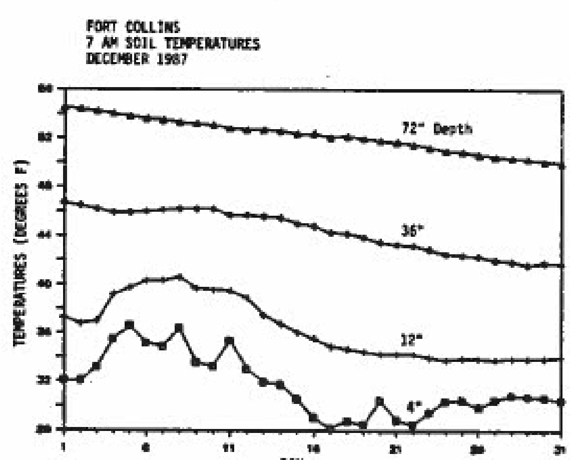


Table 1. Colorado Heating Degree Day Data through December 1987.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130	1556							3813
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024	1382							3588
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713	1053							2298
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955	1277							3260
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724	1037							2233
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668	1007							2183
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767	1108							2561
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860	1179							2630
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950	1376							3238
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737	1102							2312
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745	1125							2422
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145	1491							4597
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851	1206							2738
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37		314	658	930	1283	1309	925	927	566	384	111	7444
	87-88	54	75	254	509	950	1331							3173
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922	1255							3299
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784	1140							2572
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773	1154							2508
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754	1147							2189

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098	1516							4235
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762	1157							2498
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M	M							0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653	1032							1996
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180	1534							4794
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840	1209							2796
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87		0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805	1169							2642
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	M	7308
	87-88	M	M	M	M	M	M							0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849	1160							2522
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947	1292							3318
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754	1111							2284
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819	1209							2577
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033	1448							
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742	M							1306
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992	1269							3673
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730	1054							2223
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242	1499							4472
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707	977							2150

M = MISSING DATA

DECEMBER 1987 CLIMATIC DATA

Eastern Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	37.1	11.7	24.4	-4.4	67	-14	1252	0	36	0.71	0.45	273.1	8
FORT MORGAN	40.6	14.5	27.5	0.2	67	-11	1154	0	48	0.62	0.37	248.0	5
AKRON FAA AP	37.5	15.9	26.7	-1.9	66	-4	1181	0	35	1.76	1.51	704.0	8
HOLYOKE	42.4	17.1	29.8	0.1	68	1	1085	0	50	0.66	0.29	178.4	4
BURLINGTON	41.9	20.7	31.3	-0.6	69	2	1037	0	51	0.28	-0.04	87.5	4
LIMON WSMO	37.9	13.4	25.7	-3.0	66	-7	1209	0	37	0.70	0.50	350.0	9
CHEYENNE WELLS	42.5	18.1	30.3	-0.4	73	-2	1069	0	66	0.51	0.29	231.8	2
LAS ANIMAS	46.3	16.7	31.5	-0.2	70	-5	1032	0	75	0.60	0.36	250.0	5
HOLLY	44.3	10.1	27.2	-3.6	67	-8	1166	0	54	0.47	0.22	188.0	4
SPRINGFIELD 7WSW	45.5	20.1	32.8	-1.4	75	-8	990	0	73	1.07	0.76	345.2	5

Foothills/Adjacent Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	39.8	16.2	28.0	-1.9	62	-8	1140	0	33	0.78	0.32	169.6	9
GREELEY UNC	38.9	15.9	27.4	-2.3	65	-9	1157	0	33	0.88	0.41	187.2	7
ESTES PARK	35.6	8.4	22.0	-6.6	57	-21	1324	0	10	1.00	0.54	217.4	5
LONGMONT 2ESE	41.4	12.7	27.1	-2.4	68	-15	1169	0	37	1.73	1.30	402.3	5
BOULDER	41.7	19.9	30.8	-4.3	65	-2	1053	0	45	1.97	1.34	312.7	9
DENVER WSFO AP	39.9	16.9	28.4	-3.6	65	-6	1125	0	40	1.30	0.76	240.7	9
EVERGREEN	39.2	9.3	24.3	-3.9	58	-10	1255	0	18	1.46	0.71	194.7	6
LAKE GEORGE 8SW	30.2	1.5	15.8	-2.6	51	-21	1518	0	1	0.87	0.50	235.1	7
COLORADO SPRINGS	40.1	17.9	29.0	-1.7	68	-4	1108	0	40	0.64	0.25	164.1	8
CANON CITY 2SE	44.4	20.1	32.2	-3.8	70	-3	1007	0	61	0.60	0.02	103.4	6
PUEBLO WSO AP	43.2	14.7	28.9	-3.1	71	-11	1111	0	59	0.74	0.39	211.4	7
WALSENBURG	44.3	22.1	33.2	-1.3	66	-6	977	0	52	1.73	0.98	230.7	7
TRINIDAD FAA AP	45.1	16.2	30.7	-2.5	71	-11	1054	0	66	1.04	0.47	182.5	8

Mountains/Interior Valleys*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	27.8	4.9	16.4	-1.8	51	-26	1499	0	1	1.13	0.51	182.3	8
LEADVILLE 2SW	27.7	2.7	15.2	-2.8	53	-18	1534	0	2	0.55	-0.55	50.0	16
SALIDA	37.8	10.9	24.4	-4.4	61	-7	1254	0	16	0.36	-0.25	59.0	4
BUENA VISTA	36.6	10.5	23.5	-2.7	61	-9	1277	0	22	0.44	-0.14	75.9	4
SAGUACHE	29.4	4.2	16.8	-3.9	50	-14	1489	0	0	0.36	-0.07	83.7	5
HERMIT 7ESE	27.2	-2.0	12.6	-0.3	38	-22	1617	0	0	0.41	-1.02	28.7	4
ALAMOSA WSO AP	29.4	-0.2	14.6	-2.9	47	-27	1556	0	0	0.51	0.06	113.3	5
STEAMBOAT SPRINGS	28.6	7.6	18.1	0.9	49	-22	1448	0	0	2.67	0.13	105.1	15
GRAND LAKE 6SSW	26.5	5.3	15.9	-1.7	47	-22	1516	0	0	1.30	0.43	149.4	13
DILLON 1E	29.4	3.8	16.6	-2.1	54	-15	1491	0	3	1.10	0.23	126.4	11
CLIMAX	22.7	-0.2	11.3	-4.1	49	-20	1659	0	0	1.30	-0.81	61.6	14
ASPEN 1SW	31.2	9.4	20.3	-1.7	60	-8	1382	0	8	2.17	-0.24	90.0	14
TAYLOR PARK	27.1	-0.9	13.1	6.6	45	-27	1601	0	0	0.95	-0.70	57.6	9
TELLURIDE	36.9	10.7	23.8	0.6	58	-8	1269	0	9	1.08	-0.63	63.2	15
PAGOSA SPRINGS	38.4	7.8	23.1	-0.4	56	-8	1292	0	5	1.43	-0.46	75.7	8
SILVERTON	33.3	-2.9	15.2	1.2	54	-20	1537	0	2	1.51	-0.43	77.8	16
WOLF CREEK PASS 1	30.4	3.4	16.9	-4.9	52	-14	1484	0	1	2.86	-2.37	54.7	16

Western Valleys*

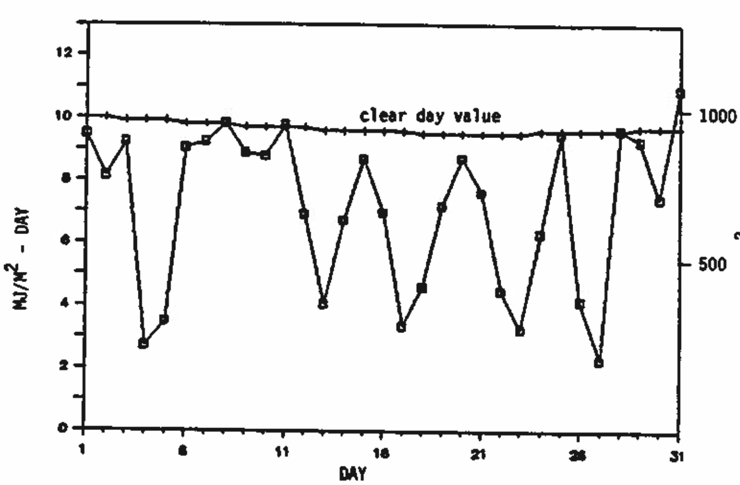
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	32.0	8.6	20.3	-1.0	58	-20	1376	0	7	1.18	-0.47	71.5	8
HAYDEN	32.5	10.3	21.4	1.4	58	-24	1343	0	11	1.87	0.22	113.3	12
RANGELY 1E	32.9	10.5	21.7	2.5	54	-23	1334	0	3	1.38	0.83	250.9	8
EAGLE FAA AP	33.9	9.7	21.8	1.9	59	-15	1331	0	10	0.71	-0.23	75.5	9
GLENWOOD SPRINGS	36.2	17.9	27.0	2.0	58	-2	1169	0	9	1.53	0.08	105.5	13
RIFLE	37.9	13.5	25.7	1.1	59	-6	1209	0	14	1.22	0.09	108.0	11
GRAND JUNCTION WS	36.9	18.8	27.8	0.0	53	4	1147	0	2	0.83	0.23	138.3	8
CEDAREDGE	37.1	17.6	27.3	-1.0	55	0	1161	0	10	1.99	0.99	199.0	16
PAONIA 1SW	38.9	18.3	28.6	-0.0	55	4	1120	0	9	1.31	-0.20	86.8	11
DELTA	42.2	16.2	29.2	0.8	55	-10	1102	0	11	0.96	0.39	168.4	5
MONTROSE NO. 2	38.1	16.6	27.4	-0.0	57	1	1160	0	8	0.79	0.09	112.9	10
URAVAN	40.6	19.3	30.0	-0.3	55	10	1077	0	5	1.39	0.36	135.0	14
NORWOOD	36.1	12.9	24.5	0.5	53	-5	1248	0	4	MISS			
CORTEZ	40.1	13.3	26.7	-1.3	55	-1	1179	0	8	1.13	-0.14	89.0	11
DURANGO	38.6	13.1	25.9	-1.6	59	-6	1206	0	16	1.69	-0.30	84.9	11
IGNACIO 1N	43.1	12.4	27.7	2.3	63	-5	1146	0	25	0.64	-0.60	51.6	9

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

DECEMBER 1987 SUNSHINE AND SOLAR RADIATION

Station	Number of Days: clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	10	4	17	--	--
Denver	8	9	14	52%	65%
Fort Collins	10	12	9	--	--
Grand Junction	6	9	16	50%	63%
Pueblo	13	4	14	56%	74%

FORT COLLINS
TOTAL HEMISPHERIC RADIATION
DECEMBER 1987



Colorado Snow Removal Problems -- A Climatological Perspective continued

It only takes a dusting of ill-timed snow to cause a few accidents and bungle rush-hour traffic. But to really knock a city like Denver off its feet takes a lot of snow and plenty of cold weather and maybe some wind. That's what happened in recent weeks as the Denver area received a belated Christmas gift of 12 to 36 inches of wind-driven snow.

It's been very interesting listening to all the ensuing discussion of snow removal strategies, budgets, taxes, and such. Especially interesting to me is the talk about the old reliable solar snow melter that traditionally has been called on to do most of the Front Range snow removal. People seem to think that it has let us down in recent years.

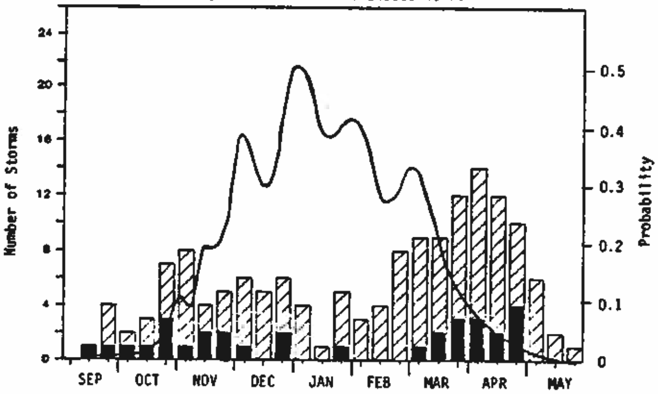
In truth, the old solar snow plow is alive and well, but what people forget is that it typically takes a few weeks vacation each year (as the graphs below will illustrate). At the winter solstice, daylength in Colorado drops to about 9 hours and 15 minutes and the sun only climbs to an angle of about 27 degrees above the south horizon at noon. At this time and for about a month either side of the solstice, the solar energy, by itself, is not enough to melt large amounts of snow quickly. Fortunately, other factors also contribute to snowmelt. Warm temperatures in the soil can help melt snow and ice from below during much of the Front Range's long snow season. Only from late November into mid February do we get little help from below for melting our snow. And then, of course, there is temperature. While Colorado's Front Range cities can experience brutal winter weather, it is usually just a day or two until warmer weather (>40°F) returns. However, as the temperature analysis shows, there is about a 2-week period beginning just after Christmas, when you just can't count on warm temperatures (and chinook winds) to get rid of snow. Interestingly, this is exactly when this winter's large snowstorm hit and also the 1982 Christmas Eve storm.

So how did we ever come to believe that snow would melt by itself along the Colorado Front Range? To answer this question we examined all Denver snow storms since 1882 that dumped at least 7.5" snow in 48-hours at the official weather station. There have been 151 such storms in the past 106 years. More than half of these storms (82) occurred from the last week of February on into May. Another 29 occurred before November 20. This means only 40 storms have occurred during the critical period from about Thanksgiving to mid February -- the period when our climate is least likely to perform urban snow removal by itself.

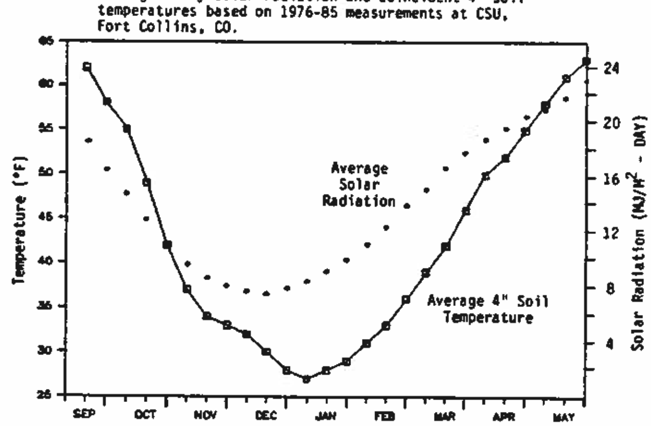
Eight inches of snow, especially when it's dry and fluffy as most of our midwinter storms are, does not shut down a city, so we also looked at only the largest storms. There have been 36 storms since 1882 that dumped at least 14" of snow on Denver. About half of these really big storms occurred in late March and April. They have also occurred as early as mid September. During the mid-winter period from mid November to mid March, there have only been 8 such storms since 1882, 5 of which have occurred in the past 10 years. Prior to 1982 no 14-inch storms had been observed in Denver during the critical late December early January period when the natural snow melter is most likely on vacation. Combining these statistics, it is evident that the vast majority of heavy snows along the Front Range normally will melt quickly and not present long-lasting problems to snow removal. But if the snow falls at the wrong time, there is a very good chance it will stick around to bother us for a long time.

Finally, the inevitable question that everyone seems to ask -- "Is the climate changing?" As usual, that's not very obvious. There has been no real change in the number of snowstorms $\geq$ 7.5" during the past century. The average is 15 per decade and that's exactly how many Denver reported during the past 10 years. There have been definitely more of the really large storms in the past few years, but it is not a part of the long-term trend. One final interesting note. After a number of years in the 1960s with few big storms, there was a flurry of larger storms in the early 1970s, a few of which occurred in late December. It was at this same time that most Front Range cities first began to routinely plow major streets. Somehow, I doubt if this interesting correlation between climate events and snow removal policy was a mere coincidence.

Total occurrences of Denver snowstorms $\geq$ 7.5" and $\geq$ 14" (dark bars) for the 1882-1987 period and coincident probability that daily maximum temperatures will not exceed 40°F.



Average daily solar radiation and coincident 4" soil temperatures based on 1976-85 measurements at CSU, Fort Collins, CO.



COLORADO CLIMATE

JANUARY 1988

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This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 4

January in Review:

January lived up to it's reputation as the coldest month of the year. With the help of frequent strong winds, it felt even colder. Plenty of snow also accompanied the cold, and most of the state ended up with above average moisture for the month. A severe blizzard brought serious hardship to much of the Eastern Plains from the 18th to the 23rd.

Colorado's March Climate:

The old adage "As the days grow longer, the storms grow stronger" often applies well to Colorado in March. Strong sunshine (solar energy reaching the ground is actually double what it was in December) warms the ground and the nearby air. But it also adds more fuel to the fire of winter storm systems. The jet stream, which remains strong in March, often brings a succession of storms across our state. The increased solar energy tends to make the atmosphere more convectively unstable, and warmer temperature means the air can hold more moisture. This results in more winds, thicker clouds and heavier shower-like precipitation. It's even possible to have a little lightning and thunder, although that normally waits until April. But don't fret! There are often pleasant respites between storms when skies are clear, temperatures pleasant and fishing, skiing, biking and golfing conditions are all simultaneously excellent. It's an exciting time of year.

From the crest of the Rockies eastward almost to Kansas, March is known for its heavy and often unexpected snows. But on Colorado's Western Slope winter begins to loose its grip. March precipitation ranges from only about 0.25-0.50" (3-8" snow) in the San Luis Valley and 0.50-1.00" (6-15" snow) in the western valleys to 0.60-2.00" (7-30) on the Eastern Plains and foothills and 2.00-5.00" (30-80" snow) in the high mountains. In the high country, it's just another in a long series of winter months. Some of the March snows can come with very strong winds as every eastern Coloradan knows. Back in 1977 a 2-day blizzard claimed 9 human lives plus countless livestock.

March temperatures vary drastically from day to day, especially east of the mountains. For the month as a whole, high temperatures average in the 50s at elevations below 6,000 feet with nighttime lows in the 20s. In the higher mountains (above 9,000 feet) temperatures are still cold with highs only in the 20s and 30s and lows typically in the single digits. A few warm days are almost a certainty with temperatures in the 40s and 50s in the mountains with 60s and 70s at lower elevations.

How Do We Know When Spring Is Here?

Spring officially arrives this year on March 20th. The classic definition for our seasons is based on the earth's orbit around the sun in combination with the tilt of the earth's axis of rotation. Strictly speaking, spring begins at the time of the spring equinox when the sun crosses the celestial equator. This means that all areas of the globe, except precisely at the north and south poles, have exactly 12 hours of day and 12 hours of night (at the poles the sun is half up and half down all day). Thereafter, for the next 6 months, days are longer than nights over the entire Northern Hemisphere. Spring covers the first three months of this period and officially ends on the summer solstice, the longest day of the year.

This is all fine and good, but in practice spring has come to mean something that is much harder to define according to the calendar. It is that time of year when flowers begin to bloom, when brown gives way to green, when mud reigns supreme, when animals give birth to their young, when love supposedly becomes the dominant human emotion, and when people get frantic about losing weight. I can deal with all of this quite nicely until the phone rings and someone asks, "How much snow do we usually get in the spring?" or "What's the average spring temperature in Haswell, Colorado" or something like that. All of a sudden we have to get specific. "Do you mean March 20-June 20, or do you mean April and May?" I ask. Few people know what they mean.

continued

J A N U A R Y   1 9 8 8   D A I L Y   W E A T H E R

For the second month in a row the jet stream was very strong and remained almost directly over Colorado. Fast moving weather systems and frequent strong winds resulted.

Date	Event
1-2	Some mountain clouds and snowshowers on the 1st -- otherwise sunny and very cold. Subzero nighttime temperatures occurred over most of the state with readings of -20° to -40°F over many mountain areas.
4-8	A frigid arctic air mass east of Colorado and a flow of mild, moist Pacific air from the west combined to produce widespread snow over the state. In the cold air east of the mountains most areas only got 1 or 2 inches of dry snow, but snows were heavier in the Arkansas Valley where 4-9" were reported. Snows were much heavier in the milder air west of the mountains. Grand Junction totalled 8" on the 4th-6th, their heaviest storm in recent years. Paonia received close to 20". Snows ended on the 7th and temperatures fell to their low point for the winter on the Eastern Plains. Pueblo had a low of -15° while Holly shivered with a -28°. Snows increased again in the mountains on the 8th.
9-14	Strong winds developed over the mountains and eastern foothills bringing an end to the long artic blast of the past 3 weeks. Temperatures soared into the 50s in many areas east of the mountains 10-11th. A strong cold front ended the brief warm-up and set off brief but severe blizzard conditions late on the 11th from the Western Slope to the eastern foothills. Very cold and windy on the 12th, then windy in the mountains but dry and warmer statewide.
15-24	A complex system of storms barraged Colorado with wicked winter weather. Temperatures were quite mild on the 15th as cloudcover spread over the state. Snow began late in the evening and continued on the 16th in parts of southern Colorado. Telluride got 8" of snow and Pueblo was surprised with 6". Then another round of snow began on the 17th as a deep low pressure area came inland across southern California. Durango awoke on the 18th to 20" of new snow (1.58" water content). Snow spread onto the plains during the day on the 18th. Temperatures dropped and strong winds developed creating dangerous blizzard conditions. Snow continued on the plains on the 19th with winds sometimes gusting to 40-60 mph closing schools and blocking nearly all roads. Measurements of snowfall and precipitation were nearly impossible, but estimates exceeded 12" over parts of the northeast plains. Drifts of 8-12' were common which kept roads blocked for several days. Snow ended on the 20th but temperatures dove. Taylor Park awoke to a cool -54°. A general improvement then began, but strong winds and blowing snow continued to cause problems. Wind gusts exceeded 100 mph early on the 23rd along parts of the Front Range. A bridge in Boulder was knocked down.
25-31	Strong northwest winds aloft 25-27th but a gradual improvement over the state. No precipitation and steadily warmer temperatures 25-28th with highs reaching the low 40s in the mountains by the 28th with some 60s east of the mountains. The 72° reading at Wheatridge was by far the highest in the state, but many snowcovered valley locations were much cooler. Clouds increased and temperatures continued to moderate on the Western Slope 29-31. However, mountain snows developed with some heavy amounts. Aspen received 11" before the end of the month, and Steamboat Springs got more than 1 foot. Cold air then slipped into eastern Colorado on the 31st along with a little light snow and freezing drizzle.

January 1988 Extremes

Highest Temperature	72°F	January 28	Wheatridge
Lowest Temperature	-54°F	January 20	Taylor Park Reservoir
Greatest Total Precipitation	5.46"		Rico
Least Total Precipitation	0.05"		Littleton
Greatest Total Snowfall*	77.5"		Steamboat Springs
Greatest Snowdepth**	93"	January 26	Tower (Buffalo Pass)

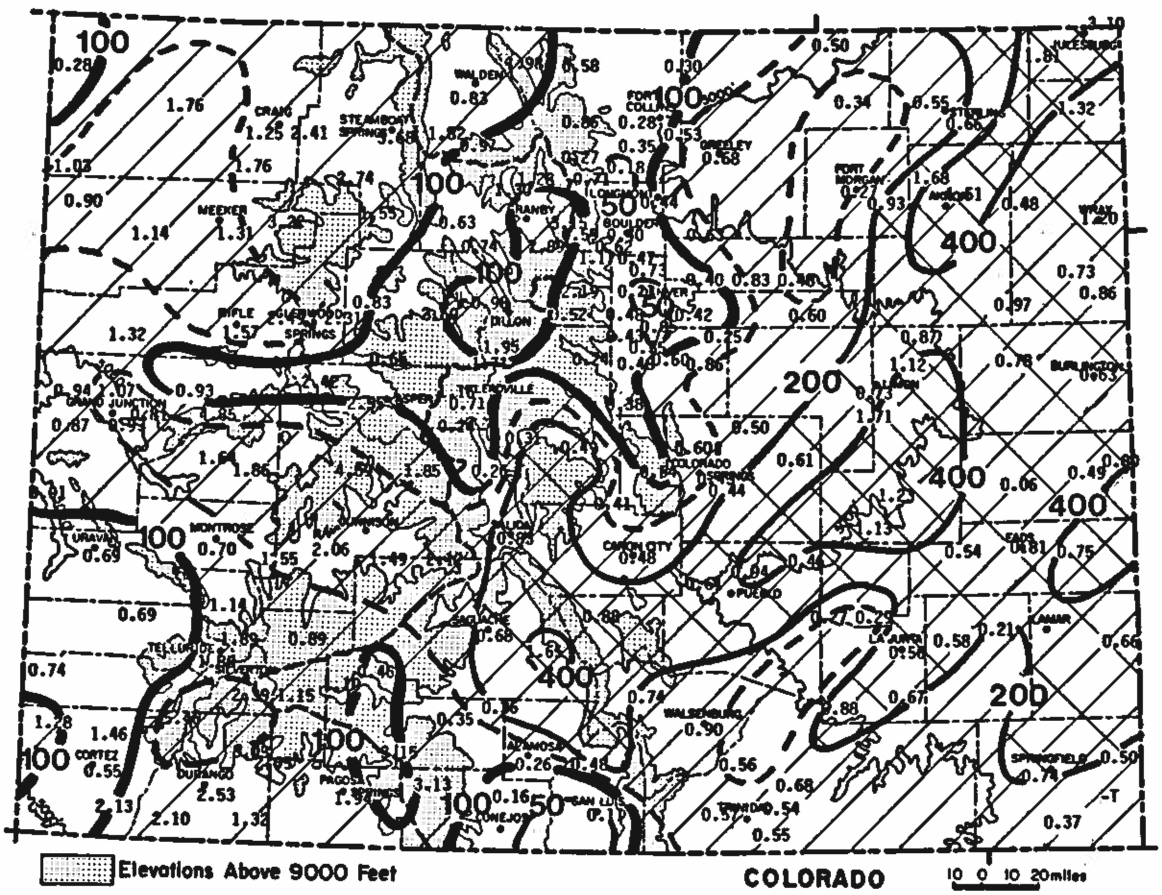
* data derived only from those stations with complete daily snowfall records.
** from Soil Conservation Service Snowpack measurements.

JANUARY 1988 PRECIPITATION

Most of Colorado experienced above average precipitation and snowfall in January. A number of areas east of the mountains, including Pueblo, Akron and Julesburg had more than 4 times the average precipitation (January averages are very low). In western Colorado, the wettest areas included most of the White, Yampa and Gunnison watersheds, the southern slopes of the San Juan mountain region and the northern half of the San Luis Valley. Dry areas included southern portions of the San Luis Valley, southwestern areas from Uravan to Cortez, and substantial parts of the Front Range and central mountains. For example, southwestern portions of the Denver area received less than half their January average.

Due to the extremely strong winds in January, many weather observers had difficulty measuring precipitation and snowfall accurately. Please keep this in mind when examining precipitation patterns, especially out on the plains.

Greatest		Least	
Rico	5.46"	Stonington	Trace (suspect due to high winds)
Bonham Reservoir	4.85"	Littleton	0.05"
Crested Butte	4.59"	Kit Carson 6S	0.06" (suspect)
Steamboat Springs	3.68"	San Luis 2SE	0.11"
Marvine Ranch	3.22"	Manassa	0.16"



Precipitation amounts (inches) for January 1988 and contours of precipitation as a percent of the 1961-1980 average. Dashed line is 150% of average.

1988 WATER YEAR PRECIPITION

Most of Colorado has received near or above average precipitation for the first 4 months of the 1988 water year. Several areas of northeast Colorado have received at least twice the average. Moisture conditions in western Colorado are quite close to average. The only areas significantly below average include portions of the Central Mountains and the upper Arkansas Valley and the northeastern slopes of the San Juan Mountains.

Comparison to Last Year

Last year at this time, the southern half of Colorado was much wetter than average. The northern and central mountains were fairly dry.

1988 Water Year to Date through January

Wettest (as % of average)

Akron FAA AP	317%	5.27"
Julesburg	300%	5.29"
Brush	254%	4.02"

Driest (as % of average)

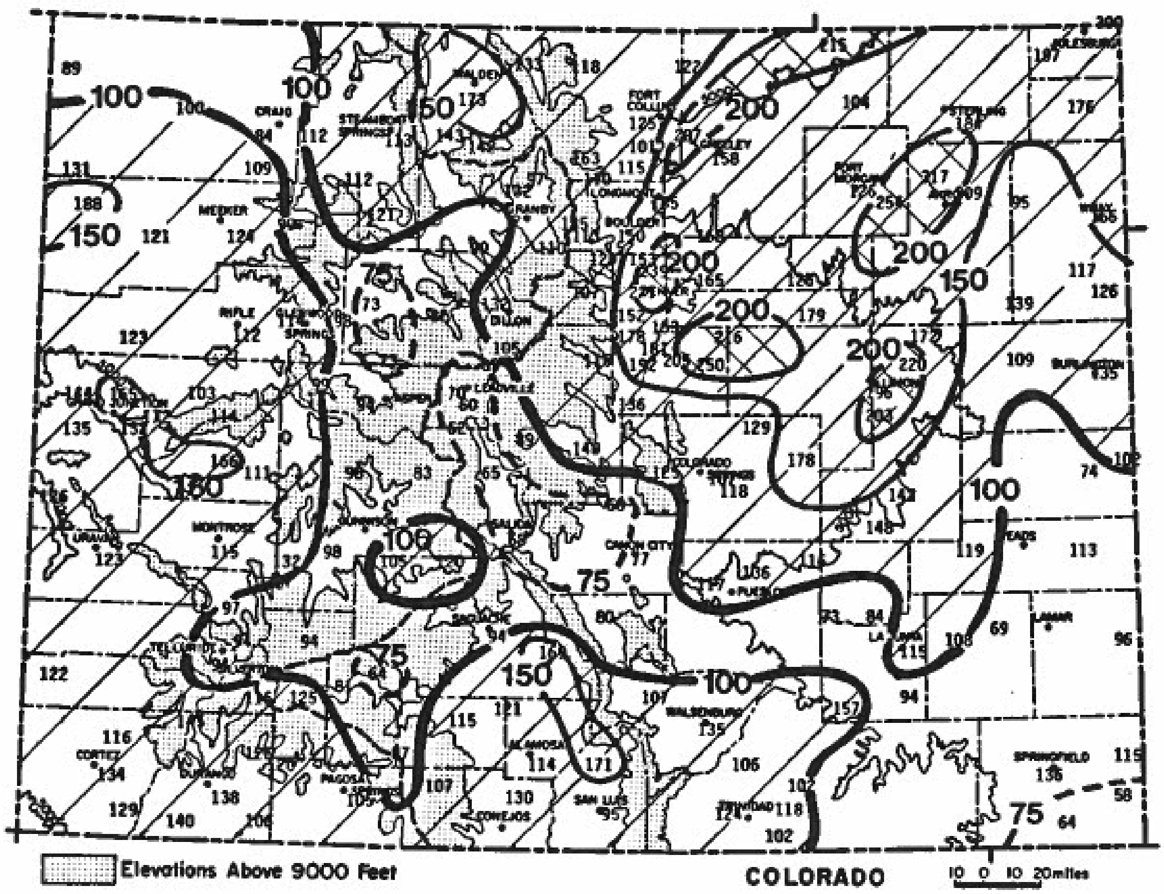
Stonington	58%	1.09"
Leadville 2SW	60%	2.62"
Twin Lakes Reservoir	62%	1.44"

Wettest (total precipitation)

Wolf Creek Pass 1E	14.63"	87%
Bonham Reservoir	13.56"	114%
Rico	13.46"	145%

Driest (total precipitation)

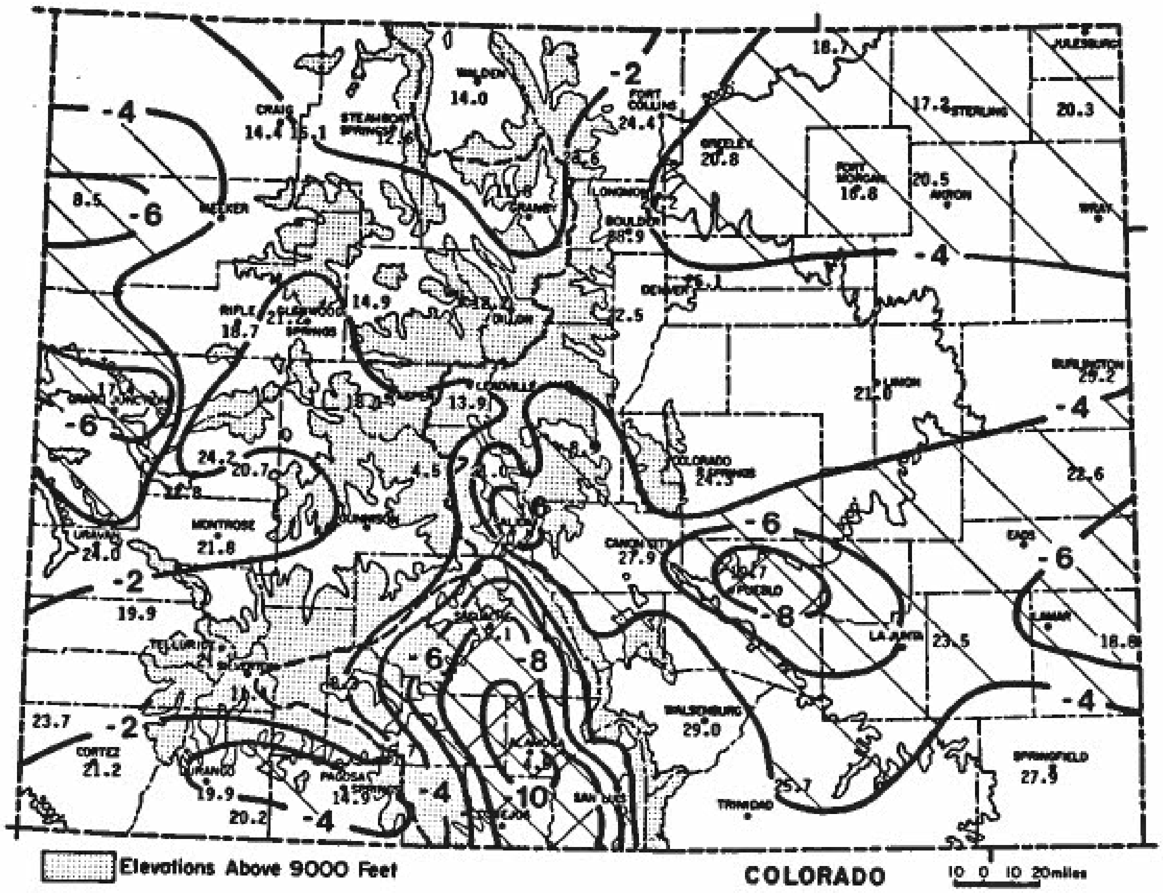
John Martin Dam	1.00"	69%
Fowler	1.02"	73%
Stonington	1.09"	58%



Precipitation for October 1987 through January 1988 as a percent of the 1961-1980 average.

JANUARY 1988 TEMPERATURES AND DEGREE DAYS

All of Colorado was colder than average. This is the first time the entire state has been colder than average in January since 1984. The coldest areas were the snowcovered valleys in western and southern parts of the state. Pueblo had 13 nights with subzero temperatures and ended up 9.3° below the 1961-80 average. In Alamosa only 1 night stayed above 0°. Their monthly mean was 10.3° below normal. The warmest areas, compared to average, were the higher mountains and eastern foothills where the winds were strongest. There, temperatures were mostly 1° to 3° colder than average.



January 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

JANUARY 1988 SOIL TEMPERATURES

Cold temperatures and strong winds sent soil temperatures dropping. The frost line dipped to 1 to 2 feet in Fort Collins. Beneath pavement and in areas where winds cleared the snow, even deeper frost penetration were observed.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

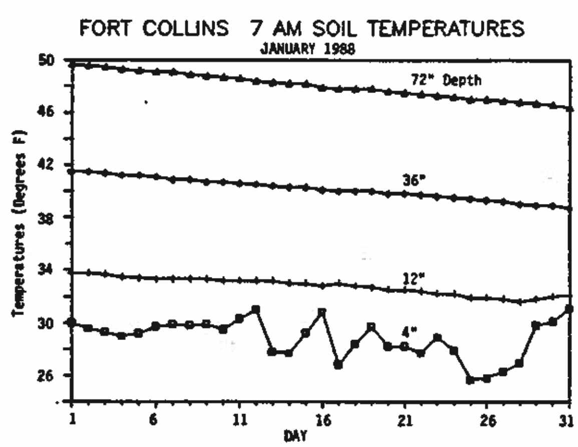


Table 1. Colorado Heating Degree Day Data through January 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130	1556	1867						5680
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024	1382	1450						5038
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713	1053	1107						3405
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955	1277	1357						4617
BURLINGTON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724	1037	1221						3454
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668	1007	1144						3327
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767	1108	1256						3817
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860	1179	1351						3981
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950	1376	1561						4799
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737	1102	1300						3612
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745	1125	1227						3649
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145	1491	1629						6226
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851	1206	1391						4129
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37	39	314	658	930	1283	1309	925	927	566	384	111	7483
	87-88	54	75	254	509	950	1331	1544						4717
EVERGREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922	1255	1310						4609
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784	1140	1252						3824
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773	1154	1484						3992
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754	1147	1469						3658

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098	1516	1642						5877
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762	1157	1363						3861
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M	M	M						0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653	1032	1278						3274
LEADVILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180	1534	1577						6371
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840	1209	1354						4150
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87	0	0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805	1169	1383						4025
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	94	7402
	87-88	M	M	M	M	M	M	M						0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849	1160	1332						3854
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947	1292	1548						4866
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754	1111	1399						3683
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819	1209	1430						4007
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033	1448	1619						
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742	M	1475						2781
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992	1269	1354						5027
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730	1054	1209						3432
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242	1499	1572						6044
WALSENBURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707	977	1109						3259

M = MISSING DATA

JANUARY 1988 CLIMATIC DATA

Eastern Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	30.5	6.9	18.7	-6.5	53	-11	1429	0	2	0.50	0.19	161.3	6
STERLING	29.5	4.9	17.2	-5.7	51	-17	1475	0	1	0.55	0.21	161.8	4
FORT MORGAN	29.9	3.7	16.8	-5.9	53	-16	1484	0	3	0.27	0.09	150.0	2
AKRON FAA AP	30.6	10.4	20.5	-4.4	54	-8	1373	0	3	1.68	1.40	600.0	5
HOLYOKE	32.6	8.0	20.3	-6.0	51	-14	1377	0	2	1.32	0.94	347.4	4
BURLINGTON	35.4	15.1	25.2	-3.5	65	-8	1221	0	21	0.63	0.39	262.5	3
LIMON WSMO	33.9	8.2	21.0	-3.5	59	-12	1354	0	13	0.80	0.51	275.9	7
CHEYENNE WELLS	33.7	11.5	22.6	-5.5	55	-10	1309	0	3	0.49	0.33	306.2	5
LAS ANIMAS	37.9	9.2	23.5	-4.8	65	-14	1278	0	28	0.58	0.37	276.2	6
HOLLY	34.2	3.4	18.8	-8.1	59	-28	1421	0	15	0.56	0.36	280.0	3
SPRINGFIELD 7WSW	40.6	15.1	27.9	-2.9	66	-9	1142	0	39	0.74	0.40	217.6	7

Foothills/Adjacent Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	36.9	11.9	24.4	-2.0	58	-8	1252	0	15	0.28	-0.16	63.6	5
GREELEY UNC	32.9	8.6	20.8	-5.3	57	-11	1363	0	6	0.68	0.30	178.9	4
ESTES PARK	35.4	11.9	23.6	-3.2	54	-14	1274	0	6	0.27	-0.17	61.4	2
LONGMONT 2ESE	36.4	3.9	20.2	-5.5	59	-15	1383	0	13	0.44	0.03	107.3	3
BOULDER	40.9	16.9	28.9	-2.6	67	-2	1107	0	43	0.40	-0.23	63.5	4
DENVER WSFO AP	38.1	12.2	25.1	-3.4	63	-12	1227	0	22	0.40	-0.11	78.4	4
EVERGREEN	40.3	4.6	22.5	-3.6	65	-22	1310	0	22	0.48	-0.00	100.0	4
LAKE GEORGE 8SW	26.4	-8.6	8.9	-6.6	47	-31	1731	0	0	0.49	0.26	213.0	6
RUXTON PARK	31.6	1.8	16.7	-3.8	51	-15	1488	0	1	0.54	-0.00	100.0	6
COLORADO SPRINGS	36.2	12.4	24.3	-3.6	62	-4	1256	0	22	0.43	0.19	179.2	5
CANON CITY 2SE	41.4	14.4	27.9	-5.6	68	-9	1144	0	43	0.48	0.20	171.4	6
PUEBLO WSO AP	34.8	4.5	19.7	-9.3	57	-15	1399	0	12	0.94	0.72	427.3	5
WALSENBURG	41.8	16.3	29.0	-2.9	65	1	1109	0	25	0.90	0.36	166.7	9
TRINIDAD FAA AP	40.6	10.8	25.7	-4.8	65	-4	1209	0	27	0.68	0.27	165.9	7

Mountains/Interior Valleys*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	26.2	1.7	14.0	-1.1	44	-31	1572	0	0	0.83	0.20	131.7	11
LEADVILLE 2SW	26.6	1.1	13.9	-0.6	51	-23	1577	0	1	0.71	-0.49	59.2	15
SALIDA	36.7	3.6	20.2	-7.7	53	-26	1382	0	4	0.83	0.48	237.1	3
BUENA VISTA	36.4	5.6	21.0	-4.7	54	-13	1357	0	3	0.26	-0.01	96.3	6
SAGUACHE	23.6	-5.5	9.1	-8.8	34	-23	1725	0	0	0.68	0.41	251.9	5
HERMIT 7ESE	24.0	-7.4	8.3	-2.0	32	-30	1751	0	0	1.10	0.28	134.1	2
ALAMOSA WSO AP	25.0	-16.0	4.5	-10.3	40	-31	1867	0	0	0.26	0.01	104.0	2
STEAMBOAT SPRINGS	24.0	1.2	12.6	-1.9	42	-30	1619	0	0	3.68	0.95	134.8	19
GRAND LAKE 6SSW	24.5	-0.8	11.8	-1.2	42	-29	1642	0	0	1.30	0.19	117.1	16
DILLON 1E	26.9	-2.6	12.2	-3.3	47	-25	1629	0	0	0.98	0.12	114.0	13
CLIMAX	20.0	-5.8	7.1	-5.6	42	-28	1785	0	0	1.71	-0.52	76.7	17
ASPEN 1SW	30.1	6.0	18.1	-1.9	56	-16	1450	0	3	2.55	0.05	102.0	14
TAYLOR PARK	23.4	-14.3	4.5	2.4	40	-54	1864	0	0	1.85	0.41	128.5	13
TELLURIDE	34.8	7.4	21.1	-0.0	57	-13	1354	0	6	1.86	0.16	109.4	13
PAGOSA SPRINGS	35.6	-5.9	14.9	-5.3	52	-21	1548	0	1	1.94	0.06	103.2	6
SILVERTON	32.0	-9.3	11.4	-0.0	50	-29	1656	0	0	2.39	0.78	148.4	14
WOLF CREEK PASS 1	31.7	1.6	16.7	-0.2	48	-17	1489	0	0	3.15	-0.58	84.5	10

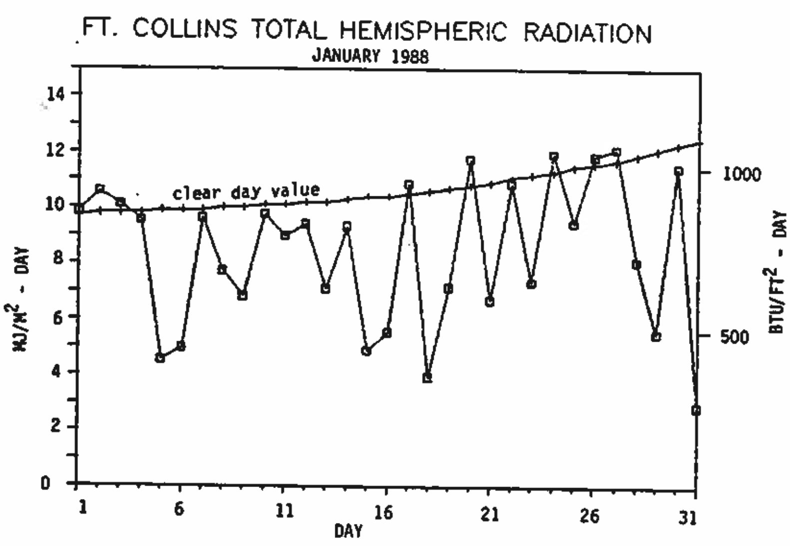
Western Valleys*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	25.0	3.8	14.4	-2.6	39	-18	1561	0	0	1.25	-0.05	96.2	13
HAYDEN	24.8	5.3	15.1	-1.2	40	-19	1539	0	0	2.41	0.92	161.7	19
RANGELY 1E	19.9	-3.0	8.5	-7.1	31	-24	1745	0	0	0.90	0.37	169.8	7
EAGLE FAA AP	29.0	0.9	14.9	-3.2	43	-23	1544	0	0	0.83	-0.05	94.3	10
GLENWOOD SPRINGS	31.5	10.9	21.2	-1.4	46	-9	1353	0	0	2.34	0.76	148.1	14
RIFLE	33.1	4.2	18.7	-2.3	47	-14	1430	0	0	1.57	0.67	174.4	13
GRAND JUNCTION WS	28.8	5.9	17.4	-6.3	42	-6	1469	0	0	1.07	0.49	184.5	7
CEDAREDGE	36.6	11.9	24.2	-1.2	55	-1	1253	0	4	1.64	0.78	190.7	7
PAONIA 1SW	33.9	7.5	20.7	-3.6	47	-6	1363	0	0	1.86	0.64	152.5	10
DELTA	35.2	10.4	22.8	-2.2	55	-7	1300	0	3	0.00	-0.35	0.0	0
MONTROSE NO. 2	35.1	8.5	21.8	-2.1	48	-3	1332	0	0	0.70	0.20	140.0	11
URAVAN	37.8	10.2	24.0	-3.5	52	-2	1262	0	2	0.69	-0.31	69.0	8
NORWOOD	34.0	5.8	19.9	-1.5	50	-10	1390	0	0	0.69	-0.39	63.9	5
YELLOW JACKET 2W	35.4	12.1	23.7	-0.2	54	-4	1275	0	2	1.28	0.02	101.6	6
CORTEZ	36.7	5.6	21.2	-3.3	52	-6	1351	0	1	0.55	-0.48	53.4	6
DURANGO	34.2	5.5	19.9	-4.6	50	-9	1391	0	0	2.53	0.73	140.6	8
IGNACIO 1N	37.8	2.5	20.2	-0.5	51	-17	1381	0	2	0.00	-1.37	0.0	0

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

JANUARY 1988 SUNSHINE AND SOLAR RADIATION

Station	Number of Days: clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	9	6	16	--	--
Denver	9	4	18	59%	72%
Fort Collins	7	16	8	--	--
Grand Junction	5	7	19	49%	58%
Pueblo	8	10	13	62%	75%



How Do We Know When Spring Is Here? continued

We could attempt to assign new calendar dates to spring based on characteristics of our climate. If, for example, we used temperature, we might define spring as the period of the year when daylength is increasing and daytime high temperatures average between 55° and 75°F. For many Front Range cities, that would create a spring season that would run from sometime in late March into early June. For southeastern Colorado, spring would start a couple weeks earlier and end in May. Up in the mountains, depending on the location, spring wouldn't begin until late April, May or even June. Another way we could define spring is by precipitation characteristics. For example, the first day of spring could be the average date of the first rainshower of the year. Spring could end when there is no longer a chance of getting snow. This would produce a spring season ranging from about mid February to mid May out near Grand Junction and Durango, late February to June 1 in Denver, and mid April to late June up in the mountains. Using definitions like these, we could fairly easily note the differences in climate from one part of the state to another simply by comparing relative dates of spring.

There is something to be said for such an approach, but I can assure you it would introduce a fair piece of confusion, too. If, for example, up in one of our mountain communities a weather station had to be moved from one end of town to another, spring might have to be redefined. The Chamber of Commerce would have to print up new brochures. Another problem that would most certainly crop up is that every time we computed new temperature and precipitation averages for the State, the seasons would change. Depending on which book you picked up, you would likely find a different definition of spring while causing some confusion, this could actually be an interesting way, and perhaps valid, to investigate the effects of greenhouse gases or volcanic dust (etc., etc.) on our climate. If spring comes progressively earlier or later over a period of decades, it is likely related to some scale of climate change.

So, where does this leave us? I suggest, with some reluctance, that we stick with the classic definition of spring and simply recognize that "spring-like" weather comes at different times to different places. No two years are ever the same, nor should they be. Enjoy the diversity that nature has to offer -- and don't be surprised if the warmth, fragrance, soft winds, and bubbling sounds of tiny streams of water from melting snow brings on a powerful urge to write poetry and whistle in harmony.

JCEM WTHRNET -- Welcome Aboard

We are pleased to present a new addition to Colorado Climate. Starting this month, we are adding 2 new pages and a wealth of additional detailed data to our report. This is made possible by the WTHRNET (Wind, Temperature, Humidity and Radiation Network) project of the Joint Center for Energy Management (JCEM) at the University of Colorado at Boulder and Colorado State University. The goal of this project is to improve climate information resources in Colorado as they apply to energy consumption and conservation. By learning more about our climate and by making more detailed data available, it is hoped that the use of renewable energy resources such as solar and wind can be increased and traditional energy sources can be used more efficiently. Dr. Jan Kreider of the University of Colorado is the director of the JCEM and the WTHRNET project leader.

We hope we will be able to provide high quality, detailed data like this for many years to come. We look forward to hearing your comments and suggestions about this new information resource.

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Look out! It's that time again! In order to keep our mailing list lean, we will be verifying mailing addresses and removing uninterested readers from our list. Please look for a subscription renewal form in the mail in the next few weeks -- and respond promptly. Thanks!!

Joint Center for Energy Management Weather Data

Starting with this issue, weather data from a new Colorado weather data collection network will appear each month in Colorado Climate. This information is provided by the Joint Center for Energy Management, a collaborative venture of the engineering colleges of the University of Colorado (CU) and Colorado State University (CSU).

The Joint Center for Energy Management was established in 1987 with funds from the Colorado Office of Energy Conservation, and is dedicated to excellence in energy-related education, research and development, and technical assistance. Center programs focus on design and technology of cost-effective, energy-efficient buildings and industrial processes, as well as the application of renewable energy resources.

The Center is collecting weather data to enhance the quality and quantity of Colorado weather data used by designers, agricultural interests, utilities and others. Their statewide data collection network, known as WTHRNET, consists of eight data collection stations, spanning the geographical and climatic diversity of Colorado. These stations are tied into a central network management computer at the JCEM office, and data are sent automatically each day to this computer. Weather stations are instrumented to monitor hourly average temperature, relative humidity, and wind energy, speed and direction. In addition, hourly integrated solar flux is recorded on four different surfaces, yielding data on direct and diffuse solar radiation.

Stations have been operating since 1987 on Alamosa, Carbondale, Durango, Montrose, Steamboat Springs and Walsh. Stations are slated for installation in Sterling and Stratton in 1988.

JCEM weather data for January are shown below:

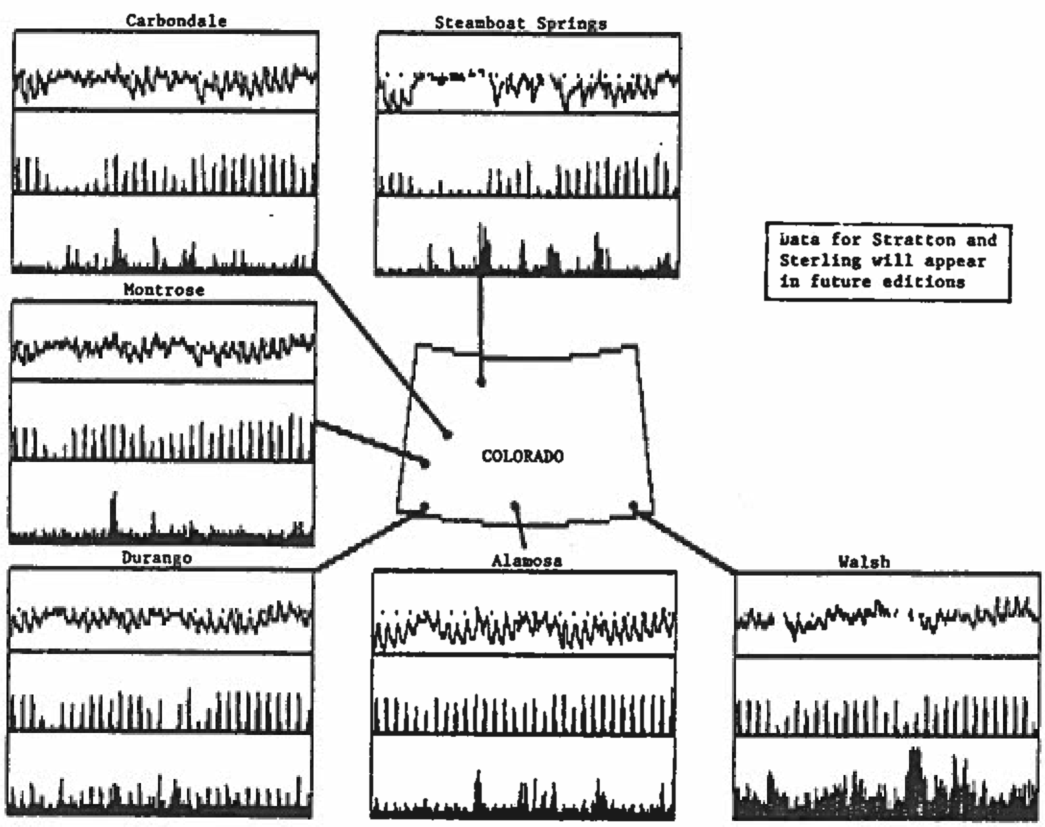
	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
Ambient Temperature [degrees Fahrenheit]						
maximum	41.8	48.1	46.5	47.5	42.3	66.8
average	4.2	17.5	15.2	19.1	7.8	25.2
minimum	-31.3	-9.5	-21.4	-11.1	-33.9	-9.1
Time of Temperature Extremes [day/hour]						
maximum	30/13	28/12	11/13	11/14	11/12	29/14
minimum	2/7	1/8	20/8	20/8	3/8	7/6
Monthly Average Relative Humidity [percent]						
5 AM	77	82	88	82	83	69
11 AM	66	60	66	61	76	54
2 PM	53	58	52	53	59	49
5 PM	56	59	60	61	73	56
11 PM	80	81	86	81	85	74
Monthly Average Wind Direction [degrees clockwise from North]						
1000 to 1800	176	195	209	186	175	198
2200 to 0600	204	70	170	176	141	271
Monthly Wind Speed Distribution [hours per month]						
0 to 3 mph	543	526	618	562	597	61
3 to 12 mph	193	212	123	176	133	573
12 to 24 mph	8	6	3	6	14	99
> 24 mph	0	0	0	0	0	11
Monthly Insolation [Btu/square ft/day]						
daily average	929	789	636	813	476	866
Cloudiness [hours per month] (The numbers on the left represent the hourly "clearness index", i.e. the ratio of extraterrestrial horizontal solar radiation to that measured on the ground)						
60% to 80%	160	131	89	115	42	150
40% to 60%	85	62	57	59	71	58
20% to 40%	38	57	69	65	56	53
0% to 20%	6	40	63	26	111	30

The following diagram illustrates January weather at JCEM weather station sites. For each city three graphs are shown:

1. The top graph shows the hourly average air temperature from -40 to 110 degrees Fahrenheit. The dotted line in the middle denotes the freezing point.
2. The middle graph shows the hourly integrated horizontal insolation from 0 to 400 Btu/square foot per hour.
3. The bottom graph shows the hourly average wind speed from 0 to 30 miles per hour.

Cloudy days are apparent by decreased insolation levels, usually accompanied by a decrease in the magnitude of the diurnal temperature swings. This phenomenon is seen along the western slope at the beginning of the month. Occasionally a storm also produces high winds, as observed in Walsh on January 19th.

Weather Data for January, 1988



For more information concerning JCEM weather data, please write to Peter Curtiss, JCEM, WTHRNET, Campus Box 428, Boulder, CO, 80309.

COLORADO CLIMATE

FEBRUARY 1988

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 5

February in Review:

Long-awaited springlike weather finally made an appearance in Colorado in the last half of February. Temperatures for the month ended up near average to a bit below average over most of the state. A lack of mountain snows in the last half of February left most of western Colorado drier than average for the month. Areas east of the mountains weren't far from average with less than 0.50" of moisture at most reporting stations.

Colorado's April Climate:

Spring came early to Colorado last year with warm April temperatures and sparse precipitation. There is no guarantee that will happen again. April is better known for its interesting assortment of warm sunny days regularly interrupted by strong storms which may bring heavy snows, strong winds or even thunder and hail. (April hail rarely does much damage.) While the city folks may prefer it warm and dry, many long-time farmers and ranchers prefer it cool and damp. April rains and snows are a great help for getting rangeland and dryland crops off to a good start for the year.

Up in the mountains, winter finally begins to ease a bit. Still, most April precipitation falls as snow, and in most years the snowpack reaches its greatest depth sometime during the month. For parts of the central and northern mountains along the Continental Divide, and over much of the Front Range foothills, April is actually the snowiest month of the year. Back in 1921, a remarkable 75.8" of snow fell at Silver Lake (west of Boulder) in just 24 hours on the 14th-15th to set an all-time record for North America. Significant snows may also fall at lower elevations. Denver, for example, averages close to 10" for the month. Fortunately, most April snows melt quickly. Precipitation for the month averages between 1 and 2 inches over much of the state but increases to as much as 4" or more in some of the northern and central mountains. Less than 1" of moisture usually falls on some of the western valleys.

If you don't like variations in temperature, this may not be the place for you. While April temperatures average in the 50s and 60s during the day at elevations below 7,500 feet, there will be days that reach into the 70s (80s on the southeast plains). But don't let periods of warm weather lure you into planting tomatoes. Except near Grand Junction, occasional freezing temperatures can be expected throughout the month and sudden temperature drops of 40 degrees or more are not unusual (especially east of the mountains). Meanwhile, up in the mountains it's still chilly. Highs in the 30s and 40s are common with lows in the teens.

April is a great month for cloud watching -- you'll see all kinds. Keep your eyes open and you'll be in for a treat.

The Colorado Freeze-Thaw See-Saw:

It's time for a quiz. How many times does the temperature cross 32°F in an average year. I bet you haven't thought about that too often or too seriously. Until recently, I hadn't either. Most of us who are interested in climate tend to think in terms of average high and low temperatures, normal variations, and extreme values. But when we consider the effects our climate has on our environment, thresholds become especially important. There is no threshold in nature that is more important than 32°F (0°C) -- the temperature at which water freezes and thaws. Hydrologic, geologic and biologic processes are all extremely sensitive to this threshold.

(continued)

FEBRUARY 1988 DAILY WEATHER

Date	Event
1-5	Cold, wintery period. Large artic high pressure area north and east of Colorado pumped cold, damp air into the state from the east. Light snow and freezing drizzle made driving hazardous from the Front Range out onto the Eastern Plains on the 1st. Clouds and precipitation also increased in western Colorado, and snows became locally heavy 2-3rd in the southwest as a Pacific storm system moved eastward. More than 20" of snow fell at Pagosa Springs, and Wolf Creek Pass totalled 25". Moderate snows also spread across southeast Colorado. Walsenburg measured 9" on the 3rd and Burlington and Cheyenne Wells received about 3". Skies cleared on the 4th and winds aloft shifted to the northwest. Some locally frigid temperatures were noted early on the 4th such as -24° at Kremmling and -35° at Taylor Park. Strong northerly winds, late on the 4th reinforced the artic chill and set off some light snow flurries on the 5th along the eastern foothills. Highs on the 5th were generally only in the teens on the plains.
6-8	Dry and warmer. Windy in exposed mountain and eastern foothill locations, but calm and continued very cold in Colorado's snowcovered valleys. Light snow in some northern and central mountain locations on the 8th.
9-10	Mild on the 9th but a strong, fast-moving upper air disturbance combined with a new artic blast from the north to set off a major snowstorm across parts of northern Colorado. 6-12" of snow was common by midday on the 10th across the northern mountains and Front Range. 11" of snow was reported near Loveland and Mount Evans reported 13". Only a little snow made it into the southern mountains.
11-15	A nice warming trend 11-13th with temperatures climbing into the 40s in the mountains and 50s and 60s on the eastern plains by the 13th. Denver and Pueblo both hit 64° on the 13th -- their warmest temperature in many weeks. Walsh and Springfield tied for the honor of the state's warm spot at 72°. The warmth ended abruptly as a Pacific cold front slashed across the state late on the 13th with high winds and a period of snow. Winds gusted to 68 mph at Greeley and up near Mount Evans 3" of new snow was accompanied by 81 mph wind gusts. Some property damage was reported. Windy and cool on the 14th followed by increasing clouds but warmer again on the 15th.
16-18	An unsettled, chilly day on the 16th. A few inches of mountain snows developed into a surprisingly heavy wet snowstorm from the foothills near Denver southeastward onto the plains. As much as 10" was on the ground in west Denver early on the 17th with 7" at Colorado Springs and 1-5" across some of the southeastern plains. Pleasant sunshine returned on the 17th but cold temperatures aloft helped trigger scattered snowshowers again on the 18th. Cold nighttime temperatures throughout the period, especially in the mountains.
19-23	Strong north to northwest winds aloft over the state. Sunny, dry and mild in western Colorado. A nice warming trend east of the mountains 19-21st was interrupted by a rude cold front early on the 22nd which sent temperatures plummetting on the plains and produced some light snow, especially in the northeast continuing on the 23rd.
24-29	A large high pressure ridge brought spring fever to all parts of Colorado. Winds became light even in the high mountains and temperatures climbed into the 40s up high with 50s and 60s across the lower elevations. A little cooler east of the mountains on the 28th but warm again on the 29th. A storm system over California 28-29th sent moisture into western Colorado. Just a few light rain and snow showers were reported.

February 1988 Extremes

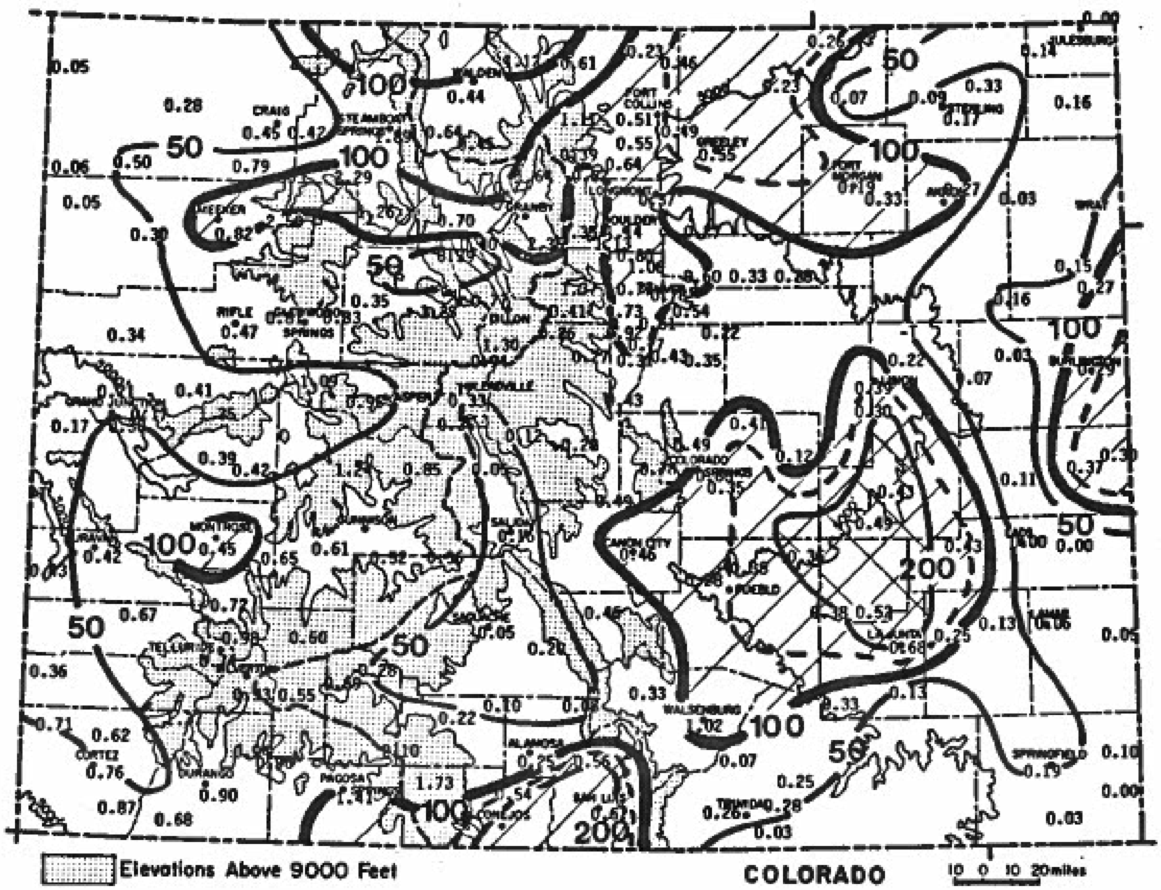
Highest Temperature	72°F	February 13	Springfield 7WSW and Walsh
Lowest Temperature	-35°F	February 4	Taylor Park Reservoir
Greatest Total Precipitation	2.50"		Marvine Ranch
Least Total Precipitation	0.00"		Eads and Stonington
Greatest Total Snowfall*	53"		Marvine Ranch
Greatest Snowdepth**	118"		Tower (Buffalo Pass)

* data derived only from those stations with complete daily snowfall records.
** from Soil Conservation Service Snowpack measurements.

FEBRUARY 1988 PRECIPITATION

Heavy precipitation was hard to come by in February. Only 4 of the National Weather Service's many cooperative weather stations reported more than 2.00" of moisture for the month, and only about 25 stations reported more than 1 inch. Above average precipitation was limited to portions of the northern mountains, an area from just southwest of Denver northward to Fort Collins and northeastward across the Pawnee Grasslands, an area surrounding the Arkansas valley from Canon City to LaJunta, and small portions of extreme south central and east central Colorado. The remainder of the state was quite dry with several areas receiving less than half of the February average. The driest areas included much of extreme western Colorado, northern portions of the San Luis Valley and the upper Arkansas Valley, and several locations on the northeastern and southeastern plains.

Greatest		Least	
Marvine Ranch	2.50"	Brandon	0.00" (or Trace)
Winter Park	2.35"	Eads	0.00" "
Pyramid	2.29"	Julesburg	0.00" "
Wolf Creek Pass 1E	2.10"	Stonington	0.00" "
Steamboat Springs	1.89"	Gateway	Trace
		Shaw	Trace



Precipitation amounts (inches) for February 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

1988 WATER YEAR PRECIPITION

Despite a dry February, Colorado continues to hold onto near average precipitation totals for the first 5 months of the 1988 water year. Above average moisture in areas that produce significant runoff is limited to portions of the northern mountains and Front Range and the southern slopes of the San Juan mountains. The most extensive moist anomaly encompasses most of the northeast quarter of Colorado where many locations have received at least 50% more precipitation than usual. The driest area is in the central mountains where several stations have received less than 80% of their average October-February totals.

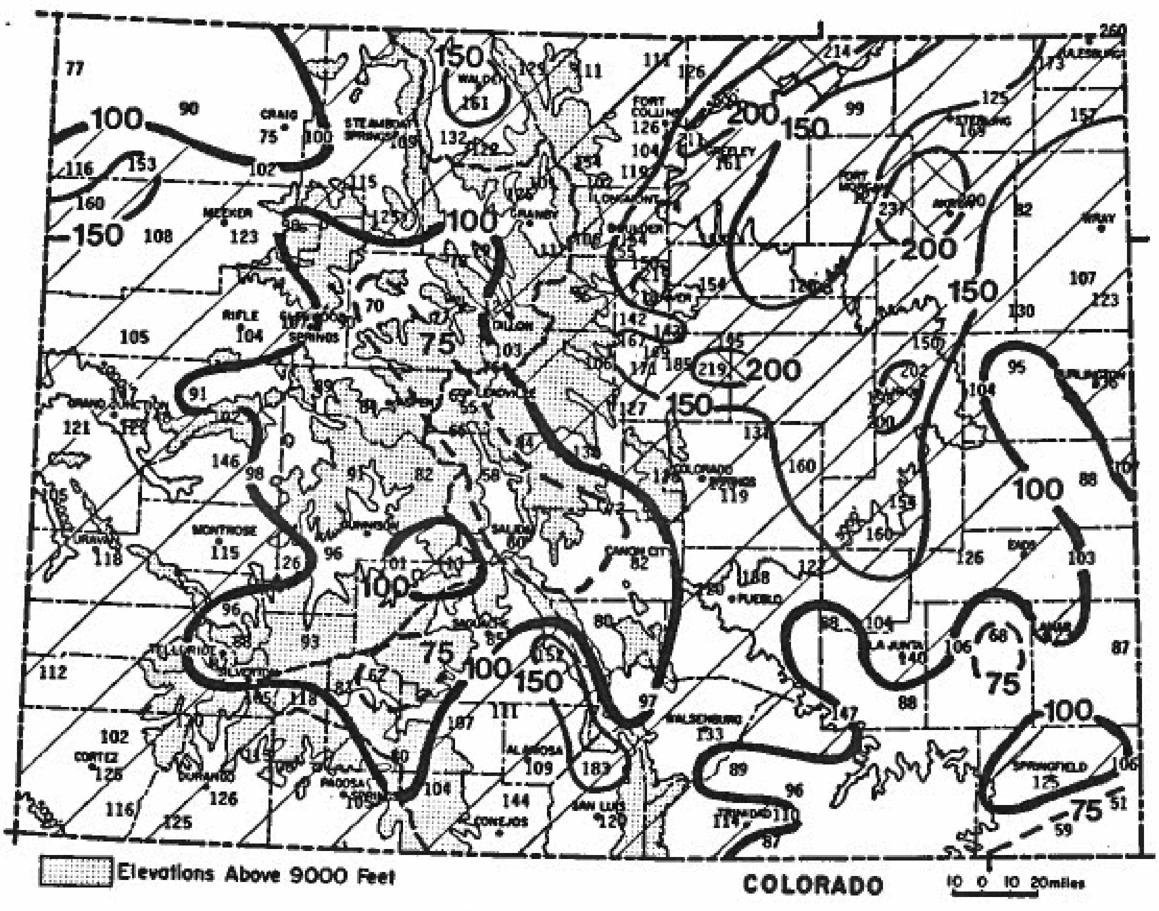
Comparison to Last Year

At this time last year most of Colorado was near or above average with much above average totals across the southeastern plains. However, many areas in the northern and central mountains were quite dry. This was a reflection of the serious snow drought that existed throughout the Rocky Mountains in Wyoming, Montana and Idaho.

1988 Water Year to Date through February

Wettest (as % of average)			Driest (as % of average)		
Julesburg	260%	5.29"	Stonington	51%	1.09"
Brush	237%	4.35"	Leadville	55%	2.95"
Wheatridge	219%	8.12"	Buena Vista	58%	1.50"

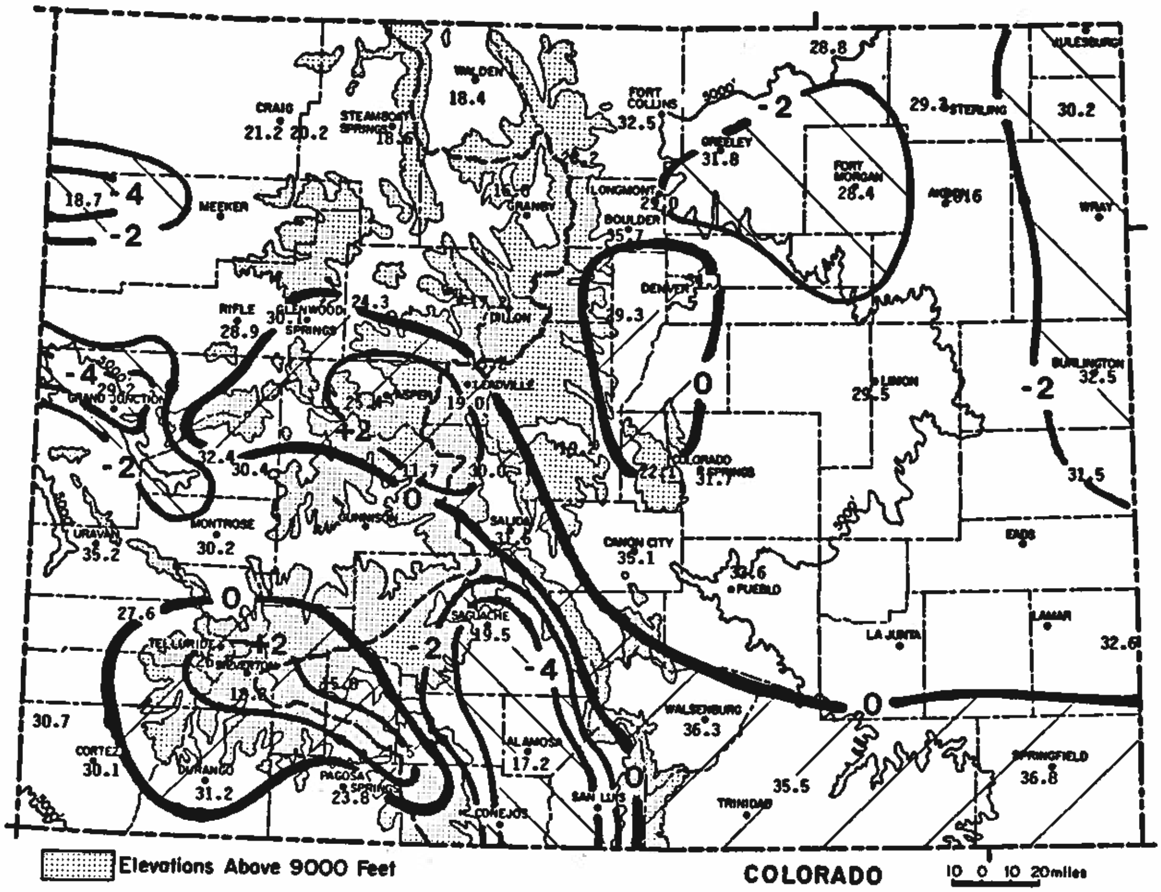
Wettest (total precipitation)			Driest (total precipitation)		
Wolf Creek Pass 1E	16.73"	80%	Stonington	1.09"	51%
Bonham Reservoir	14.91"	102%	John Martin Dam	1.13"	68%
Rico	14.83"	130%	Campo 7S	1.18"	59%



Precipitation for October 1987 through February 1988 as a percent of the 1961-1980 average.

FEBRUARY 1988 TEMPERATURES AND DEGREE DAYS

A cold start and a mild finish characterized Colorado's February temperatures. For the month as a whole, temperatures ended up near average to a little cooler than average. The coldest areas compared to average were some of the valley areas where snowcover persisted throughout all or most of the month. These areas included Alamosa and the San Luis Valley, some of the South Platte valley from Greeley to Fort Morgan, the White River valley at Rangely, and the Grand Valley (Colorado River) at Grand Junction where temperatures were generally 2 to 5 degrees colder than average. Warmer than average areas included much of the San Juan Mountains, central mountain areas including Aspen and Leadville, and parts of southeastern Colorado from Walsenburg to the Kansas border.



February 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

FEBRUARY 1988 SOIL TEMPERATURES

The deepest frost penetration of the winter occurred in early February. Near-surface temperatures then began their normal spring rise, but some frozen ground persisted throughout the month.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

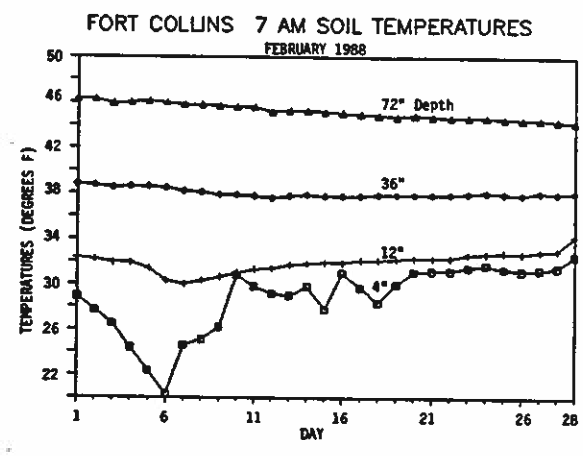


Table 1. Colorado Heating Degree Day Data through February 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130	1556	1867	1381					7061
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024	1382	1450	1146					6184
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713	1053	1107	842					4247
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955	1277	1357	1010					5627
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724	1037	1221	935					4389
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668	1007	1144	858					4185
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767	1108	1256	958					4775
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860	1179	1351	1008					4989
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950	1376	1561	1264					6063
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737	1102	1300	M					3612
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745	1125	1227	889					4538
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145	1491	1629	1376					7602
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851	1206	1391	972					5101
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37	39	314	658	930	1283	1309	925	927	566	384	111	7483
	87-88	54	75	254	509	950	1331	1544	1173					5890
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922	1255	1310	1029					5638
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784	1140	1252	936					4760
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773	1154	1484	1055					5047
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754	1147	1469	1031					4689

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098	1516	1642	1413					7290
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762	1157	1363	955					4816
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M	M	M	M					0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653	1032	1278	837					4111
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180	1534	1577	1326					7697
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840	1209	1354	1022					5172
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87	0	0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805	1169	1383	1035					5060
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	94	7402
	87-88	M	M	M	M	M	M	M	M					0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849	1160	1332	1003					4857
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947	1292	1548	1187					6053
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754	1111	1399	903					4586
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819	1209	1430	1039					5046
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033	1448	1619	1336					
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742	M	1475	1029					3810
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992	1269	1354	1109					6136
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730	1054	1209	850					4282
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242	1499	1572	1343					7387
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707	977	1109	826					4085

M = MISSING DATA

FEBRUARY 1988 CLIMATIC DATA

Eastern Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	40.6	16.9	28.8	-1.8	62	-4	1044	0	25	0.26	0.13	200.0	4
STERLING	42.3	16.3	29.3	-1.6	67	-1	1029	0	40	0.09	-0.08	52.9	1
FORT MORGAN	41.0	15.9	28.4	-2.5	69	1	1055	0	38	0.19	0.05	135.7	4
AKRON 4E	40.1	17.0	28.6	-0.6	65	-5	1047	0	30	0.27	0.06	128.6	6
HOLYOKE	42.6	17.8	30.2	-2.4	67	-4	1004	0	40	0.16	-0.18	47.1	2
BURLINGTON	44.1	20.9	32.5	-2.1	66	-3	935	0	48	0.29	0.09	145.0	3
LIMON WSMO	42.4	16.6	29.5	-1.6	61	-4	1022	0	34	0.39	0.21	216.7	4
CHEYENNE WELLS	43.6	19.4	31.5	-2.1	67	-7	966	0	39	0.37	0.21	231.2	4
HOLLY	50.0	15.3	32.6	-1.1	71	0	933	0	91	0.05	-0.21	19.2	3
SPRINGFIELD 7WSW	52.0	21.7	36.8	1.0	72	3	808	0	109	0.19	-0.14	57.6	4

Foothills/Adjacent Plains*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	46.5	18.6	32.5	0.0	63	2	936	0	50	0.51	0.14	137.8	4
GREELEY UNC	45.0	18.7	31.8	-2.0	65	2	955	0	51	0.55	0.27	196.4	2
ESTES PARK	42.5	13.9	28.2	-1.2	60	-5	1060	0	12	0.39	0.01	102.6	2
LONGMONT 2ESE	43.2	14.8	29.0	-2.9	64	-4	1035	0	42	0.37	0.00	100.0	4
BOULDER	49.5	22.0	35.7	-0.5	66	4	842	0	65	1.14	0.50	178.1	8
DENVER WSFO AP	47.0	21.2	34.1	0.4	67	4	889	0	54	0.60	0.02	103.4	6
EVERGREEN	45.9	12.7	29.3	0.3	62	-5	1029	0	36	0.73	-0.03	96.1	6
LAKE GEORGE 8SW	37.1	1.3	19.2	-0.5	52	-18	1320	0	2	0.28	-0.03	90.3	4
RUXTON PARK	37.1	7.2	22.1	0.1	50	-5	1238	0	0	0.78	-0.11	87.6	4
COLORADO SPRINGS	44.8	18.7	31.7	-0.8	62	-2	958	0	44	0.68	0.38	226.7	7
CANON CITY 2SE	48.8	21.4	35.1	-2.1	66	-3	858	0	76	0.46	0.04	109.5	3
PUEBLO WSO AP	49.3	17.9	33.6	-1.8	70	-4	903	0	84	0.38	0.13	152.0	6
WALSENBURG	50.9	21.8	36.3	0.8	68	-3	826	0	72	1.02	0.20	124.4	3
TRINIDAD FAA AP	51.6	19.4	35.5	0.5	68	1	850	0	95	0.25	-0.16	61.0	3

Mountains/Interior Valleys*

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	32.5	4.4	18.4	0.0	44	-14	1343	0	0	0.44	-0.02	95.7	5
LEADVILLE 2SW	35.3	2.7	19.0	2.5	51	-15	1326	0	2	0.33	-0.67	33.0	6
SALIDA	47.6	15.5	31.6	1.4	62	5	965	0	40	0.16	-0.48	25.0	2
BUENA VISTA	44.8	15.1	30.0	1.3	59	3	1010	0	23	0.05	-0.30	14.3	1
SAGUACHE	34.3	4.7	19.5	-5.4	46	-7	1314	0	0	0.05	-0.21	19.2	1
HERMIT 7ESE	30.4	-0.3	15.0	0.5	42	-18	1443	0	0	0.69	-0.03	95.8	2
ALAMOSA WSO AP	36.1	-1.8	17.2	-5.2	50	-17	1381	0	0	0.25	-0.05	83.3	3
STEAMBOAT SPRINGS	32.6	4.7	18.6	-0.9	46	-19	1336	0	0	1.89	-0.15	92.6	11
GRAND LAKE 6SSW	30.0	1.9	16.0	-0.1	42	-18	1413	0	0	0.77	-0.04	95.1	10
DILLON 1E	33.4	1.1	17.2	-1.3	47	-12	1376	0	0	0.77	-0.12	86.5	9
CLIMAX	28.8	-2.3	13.2	-1.7	48	-18	1494	0	0	0.94	-0.90	51.1	11
ASPEN 1SW	39.8	11.0	25.4	2.7	53	0	1146	0	5	0.95	-1.15	45.2	7
TAYLOR PARK	34.0	-10.6	11.7	5.7	46	-35	1539	0	0	0.85	-0.21	80.2	7
TELLURIDE	43.6	9.5	26.5	2.5	54	-3	1109	0	7	0.74	-0.73	50.3	6
PAGOSA SPRINGS	45.1	2.5	23.8	-1.9	60	-12	1187	0	15	1.41	0.07	105.2	3
SILVERTON	41.8	-5.2	18.3	4.4	55	-20	1347	0	6	0.93	-0.66	58.5	7
WOLF CREEK PASS 1	38.3	4.7	21.5	3.4	46	-4	1252	0	0	2.10	-1.81	53.7	4

Western Valleys

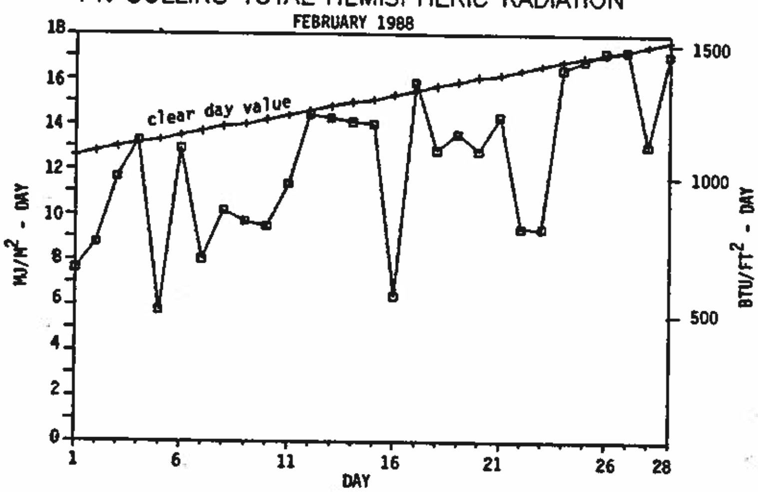
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	33.0	9.3	21.2	-0.7	42	-9	1264	0	0	0.45	-0.75	37.5	7
HAYDEN	31.4	8.9	20.2	-1.5	44	-11	1292	0	0	0.42	-0.73	36.5	9
RANGELY 1E	33.0	4.4	18.7	-5.6	51	-13	1334	0	1	0.05	-0.44	10.2	2
EAGLE FAA AP	40.4	8.2	24.3	-0.6	53	-11	1173	0	3	0.35	-0.25	58.3	5
GLENWOOD SPRINGS	43.1	17.0	30.1	0.3	59	2	1006	0	18	0.81	-0.32	71.7	8
RIFLE	46.5	11.4	28.9	-0.8	60	-1	1039	0	25	0.47	-0.28	62.7	5
GRAND JUNCTION WS	42.5	15.9	29.2	-4.8	61	2	1031	0	18	0.21	-0.26	44.7	3
CEDAREDGE	46.0	18.8	32.4	0.2	60	5	935	0	25	0.39	-0.43	47.6	3
PAONIA 1SW	43.6	17.2	30.4	-1.5	60	2	996	0	15	0.42	-0.66	38.9	3
MONTROSE NO. 2	43.6	16.8	30.2	-1.3	58	4	1003	0	14	0.45	0.04	109.8	1
URAVAN	51.2	19.3	35.2	-0.6	66	11	855	0	57	0.42	-0.14	75.0	2
NORWOOD	42.3	12.8	27.6	-0.0	54	-4	1078	0	10	0.67	-0.03	95.7	2
YELLOW JACKET 2W	44.4	17.0	30.7	1.4	57	7	987	0	18	0.71	-0.40	64.0	4
CORTEZ	44.8	15.4	30.1	-0.4	59	2	1008	0	16	0.76	-0.17	81.7	3
DURANGO	47.1	15.4	31.2	0.3	61	3	972	0	27	0.90	-0.48	65.2	5

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

FEBRUARY 1988 SUNSHINE AND SOLAR RADIATION

Station	Number of Days: clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	9	12	8	--	--
Denver	9	8	12	66%	71%
Fort Collins	8	14	7	--	--
Grand Junction	14	6	9	79%	64%
Pueblo	11	10	8	74%	74%

FT. COLLINS TOTAL HEMISPHERIC RADIATION



The Colorado Freeze-Thaw See-Saw: continued

Most of us, especially farmers and gardeners, pay attention to late spring freezes and early fall freezes. Those of us who have to scrape frost off our windshields in the morning also take note. But there is a lot going on as the temperature crosses back and forth over the freezing point that we may not notice. Perhaps we observe that a lot more pot holes appear in our streets in the spring. More than likely we blame it on the snow plows. And the chunks of rock we find in the spring on the highways up in the rugged Rockies we usually blame on the melting snow. Or maybe you were surprised by a spring dust storm when you thought the topsoil was still very moist. In truth, the freeze-thaw process has a great deal to do with the decay of our streets and similarly the erosion of our Rocky Mountains. The freeze-thaw process also loosens the soil, breaks up clods, conditions the soil for a new growing season, but also makes it susceptible to erosion by strong spring winds. The temperature crossing 32°F by itself is no big deal, but if water is present and changes phase, then things get interesting.

Unlike almost any other substance in nature, water expands as it nears the freezing point and then expands even more as it turns to ice. Just as this process can shatter a glass water bottle left too long to chill in the freezer, it can also crack pavement, break rocks, loosen soil particles and even crack the foundations under our homes.

Now, let's get back to our little quiz. We don't really measure exactly how often the temperature crosses the 32° mark. But most weather stations do measure each day's highest and lowest temperature. Whenever the high is above freezing and the low is below freezing, we know the temperature has to cross the threshold at least once. Looking at detailed temperature records at Fort Collins, we discovered that there are about 144 days per year when the daily high temperature is above freezing and the low is below. On most of these days the temperature crosses the freezing point twice -- once rising and once falling. But there are days when it only crosses once and days when it crosses the freezing point several times. We found one day in recent years when the temperature crossed back and forth 9 times.

Average number of days in a year that the Fort Collins Temperature:

Stays Above Freezing	Stays Below Freezing	Crosses the Freezing Point This Number of Times										
		1	2	3	4	5	6	7	8	9	10	Total
197	24	24	81	16	12	5	3	2	<1	<1	0	365

Making a very simple assumption that the freezing point is crossed two times on every day the high is above freezing and the low is below, we computed average annual "crossovers" for 141 locations in Colorado and, for comparison, many other major cities across the country. Fraser lead the pack with 498 crossovers per year. Wagon Wheel Gap was a close second with 495. Outside of Colorado the highest totals were all in the intermountain west. Flagstaff, Arizona, crosses the freezing point an average of 391 times per year while Ely, Nevada, averages 389 crossovers. In Colorado, the fewest crossovers occur at Palisade (221), Grand Junction (222), Canon City (223) and Boulder (237). Only 201 crossovers per year were noted in Denver when the official station was on the roof of the Post Office building downtown. This is still more crossovers than occur in most of the rest of the country.

Here is a comparative table showing estimated freezing temperature crossovers for selected locations in Colorado and throughout the U.S. This type of analysis could prove useful in examining ranges and habitats for certain plant life and also in looking at erosion processes.

Estimated Number of 32°F Crossovers Per Year for
Selected Colorado and U.S. Locations

Alamosa	384	Gunnison	398	Albuquerque, NM	233
Aspen	367	Lamar	274	Atlanta, GA	109
Berthoud Pass	295	Leadville	366	Boise, ID	206
Boulder	237	Limon	329	Boston, MA	140
Burlington	275	Meeker	367	Caribou, ME	181
Canon City	223	Mesa Verde NP	278	Dallas, TX	76
Castle Rock	355	Montrose	298	Detroit, MI	175
Colorado Springs	267	Pueblo	273	Elkins, WV	228
Denver airport	273	Salida	381	Helena, MT	270
Denver city	201	Silverton	477	Minneapolis, MN	147
Dillon	462	Steamboat Springs	392	Mt. Washington, NH	151
Durango	399	Sterling	294	New Orleans, LA	27
Evergreen	416	Trinidad	277	Orlando, FL	7
Fort Collins	288	Wagon Wheel Gap	495	Phoenix, AZ	17
Fraser	498			Rapid City, SD	241
Glenwood Springs	321			Sacramento, CA	32
Grand Junction	222			Seattle, WA	31
				St. Louis, MO	149
				Washington DC (National Airport)	123

(derived from summarized 1951-85 daily maximum and minimum temperatures)

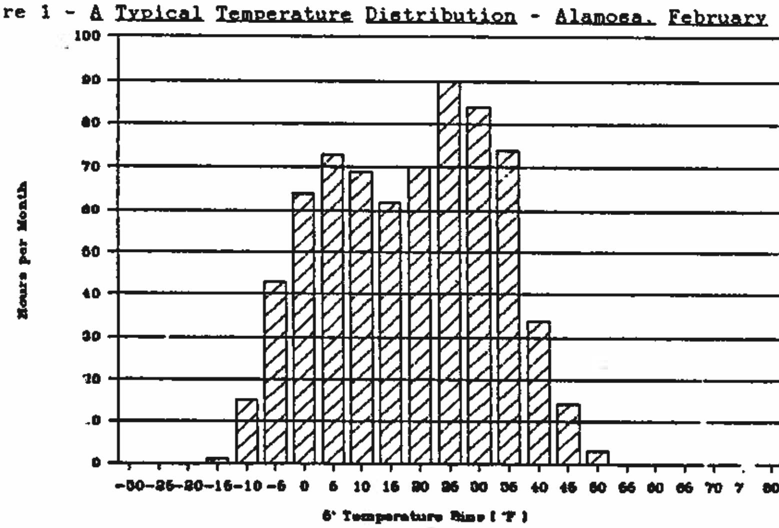
Applications of Weather Data to Energy-Related Topics

How does the weather affect energy use? We all know that when the temperature starts dropping the energy use for space heating goes up. Similarly, on a hot summer day the utilities must bring more generators on line to accomodate our air conditioners. But also consider that the evapotranspiration rate determines the amount of energy required to run irrigation pumps, or that the effectiveness of economizer cycles in large buildings depends on the relative humidity and corresponding air enthalpy. (The enthalpy measures the internal energy of the air and water vapor mixture).

And of course, after the energy use comes the utility bill. Here at JCEM we look for ways to reduce those bills by studying energy conservation, energy utilization techniques and the applications of renewable energy resources. For example, when designing a building HVAC system, it is important to know the ranges of yearly temperature and solar data before sizing chillers, heating plants, glazing areas, etc.

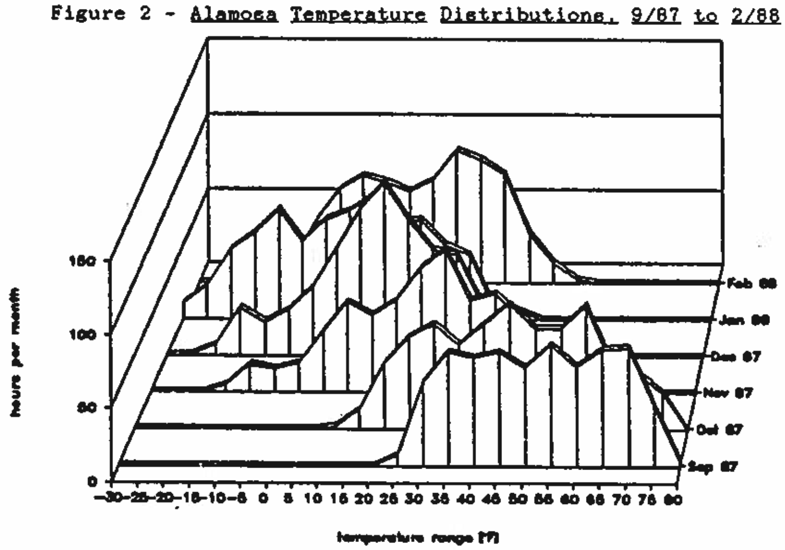
This month we will look at temperature distributions and what they can show us. Figure 1 shows the span of air temperatures in Alamosa for February. The horizontal axis is broken down into 5 degree (F) temperature bins, while the vertical axis shows the number of hours per month that the temperature was within that bin range. The two "peaks" in this graph represent the daytime and nighttime averages. These averages (and standard deviations) can be useful for determining a building heating (or cooling) load at different periods of the day, as well as for anticipating extremes.

Figure 1 - A Typical Temperature Distribution - Alamosa, February 1988



By looking at distributions for the past 6 months, we can get a feel for the temperature trends on monthly and seasonal scales. Figure 2 shows Alamosa temperatures from September, 1987 (front graph) to February, 1988 (rear graph). Notice that for certain months the temperatures are evenly distributed across a wide range. This can occur when a frontal system moves across the region, expanding the range of temperatures seen during that month. This effect is noticed more during the swing seasons of spring and fall.

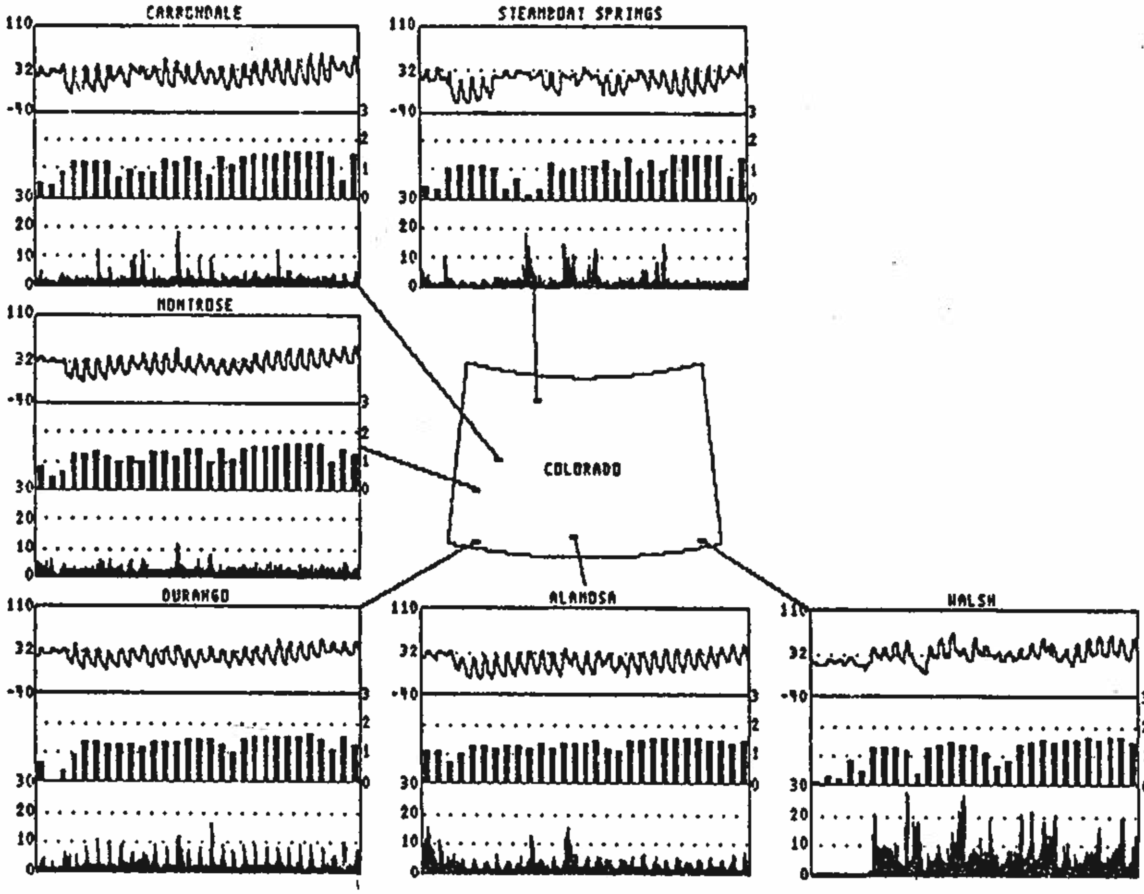
Figure 2 - Alamosa Temperature Distributions, 9/87 to 2/88



On a bright note, also notice that February was generally warmer than January, a sure sign that spring is coming! This makes sense: if you wake up on a cold but sunny morning it takes a few hours for the earth to "warm up". Similarly, the seasonal lag time between the shortest day of the year (December 21) and the coldest days is about a month. On the other end of the thermometer, we experience the hottest days of the year in July, about a month after the summer solstice.

JCEM Weather Data for February, 1988

The map of Colorado below shows the location of six JCEM weather stations. For each site (1) the top graph shows the hourly temperature in degrees F, (2) the middle bar chart gives the daily total horizontal insolation, in thousands of Btu/square foot per day and (3) the bottom graph shows the hourly wind speed in mph. Note that the wind speed sensor in Walsh was frozen during the first 5 days of the month.



Some highlights of the JCEM data are given here:

		Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
Monthly Average Temperature [°F] :		17.9	26.1	23.6	24.0	13.8	34.0
Monthly Temperature Extremes [°F (day/hour)]	Maximum :	48.4 (20/15)	54.2 (22/16)	50.1 (25/16)	57.1 (29/16)	46.[illegible] (29/14)	71.9 (13/15)
	Minimum :	-13.3 (5/ 6)	0.8 (7/ 8)	-10.6 (5/ 7)	-3.9 (5/ 7)	-26.[illegible] (4/ 6)	0.9 (11/ 4)
Average Relative Humidity / Dew Points [percent / °F]	5 AM :	85 / 1	80 / 11	90 / 8	83 / 12	85 / [illegible]	77 / 20
	11 AM :	60 / 17	49 / 27	50 / 24	54 / 26	70 / 14	53 / 35
	2 PM :	48 / 25	47 / 30	37 / 34	45 / 33	58 / 16	44 / 40
	5 PM :	47 / 24	45 / 31	40 / 32	46 / 31	67 / 10	44 / 38
	11 PM :	84 / 10	76 / 17	80 / 14	79 / 17	86 / 6	69 / 22
Average Wind Speed [miles per hour] :		3.18	3.03	2.52	2.63	2.33	8.30
Wind Speed Distribution [hours per month]	0 to 3 mph:	413	473	576	504	573	42
	3 to 12 mph:	273	217	114	192	109	420
	12 to 24 mph:	10	5	6	0	14	100
	> 24 mph:	0	0	0	0	0	8
Average Wind Direction [degrees c.w. from N]	10 AM to 6 PM:	205	202	215	204	174	145
	10 PM to 6 AM:	210	78	175	165	134	220
Total Average Horizontal Insolation : [Btu/square feet per day]		1314	1262	1157	1234	1016	1163
Clearness [hrs per month where the fraction of extra-terrestrial radiation reaching the ground is within the range shown]	60% to 80% :	206	153	161	181	131	171
	40% to 60% :	69	39	53	57	72	45
	20% to 40% :	12	41	66	48	55	37
	0% to 20% :	7	36	14	7	36	36

COLORADO CLIMATE

MARCH 1988

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This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 6

March in Review:

March brought the typical springtime see-saw of temperatures as storm systems zipped across the state one after another. Temperatures ended up near average for the month. Considering the many storm systems that crossed the area, precipitation was surprisingly light. Above average moisture was limited to the Front Range and some selected portions of the mountains.

Colorado's May Climate:

Interesting meteorological transitions often take place over Colorado in May. Warmer temperatures inspire rapid melting of mountain snowpack. But as rivers rise the potential for heavy precipitation diminishes in western Colorado, especially down in the southwest. This is convenient for our state since it tends to minimize the potential for flooding even at a time when rivers are usually running high. At this same time, however, May can be a very wet month in eastern Colorado from the lower foothills out across the plains. For one month of the year eastern Colorado seems like a humid midwestern state. May is often the cloudiest month of the year, but the low clouds and frequent showers are very beneficial for eastern Colorado agriculture. When the May wet season fails, as it sometimes does, wheat yields and range conditions usually suffer. If the rains come in over abundance, then flooding becomes a possibility. And don't forget severe weather. After months of convective tranquility, the thunderstorm season really gets rolling in eastern Colorado in May. Hail and tornadoes both become a possibility. In parts of eastern Colorado, May is the month with the greatest likelihood for hail. The biggest hailstones, however, usually wait for later in the summer to fall.

For the month as a whole, May precipitation averages only 0.50" to 1.00" on the Western Slope and increases to 1-2" in the southern mountains as well as the valleys of northern and central mountains. Two to four inch totals are typical in the northern mountains. From Denver northward to Wyoming and east to Nebraska, May is normally the wettest month of the year with totals in some areas frequently exceeding 3 inches. Southeastern Colorado is somewhat drier, but rainfall typically increases dramatically as you head east from Trinidad and LaJunta toward Kansas. Most May precipitation falls as rain below elevations of about 6500', but snows are possible and have been locally heavy in the past. Higher in the mountains snow is still common but even there May snows usually melt quickly.

Colorado still gets its fair share of abrupt temperature changes in May, but for the most part temperatures are quite pleasant. Many areas still have a threat of frost early in the month so gardeners need to be careful with sensitive plants. If you're new to an area, please check on local growing season statistics before getting carried away planting beans and tomatoes. High temperatures average in the 70s at most lower elevation locations across the state but expect some summerlike days with highs in the 80s and a fair share of damp cloudy days with only 40s and 50s. Low temperatures are generally in the 40s. Higher in the mountains temperatures drop, and by the 11,000 foot level only expect highs in the 40s and lows in the 20s throughout the month.

Here we go again -- Our hail season is upon us:

It wasn't that long ago that Colorado was the site of the largest hail research experiment of all time. In the 1960s and early 70s hundreds of researchers swarmed to places like Grover, Keota, Briggsdale and New Raymer in northeast Colorado to learn more about hail. Many farmers and ranchers from across the plains voluntarily reported each hailstorm they observed. Massive amounts of data from balloons, surface weather stations, and radars were collected in an effort to understand what makes hailstorms tick. Why was Colorado chosen? Quite frankly, it's because it hails here with a frequency and intensity that is matched in only a few other locations in the whole world. Not all of Colorado is in hail alley, but the High Plains in the lee (east side) of the Rockies is where hail falls with greatest vengeance.

(continued)

MARCH 1988 DAILY WEATHER

Date	Event
1-3	A deep upper-level low pressure trough drifted over Colorado. Grand Junction was greeted with a morning thundershower on the 1st. Rain began along the Front Range late on the 1st and turned to snow overnight as cold air pushed in from the northeast. 2-12" of new snow fell in the northern and central mountains and along the northern Front Range. Boulder totalled 0.90" of moisture from the storm. Localized fog and snowshowers continued on the 3rd but some locally heavy snows were reported. Ouray picked up 10" of wet snow by the morning of the 3rd.
4	Another disturbance whipped across Colorado triggering more snows in the northern and central mountains and a period of snow late in the day in southeast Colorado. Most snowfall was less than 4".
5-7	Cold mornings but mild afternoons 5th and 6th. Then increasing clouds from the northwest on the 6th. Snow developed late on the 6th in northwestern Colorado and spread into the mountains early on the 7th as a strong Pacific cold front flew across the state. Blustery cold winds statewide on the 7th but only a few snow showers east of the mountains.
8-9	Clearing on the 8th, but still cold and breezy on the plains. Warmer statewide on the 9th -- beautiful day with increasing clouds late.
10-11	A storm center developed and intensified ferociously over northern Colorado early on the 10th. Heavy snow fell in a small area of north central Colorado. Fort Collins reported 11" of wet snow and Red Feather Lakes 15" in just a few hours. Strong winds developed statewide and blizzard conditions closed highways in northeastern Colorado. Very strong winds averaging as much as 40 mph continued in northeast Colorado on the 11th producing white-out conditions in those areas that had received snow.
12-14	Unseasonably cold and unsettled. An upper level disturbance dropped down from the north and set off snowshowers on the 12th which became more organized along the southern Front Range. An inch of snow covered much of the southeast plains by early on the 13th with closer to 4" from Colorado Springs south to Trinidad. As skies cleared temperatures dropped to their lowest values of the month in many areas. Taylor Park's -26°F on the 14th was the coldest in the state.
15-17	A new storm system took shape west of Colorado on the 15th and dropped south-eastward. Though the storm looked strong on the weather maps, it didn't pack much punch. Most of the state got a bit of snow and temperatures east of the mountains stayed very cold. The greatest precipitation report was 1.25" of water content at Wolf Creek Pass.
18-23	At last, a significant taste of spring. After a chilly day on the 18th, temperatures climbed steadily and reached the 60s and 70s at most lower elevation locations 20-23rd with some 80s on the eastern plains.
24-27	Briefly colder on the 24th as a strong cold front crossed the state. A good round of snows in the northern and central mountains with 8" at Fraser and Breckenridge. Windy on the plains with areas of blowing soil continuing onto the 25th. Very warm 26-27th in advance of yet another approaching storm. Some record high temperatures on the 27th such as Pueblo's 85°. Holly's 92° earned it the hot spot award for the month.
28-31	Dramatically colder -- 40° temperature drops in many locations on the 28th. Scattered snow showers in mountains and eastern foothills on the 28th. Briefly warmer on the 29th prior to one more winter blast 30-31st. Snows developed and became heavy late on the 30th along the Front Range and continued on the 31st especially in southern Colorado. Snows were surprisingly powdery for so late in the season. Fort Collins picked up 19" of the white stuff and the Coal Creek station west of Boulder totalled 28" from just 1.12" of moisture. Surprisingly little snow fell in the mountains with only a trace at Steamboat Springs, Dillon and Durango. Unseasonably chilly temperatures persisted.

March 1988 Extremes

Highest Temperature	92°F	March 27	Holly
Lowest Temperature	-26°F	March 14	Taylor Park Reservoir
Greatest Total Precipitation	4.88"		Bonham Reservoir
Least Total Precipitation	0.00"		Stonington
Greatest Total Snowfall*	81"		Mount Evans Research Center
Greatest Snowdepth**	128"		Tower (Buffalo Pass)

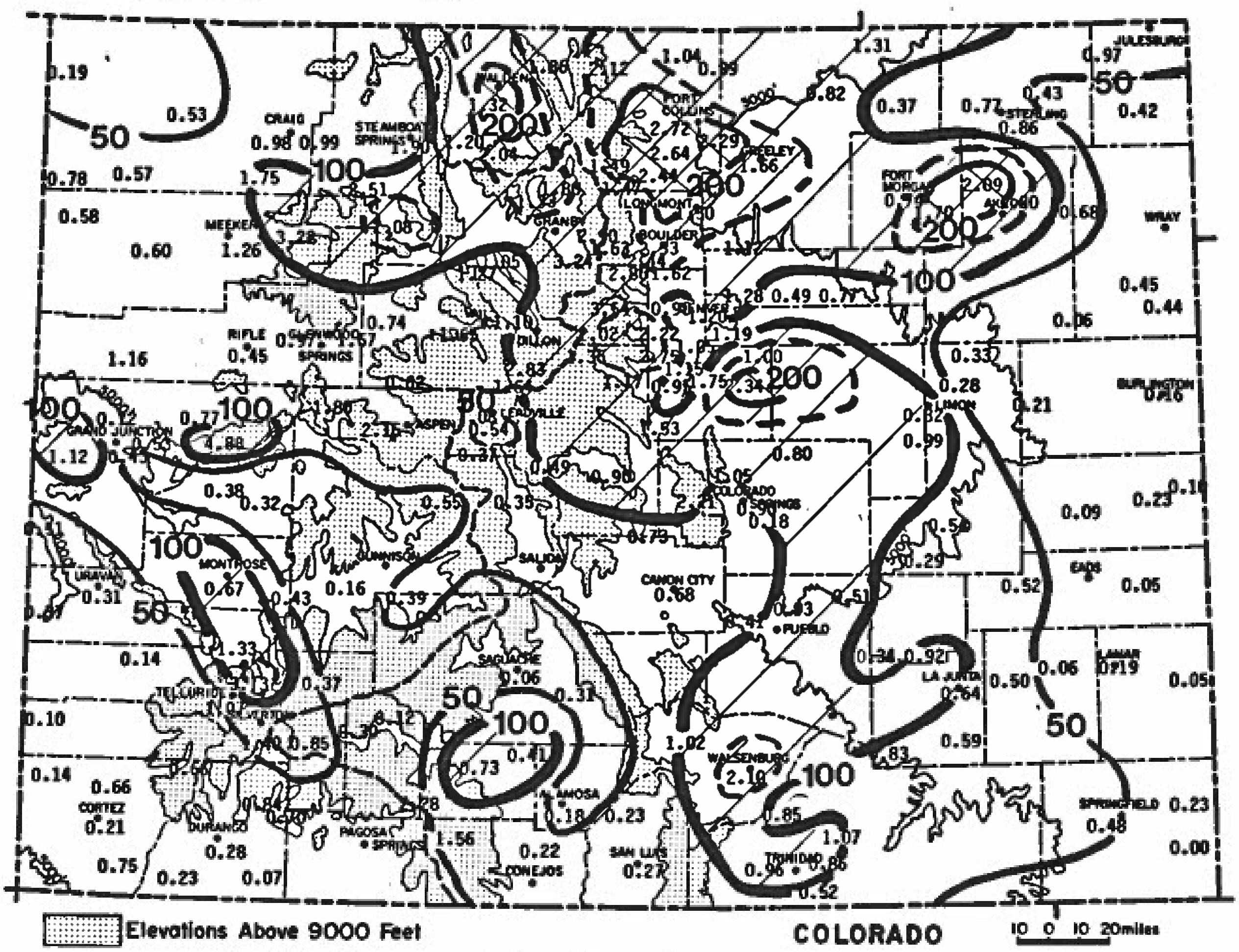
* data derived only from those stations with complete daily snowfall records.
** from Soil Conservation Service Snowpack measurements.

MARCH 1988 PRECIPITATION

Despite an abundance of significant storm systems, much of Colorado was drier than average in March. Less than half the average precipitation was observed in extreme northwest Colorado, over much of the southwest quarter of the state and across all of the extreme eastern plains. A number of locations including Cortez, Durango and Burlington, had less than 20% of their average. Most areas in the central and southern mountains were well below average.

The wettest area, compared to average, was north central Colorado. More than double the March average was observed in the Estes Park, Loveland and Fort Collins area. Windsor's 2.29" monthly total was more than 3 times their average. Fort Collins' snowfall total of 39.6" shattered the 100-year record for greatest monthly snowfall. Most of the rest of the Front Range was also near or above average. A few areas in the mountains were wet including Yampa, Grand Lake, Winter Park, Breckenridge and Ouray.

Greatest		Least	
Bonham Reservoir	4.88"	Stonington	0.00"
Mount Evans Research Center	3.54"	Holly	0.05"
Winter Park	3.24"	Brandon	0.05"
Marvine Ranch	3.22"	Saguache	0.06"
Ouray	3.13"	John Martin Dam	0.06"
Silver Lake	2.90"	Joes	0.06"



Precipitation amounts (inches) for March 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

1988 WATER YEAR PRECIPITION

Drier than average conditions are expanding in Colorado as we are now 6 months into the 1988 water year. Most of the central and southern mountain areas are below average with portions of central Colorado below 70% of average. However, there are still many moist areas, such as most of the Colorado Front Range and northeastern plains, many Western Slope valleys and the majority of the northern mountains. A few local areas including Akron, Windsor, and Castle Rock have had more than double their average moisture to date. It has now been 11 years since the last time Grand Junction experienced below average precipitation for the October-March period.

Comparison to Last Year

At this time last year, dry conditions existed throughout the northern and central mountains, while most of the remainder of the state was more moist than usual. The wettest areas, compared to average, were found in southeast Colorado.

1988 Water Year to Date through March

Wettest (as % of average)

Akron FAA	278%	7.49"
Brush	239%	6.05"
Windsor	239%	6.64"

Driest (as % of average)

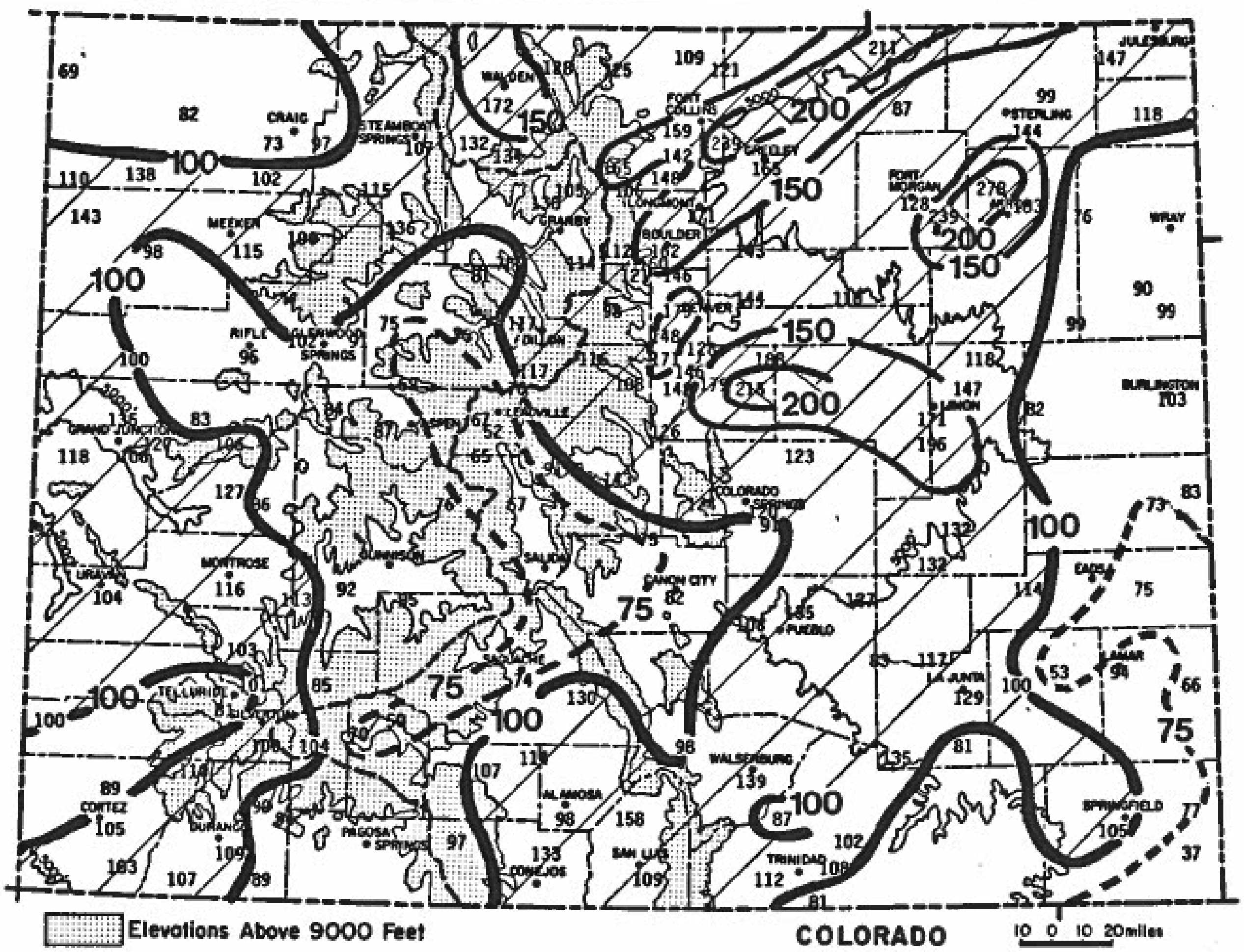
Stonington	37%	1.09"
Creede 2S	50%	3.13"
Leadville 2SW	52%	3.49"

Wettest (total precipitation)

Bonham Reservoir	19.79"	106%
Wolf Creek Pass 1E	19.01"	74%
Rico	15.49"	110%

Driest (total precipitation)

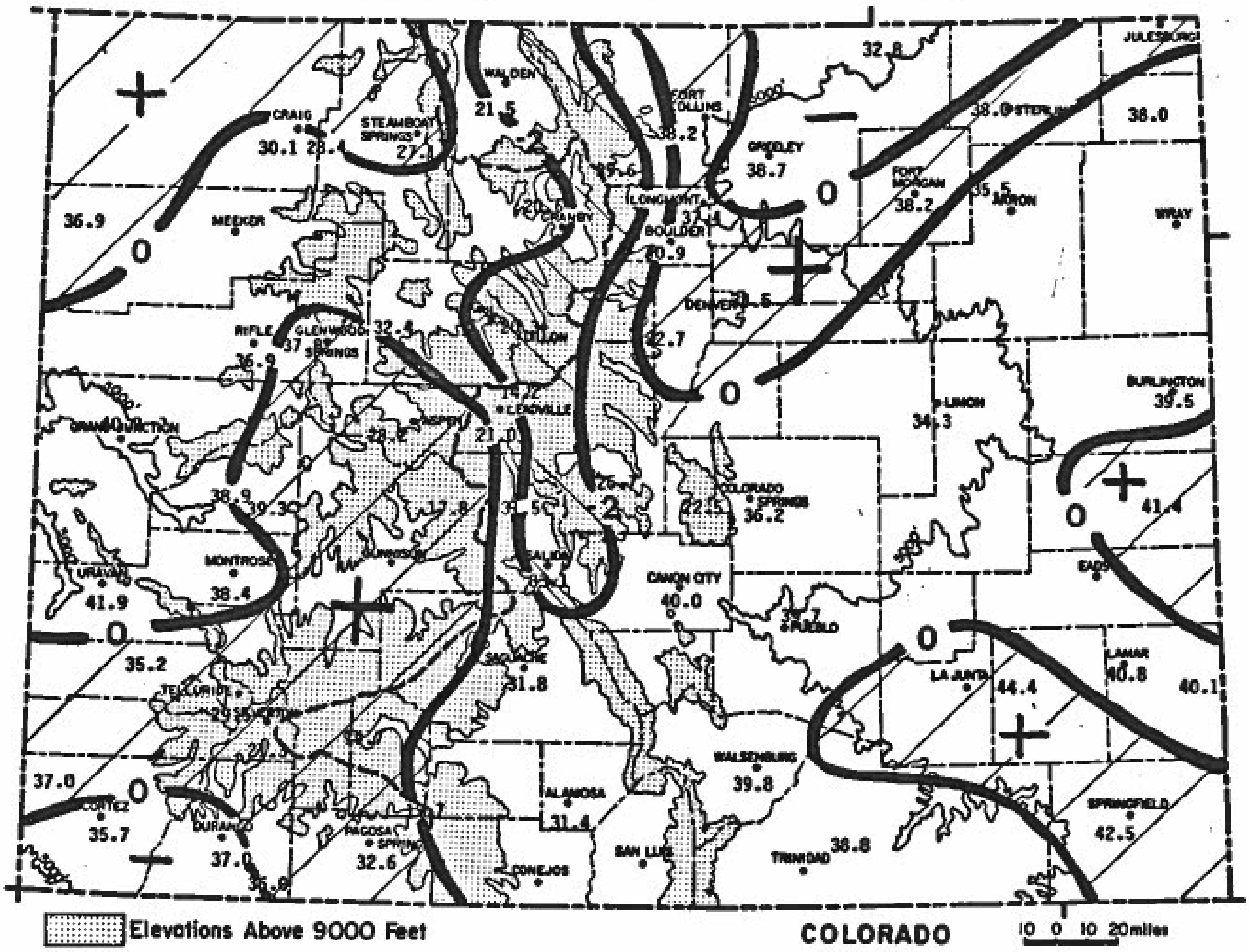
Stonington	1.09"	37%
John Martin Dam	1.19"	53%
Brandon	1.50"	75%



Precipitation for October 1987 through March 1988 as a percent of the 1961-1980 average.

MARCH 1988 TEMPERATURES AND DEGREE DAYS

March temperatures had their normal variety of ups and downs but ended up very close to average for the month as a whole. More than half the reporting stations were cooler than average, but there was no organized pattern to the temperature anomalies and nearly all stations were within 2 degrees of the 1961-80 average.



March 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

MARCH 1988 SOIL TEMPERATURES

Soil temperatures were slow to recover until warm weather in late March finally sent them soaring.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

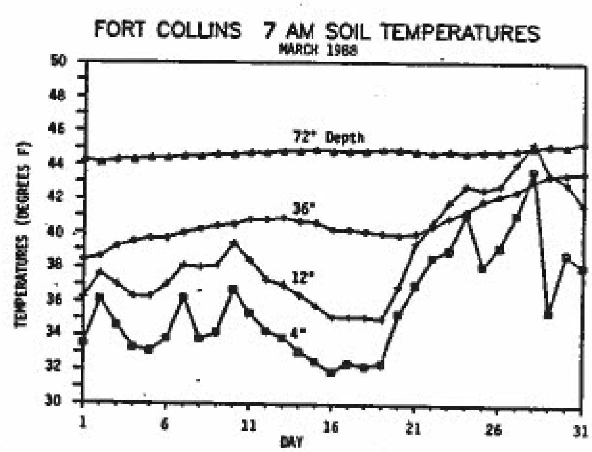


Table 1. Colorado Heating Degree Day Data through March 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130	1556	1867	1381	1031				8092
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024	1382	1450	1146	1136				7320
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713	1053	1107	842	739				4986
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955	1277	1357	1010	1030				6657
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724	1037	1221	935	779				5168
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668	1007	1144	858	767				4952
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767	1108	1256	958	886				5661
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860	1179	1351	1008	899				5888
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950	1376	1561	1264	1076				7139
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737	1102	1300	M	M				3612
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745	1125	1227	889	811				5349
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145	1491	1629	1376	1379				8981
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851	1206	1391	972	859				5960
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37	39	314	658	930	1283	1309	925	927	566	384	111	7483
	87-88	54	75	254	509	950	1331	1544	1173	1002				6892
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922	1255	1310	1029	992				6630
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784	1140	1252	936	821				5581
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773	1154	1484	1055	826				5873
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754	1147	1469	1031	741				5430

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098	1516	1642	1413	1372				8662
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762	1157	1363	955	807				5623
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M	M	M	M	M				0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653	1032	1278	837	638				4749
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180	1534	1577	1326	1355				9052
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840	1209	1354	1022	943				6115
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87	0	0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805	1169	1383	1035	847				5907
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	94	7402
	87-88	M	M	M	M	M	M	M	M	M				0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849	1160	1332	1003	817				5674
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947	1292	1548	1187	996				7049
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754	1111	1399	903	777				5363
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819	1209	1430	1039	865				5911
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033	1448	1619	1336	1167				
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742	M	1475	1029	831				4641
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992	1269	1354	1109	1092				7228
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730	1054	1209	850	803				5085
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242	1499	1572	1343	1340				8727
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707	977	1109	826	773				4858

M = MISSING DATA

MARCH 1988 CLIMATIC DATA

Eastern Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
NEW RAYMER 21N	45.6	20.0	32.8	-2.4	75	3	992	0	77	1.31	0.67	204.7	10
STERLING	52.3	23.6	38.0	1.2	78	9	831	0	124	0.77	-0.03	96.2	5
FORT MORGAN	52.6	23.7	38.2	0.8	82	11	826	0	123	0.74	0.18	132.1	6
AKRON FAA AP	49.1	22.0	35.5	-0.8	79	2	904	0	98	2.09	1.22	240.2	9
HOLYOKE	52.1	23.9	38.0	-0.6	84	7	830	0	124	0.42	-0.71	37.2	4
BURLINGTON	53.2	25.8	39.5	-0.5	83	11	779	0	122	0.16	-0.66	19.5	3
LIMON WSMO	48.5	20.2	34.3	-1.9	78	2	943	0	93	0.82	0.08	110.8	9
CHEYENNE WELLS	57.3	25.5	41.4	2.0	85	7	722	0	170	0.23	-0.46	33.3	3
LAMAR	59.6	22.0	40.8	-1.9	91	7	744	1	194	0.19	-0.74	20.4	4
LAS ANIMAS	63.2	25.5	44.4	0.9	90	13	638	5	230	0.50	-0.12	80.6	8
HOLLY	59.2	21.1	40.1	-0.6	92	5	764	0	189	0.05	-0.65	7.1	2
SPRINGFIELD 7WSW	59.8	25.2	42.5	0.9	84	9	692	1	193	0.48	-0.43	52.7	7

Foothills/Adjacent Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	51.3	25.2	38.2	0.7	75	3	821	0	103	2.72	1.62	247.3	9
GREELEY UNC	52.2	25.3	38.7	-1.3	76	9	807	0	121	1.66	0.71	174.7	8
ESTES PARK	41.0	18.2	29.6	-2.9	61	-15	1091	0	16	1.49	0.76	204.1	8
LONGMONT 2ESE	51.9	22.8	37.4	-0.0	76	5	847	0	118	1.50	0.59	164.8	7
BOULDER	54.2	27.5	40.9	0.6	75	4	739	0	130	2.53	1.17	186.0	9
DENVER WSFO AP	51.0	26.0	38.5	0.1	78	13	811	0	109	1.28	0.14	112.3	10
EVERGREEN	48.3	17.2	32.7	0.5	70	-2	992	0	79	2.22	0.92	170.8	9
LAKE GEORGE 8SW	39.9	11.5	25.7	-0.8	59	-13	1212	0	24	0.90	0.35	163.6	10
RUXTON PARK	37.1	7.9	22.5	-3.1	58	-8	1308	0	19	2.21	0.66	142.6	14
COLORADO SPRINGS	49.4	23.0	36.2	-0.4	76	6	886	0	94	0.90	0.10	112.5	10
CANON CITY 2SE	54.7	25.3	40.0	-0.7	82	7	767	0	147	0.68	-0.15	81.9	8
PUEBLO WSO AP	56.5	22.8	39.7	-1.3	85	10	777	0	162	0.93	0.20	127.4	11
WALSENBURG	55.4	24.1	39.8	-0.1	76	7	773	0	144	2.10	0.78	159.1	10
TRINIDAD FAA AP	55.7	21.9	38.8	-1.5	80	5	803	0	149	1.07	0.18	120.2	10

Mountains/Interior Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	35.1	7.8	21.5	-2.6	51	-22	1340	0	1	1.32	0.75	231.6	11
LEADVILLE 2SW	36.2	5.9	21.0	0.0	50	-12	1355	0	0	0.54	-0.76	41.5	12
SALIDA	47.9	18.3	33.1	-3.1	68	-4	982	0	64	0.02	-0.76	2.6	1
BUENA VISTA	45.7	17.3	31.5	-2.1	64	4	1030	0	55	0.35	-0.28	55.6	6
SAGUACHE	45.7	18.0	31.8	-1.1	67	7	1021	0	42	0.06	-0.36	14.3	1
HERMIT 7ESE	35.2	4.2	19.7	0.4	49	-20	1396	0	0	0.30	-1.16	20.5	2
ALAMOSA WSO AP	48.1	14.8	31.4	-0.2	68	2	1031	0	59	0.18	-0.25	41.9	7
STEAMBOAT SPRINGS	39.9	14.3	27.1	0.3	60	-2	1167	0	9	1.90	-0.02	99.0	10
GRAND LAKE 6SSW	36.1	5.0	20.6	-1.8	51	-17	1372	0	2	1.33	0.48	156.5	18
DILLON 1E	34.4	6.1	20.3	-3.0	53	-14	1379	0	4	1.10	-0.01	99.1	11
CLIMAX	29.4	-1.0	14.2	-4.2	44	-18	1566	0	0	1.64	-0.49	77.0	16
ASPEN 1SW	42.0	14.5	28.2	0.7	62	-4	1136	0	27	2.15	-0.05	97.7	12
TAYLOR PARK	35.9	-0.3	17.8	5.6	50	-26	1453	0	0	0.55	-0.71	43.7	7
TELLURIDE	44.8	14.3	29.5	1.1	63	-5	1092	0	28	1.07	-0.88	54.9	12
PAGOSA SPRINGS	51.0	14.2	32.6	0.3	69	2	996	0	71	0.20	-1.24	13.9	3
SILVERTON	41.2	1.4	21.3	1.3	60	-20	1346	0	18	1.40	-0.51	73.3	16
WOLF CREEK PASS 1	35.3	4.1	19.7	-1.5	50	-9	1398	0	0	2.28	-2.58	46.9	6

Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	42.2	17.9	30.1	-0.3	65	2	1076	0	32	0.98	-0.57	63.2	10
HAYDEN	39.8	16.9	28.4	-0.0	59	-3	1128	0	8	0.99	-0.19	83.9	13
RANGELY 1E	50.6	23.2	36.9	1.9	69	12	864	0	75	0.58	-0.19	75.3	8
EAGLE FAA AP	46.6	18.2	32.4	-0.5	68	2	1002	0	53	0.74	-0.03	96.1	9
GLENWOOD SPRINGS	51.6	24.0	37.8	1.7	70	10	836	0	83	0.97	-0.27	78.2	11
RIFLE	52.5	21.2	36.9	-0.8	73	9	865	0	99	0.45	-0.40	52.9	6
GRAND JUNCTION WS	53.7	28.2	40.9	-1.3	77	18	741	0	100	0.72	-0.10	87.8	7
CEDAREDGE	53.3	24.5	38.9	0.1	72	7	803	0	95	0.38	-0.62	38.0	3
PAONIA 1SW	53.7	25.0	39.3	0.4	75	10	788	0	112	0.32	-0.96	25.0	5
MONTROSE NO. 2	52.6	24.2	38.4	-0.2	73	10	817	0	101	0.67	0.14	126.4	4
URAVAN	57.5	26.3	41.9	-1.3	76	16	708	0	145	0.31	-0.66	32.0	7
NORWOOD	49.7	20.7	35.2	1.4	67	5	915	0	61	0.14	-0.97	12.6	2
YELLOW JACKET 2W	50.5	23.5	37.0	2.0	69	9	862	0	69	0.14	-0.92	13.2	3
CORTEZ	52.1	19.3	35.7	-1.6	71	8	899	0	88	0.21	-1.13	15.7	3
DURANGO	53.8	20.2	37.0	-0.3	72	9	859	0	105	0.28	-1.35	17.2	2
IGNACIO 1N	54.5	17.6	36.0	0.8	72	8	890	0	108	0.07	-1.13	5.8	2

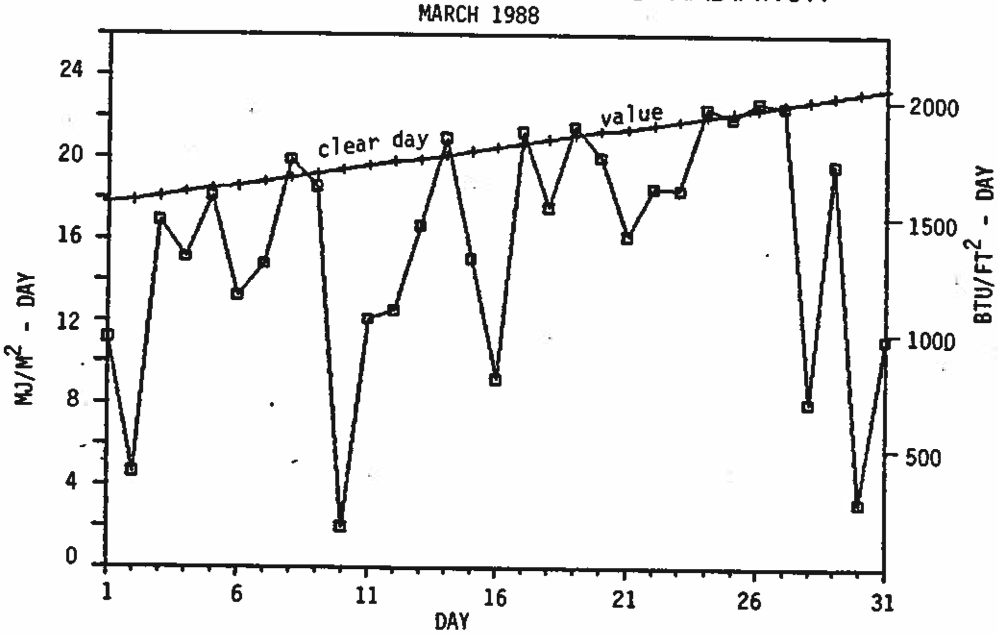
* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

MARCH 1988 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	8	13	10	--	--
Denver	7	7	17	73%	71%
Fort Collins	5	15	11	--	--
Grand Junction	9	11	11	73%	64%
Pueblo	7	14	10	77%	75%

FT. COLLINS TOTAL HEMISPHERIC RADIATION

MARCH 1988



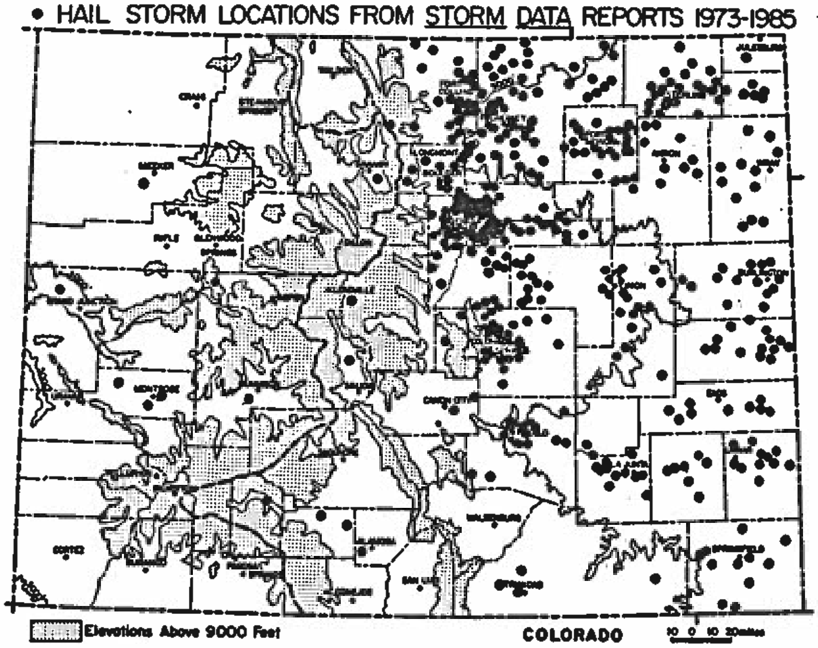
Here we go again -- Our hail season is upon us: continued

There isn't much active research going on at present on the topic of hail. But that doesn't mean that hail is no longer a problem. Each year millions of dollars of property damage is inflicted by hailstorms right here in Colorado. More damage is done by hail in this part of the country than by any other type of natural hazard.

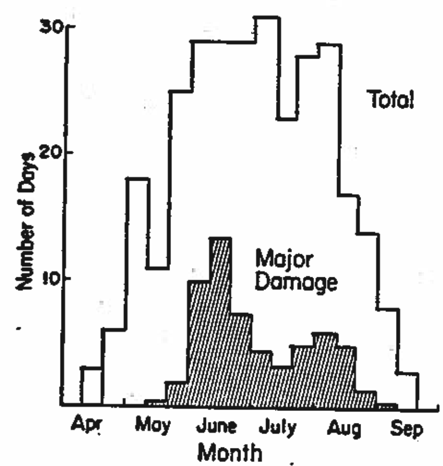
What do we know about hail in Colorado? Here are a few statistics:

- Hail is one of the most variable climatic elements. It tends to be very spotty and varies greatly in size and frequency from year to year and place to place.
- Colorado is one of the most hail-prone states in the United States.
- Hail is possible anywhere in Colorado. However, the vast majority of Colorado damaging hailstorms occur on the High Plains east of the mountains.
- Except for in the high mountains, hailstorms are apparently most frequent near the Colorado-Wyoming-Nebraska border and on the Palmer Ridge from Pikes Peak toward Limon. Any point in these regions can expect hail on an average of at least 5 days each year.
- Hail occurs even more frequently in the high mountains. Almost any strong mountain thunderstorm will produce hail (or graupel). High elevation hail is small and soft and rarely does damage.
- The Colorado "hail season" runs from about April 15 to September 15. Destructive hailstorms have a shorter season and usually occur from late May to late August. Colorado hailstorms are most likely in June. A lull in hail frequency is noted in mid July followed by a secondary maximum in late July and early August (coinciding with the peak of the Southwest Monsoon moisture surge).
- There are two periods when damaging hail is most likely. These are the best times to keep your new car in the garage:
  1) June 2-18
  2) July 24-August 12
- Most Colorado hail occurs between noon and 8 pm. Along the Front Range, the most likely times for hail are around 2:30 pm and again around 5:00 pm.
- The majority of Colorado hailstones are between 1/8" and 5/8" diameter. Each year there are numerous reports of hail in excess of 1" diameter. Hailstones as large as 4 1/2" in diameter have been reported in Colorado. The majority of roof and automobile damage from hail results from stones at least 3/4" in diameter. Much of the agricultural damage is done by smaller stones especially when strong winds accompany the hail.

• HAIL STORM LOCATIONS FROM STORM DATA REPORTS 1973-1985



Number of "Significant" Hail Days in Colorado for Each 10-day Period, 1973-1985 (from Storm Data Reports)



A publication on hail in Colorado has been prepared by the Colorado Climate Center. It will become available when funds for publication are secured.

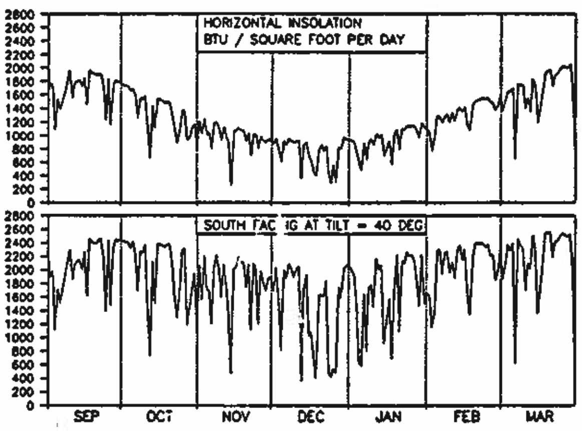
WTHRNET WEATHER DATA - MARCH 1988

How Does the Sun Affect Our Energy Use?

There are several ways in which the sun directly affects the amount of energy we use. For example, we all are familiar with the summer cooling loads created when solar radiation passes through windows. This "greenhouse effect," as it is sometimes called, occurs because infrared radiation which passes through glass is diffracted in the process, preventing its escape back through the glass. Sunlight can also heat up a wall, causing delayed heat delivery to the interior which can continue into the evening. The sun also affects energy use indirectly by heating up the ambient air and by putting more water into the air through evaporation. The hot air must be cooled before it is circulated in a building (the sensible load) while the increased humidity means there is more water vapor to be condensed out of that air (the latent load). Solar gains can therefore account for a sizable portion of building cooling requirements.

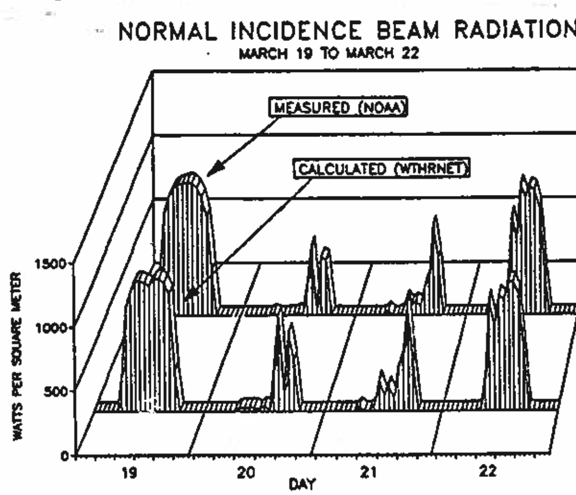
However, solar heat can have a positive impact where thermal energy is needed, such as solar water heating or passive heating of buildings in the winter. Solar energy can also be converted to electrical energy through photovoltaic arrays. Probably the most common image of solar energy use is the flat plate collectors which punctuate the roof lines of many Colorado homes. When using this kind of conversion equipment, the orientation of the collector plane plays an important role. Figure 1 shows the daily total insolation in Alamosa from September 1987 to March 1988 on two different planes: the horizontal and a south-facing plane tilted 40 degrees up from the horizontal. Since Colorado is centered on the 39th parallel, this second configuration puts the collector plane parallel to the polar axis of the earth. The advantage of this commonly used "tilt equals latitude" orientation is evident from the graphs: the tilted plane receives significantly more radiation than the horizontal, and at a much more uniform intensity over the year. These graphs cover the period from the atumnal to vernal equinoxes. The solar intensity will follow a sinusoidal periodicity, with the longest and shortest days of the year falling on the summer and winter solstices. The winter solstice is seen in the middle of this graph on December 21. The words solstice and equinox come from the Latin solstitium ("the standing of the sun") and aequinoctium ("equal night"). The sun "stands still" at the solstices because it has reached its lowest or highest point in the sky, and will now start to move back the other way. The "equal night" refers to the fact that the day and night are exactly the same length - 12 hours. At the equinoxes the length of daytime hours changes faster than at any other time of the year. Combined with Daylight Savings Time, it suddenly seems as if the days have gotten very long indeed!

Fig. 1



Beam, Diffuse and Reflected Radiation

Solar radiation has essentially three components: beam radiation comes directly from the solar disk, diffuse radiation comes from the rest of the sky, and reflected radiation from sunlight bouncing off the ground. Colorado, with a mean altitude of 6800 feet and many clear days, receives more than its fair share of solar radiation. On a clear day with snow on the ground the radiation intercepted by a tilted collector can be greater than that of one similarly oriented outside the atmosphere! (The effects of the reflected radiation are most notable after skiing on a clear day without using any suntan lotion). The magnitude of the beam and diffuse components are of great importance when designing photovoltaic systems, particularly ones which "track" the sun across the sky. The traditional method for measuring beam radiation has been to use a pyrheliometer, which follows the sun's daily motion and has a narrow acceptance angle. The WTHRNET system, however, uses a series of fixed pyranometers to decompose the radiation incident on four planes into the various solar radiation components. This arrangement is convenient in that it is much less expensive and does not require constant maintenance to assure proper tracking. Beam values calculated using data from an experimental station on the roof of the CU Engineering Center closely match those measured with a NOAA pyrheliometer one half mile away.

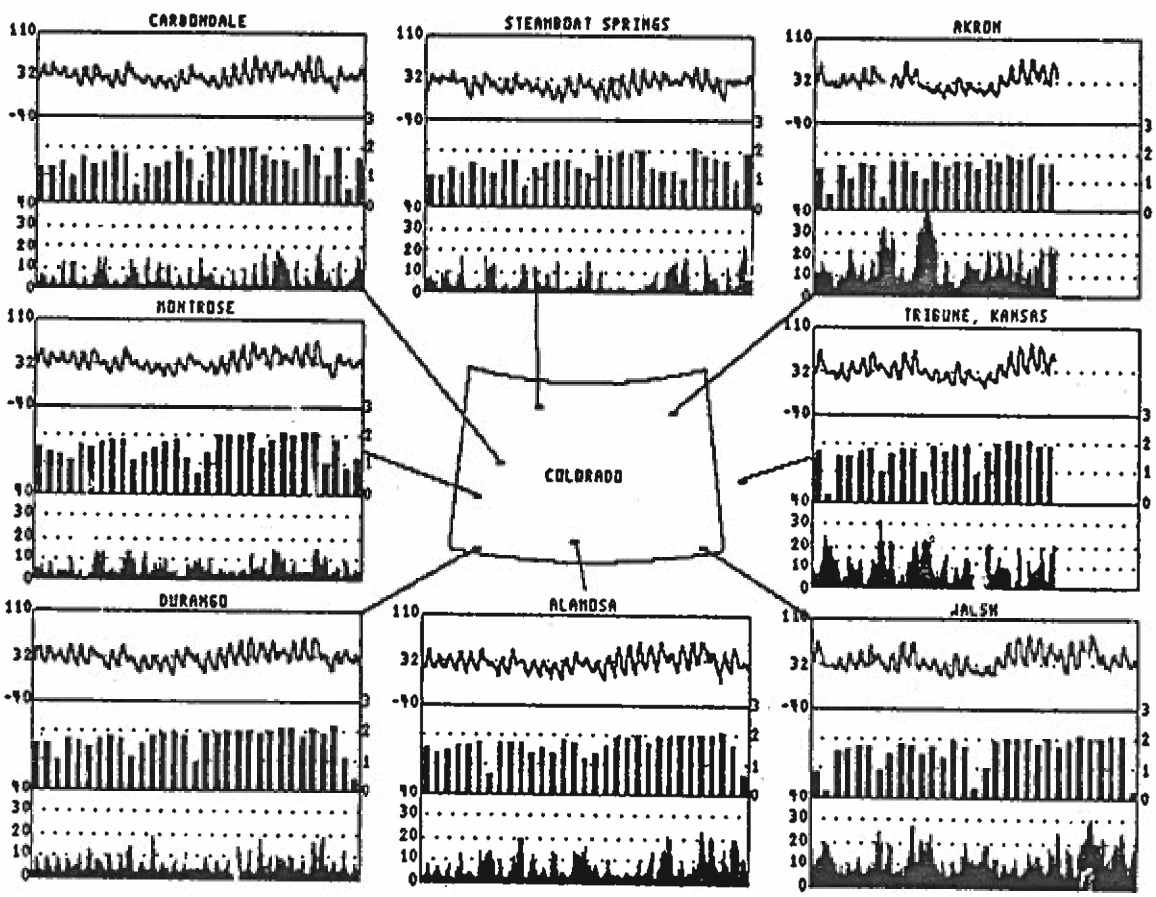


WTHRNET WEATHER DATA - MARCH 1988

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
monthly average temperature (°F)						
	31.6	32.8	32.8	36.9	23.3	41.2
monthly temperature extremes (°F day/hr)						
maximum:	66.7 27/14	66.1 27/16	67.8 21/14	71.3 27/15	53.8 26/16	83.1 27/15
minimum:	0.4 29/ 6	4.9 14/ 7	4.1 14/ 6	10.5 14/ 6	-7.8 18/ 5	12.5 14/ 5
monthly average relative humidity / dewpoint (percent / °F)						
5 AM:	73 / 13	63 / 15	80 / 18	69 / 21	87 / 10	62 / 22
11 AM:	36 / 32	35 / 33	43 / 30	39 / 35	60 / 23	37 / 43
2 PM:	25 / 39	29 / 39	34 / 39	31 / 42	55 / 27	32 / 49
5 PM:	25 / 40	28 / 39	31 / 38	29 / 42	59 / 25	32 / 48
11 PM:	50 / 21	51 / 21	63 / 23	55 / 26	80 / 15	52 / 28
monthly average wind direction (degrees clockwise from north)						
day:	213	202	255	238	205	201
night:	184	94	196	188	147	232
monthly average wind speed (miles per hour)						
	5.93	4.30	4.27	4.40	3.98	10.56
wind speed distribution (hours per month in mph bins)						
0 to 3:	243	360	400	287	452	18
3 to 12:	400	357	305	432	243	476
12 to 24:	101	27	39	25	49	232
> 24:	0	0	0	0	0	19
monthly average daily total insolation (Btu/ft²·day)						
	1654	1707	1499	1583	1478	1589
"clearness" distribution (hours per month in clearness index bins)						
60-80%	240	118	160	163	144	219
40-60%	65	51	69	56	84	55
20-40%	41	51	61	58	70	34
0-20%	14	35	32	22	23	46

The State-Wide Picture

Figure 3 below shows the monthly weather for the eight WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40 degrees to 110 degrees Fahrenheit, the middle one gives the daily total solar radiation on a horizontal plane, up to 4000 Btu per square foot per day, and the bottom graph illustrates the hourly average wind speed from 0 to 40 miles per hour. Starting with this month the JCEM weather page will present data from Akron and Tribune, Kansas. Weather information from these two sites is presented temporarily while JCEM stations in Stratton and Sterling are being modified and repaired. The Akron and Tribune station data are stored on tape and collected once a month - the last visit to these sites occured on March 23, hence there is no data shown after that date.



COLORADO CLIMATE

APRIL 1988

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 7

<u>April in Review:</u>

An Eastern Plains blizzard at the beginning of April and a damp, unsettled period during the latter portion of the month were the only significant precipitation episodes. Most of central Colorado ended up drier than average for the month with wetter areas limited to the western, eastern and southernmost counties. Temperatures were a little below average in parts of eastern Colorado, but the remainder of the state was a few degrees warmer than average.

<u>Colorado's June Climate:</u>

By the time June rolls around each year, consistently hot summer weather is usually well established in southern and southwestern Colorado. Things are a little more tentative across northern parts of the state where occasional cool wet weather and mountain snows are still possible early in the month. Cold fronts and organized storm systems becomes very infrequent by late June. Summer heat with low humidity and scattered afternoon and evening thunderstorms then becomes the rule.

June is a favorite month for some of our more adventurous people. High streamflow from melting mountains snowpack keeps rafters and kayakers happy. It's also a great month for storm lovers and chasers.

June is Colorado's prime month for severe weather. The last remnants of springtime cold fronts and jet stream disturbances combine with moist air east of the mountains and atmospheric instability (see April 1986 issue of <u>Colorado Climate</u> for more explanations) to trigger intense thunderstorms. Many of these stronger storms produce hail and some even produce tornadoes (see special story in this issue). Severe flooding has also occurred in Colorado during the first 3 weeks of June such as the infamous 1921 and 1965 floods.

June precipitation patterns show an interesting and fairly reliable pattern. The northeastern corner of the state averages more than 3" in June, but rainfall drops off both to the west and south. The Front Range averages about 1.50"-2.00", most of the mountains 1"-2" and less than 1.00" over most of the Western Slope. In extreme southwest Colorado from Grand Junction to Cortez, only about 0.50" of rain can be expected.

June temperatures tend to climb steadily through the month. Daily highs average in the 70s early in the month at lower elevations, but 80s and 90s are typical later in the month. Nighttime lows in the 40s and 50s are normal. June temperatures general cool with elevation. Above 10,000 feet, daytime highs are only in the 50s with lows still around the freezing point.

<u>It's Twister Time Again:</u>

Since Colorado tornadoes are most likely in June, it's a dandy time to bring up the subject. Colorado, historically, does not have a reputation for being a tornado-prone state. Since 1916 there have been 26 tornado-related deaths reported. No deaths have been noted since 2 people lost their lives in Sedgwick County in June 1960. As of 1980, Colorado ranked 32nd out of 50 states in terms of tornado deaths, 31st out of 50 in terms of tornadoes per square mile and 19th out of 50 in terms of total number of tornadoes per year.

Beginning in about 1976 an interesting change has occurred. While no deaths have been attributable to tornadoes, Colorado has become a rising star among states in terms of reported tornado frequencies. During the last dozen years, we have begun moving up in the ranks, and in the decade of the 80s we have been as high as 6th and 7th in the nation on a number of occasions. Only the likes of Texas, Oklahoma, Florida and Kansas reliably beat us out in the national rankings. 1982 was Colorado's big year for tornadoes with a whopping total of 58 -- more than 3 times the 1951-1980 average. Forty-one tornadoes were reported in 1987.

(continued)

APRIL 1988 DAILY WEATHER

Date	Event
1-2	The Front Range snowstorm of March 30-31 dropped southward but then moved northward again with strong winds and wet, slushy snows across portions of the Eastern Plains. Southeast Colorado was hardest hit. Many areas east of a line from Sterling to Pueblo got more than a foot of blizzard snow. Water contents were also high. Springfield reported 1.61" of precipitation (16" snow), Bonny Reservoir had 1.78" (10" snow) and Holyoke 1.82" (10" snow). Areas near LaJunta appeared hardest hit. Two observers measured more than 20" of snowfall with a water content of more than 2.30". Amazingly, while the storm still raged in northeast Colorado on the 2nd, temperatures along the Front Range climbed to near 60°. In the mountains and west, skies were clear and temperatures chilly. Most of the state recorded their coldest temperatures of the month on the 1st and 2nd. Teens and twenties were common at night on the eastern plains with many subzero readings in the mountains. Antero Reservoir's -12°F observation on the 1st was the coldest in the state.
3-7	Dramatically warmer with rapid snowmelt 3-4th. Low elevation temperatures soared into the 60s and 70s except where heavy snow remained. Windy and briefly cooler late 4th-5th with some mountain snows. Then warming again 6-7th. Highs reached 80° on the 7th at Grand Junction and at several places east of the mountains. Holly's 89° reading was the warmest in the state. Recent heavy snows were quickly forgotten.
8-10	Very windy and dramatically colder again on the 8th as a strong Pacific cold front raced across the Rockies. Visibilities across Colorado were greatly reduced on the 8th by dust in the air, apparently blown in from the Great Basin. Some muddy snowshowers developed late on the 8th, mostly along and east of the Front Range. More snow developed on the 9th as cold, unstable air covered the state. Most areas along the Front Range received 1-3" of snow but as much as 14" were reported in the higher foothills. Highs on the 9th were only in the teens and twenties in the high mountains. More sunshine and a gradual warming trend began on the 10th, especially in the western and southern portions of Colorado.
11-13	Sunny, dry and pleasant across the state with mild days and frosty nights.
14-23	Two Pacific storm systems in series affected Colorado. Moist southwesterly winds aloft 14-16th spread clouds over much of the state, but precipitation was primarily limited to southwest Colorado. Palisade received 0.55" late on the 14th and Durango was drenched with 1.18" on the 16th. The first storm then slipped south of Colorado on the 17th while cool air pushed down from the north. Some thunderstorms developed in eastern Colorado. Evergreen picked up 0.82" of moisture on the 17th and as much as an inch fell on parts of the southeast plains. A bit drier, but still unsettled 18-19th. A thunderstorm spawned the first reported tornado of the year on the 19th near Fort Lupton. The second Pacific storm system then took control 20-23rd with good moisture flow into southwest Colorado. Wolf Creek Pass received 1.75" of moisture during this episode with lesser amounts elsewhere across western Colorado. Quite cold statewide. Significant precipitation, including thunderstorms and heavy foothills snow late 21st-22nd in northeast Colorado. Sterling received 0.97" of precipitation including several inches of wet snow. Little or no moisture from this storm reached southeast Colorado.
24-26	Continued chilly and unsettled with some scattered light showers and mountain snows. Cold blustery winds and significant snows in the north and central mountains on the 25th as a strong upper level disturbance moved across from the northwest. Steamboat Springs received more than 0.50" of moisture in the form of wet snow.
27-30	A return to warmer temperatures. Quite cold early on the 27th, then steadily warmer through the period some clouds and light showers moved across southern Colorado on the 29th. Very warm and windy on the 30th as a deep low pressure area and frontal systems approached from the west. Highs of 80° or above across most low elevation areas.

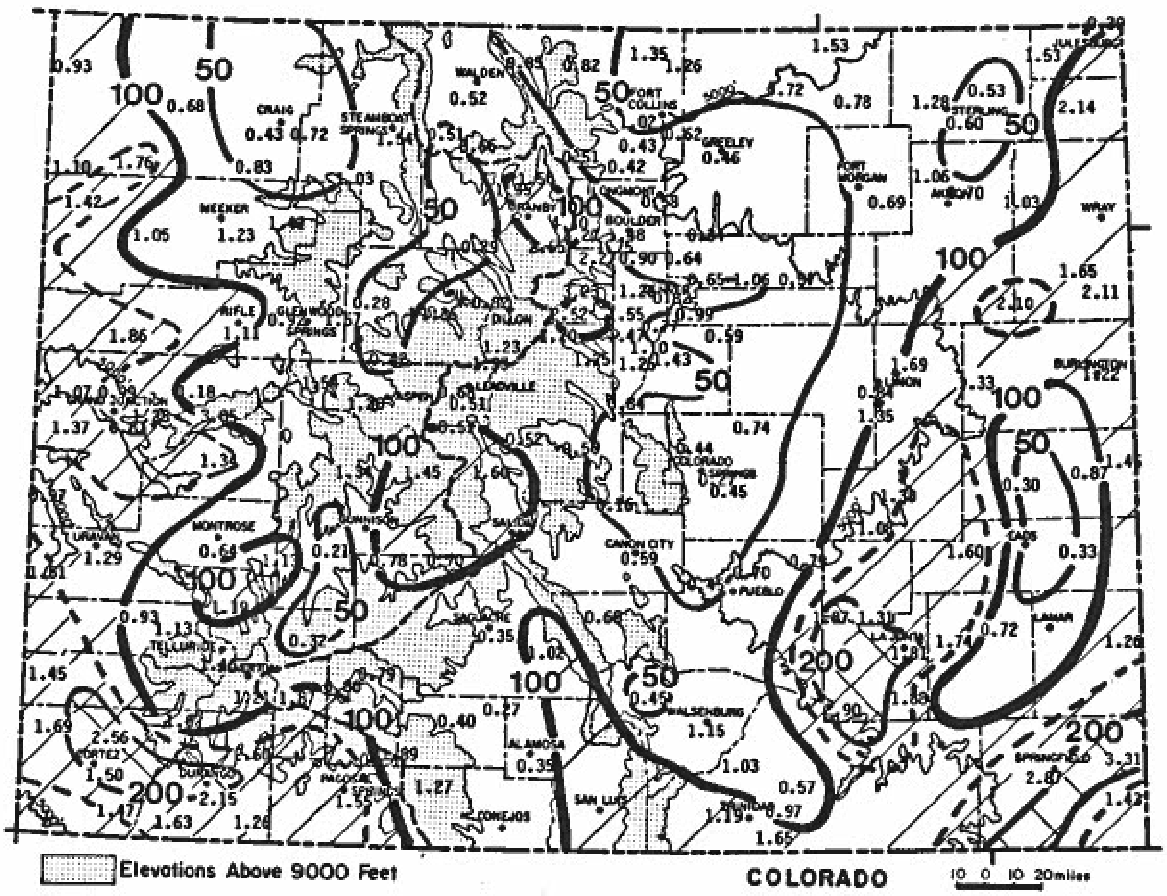
April 1988 Extremes

Highest Temperature	89°F	April 17	Holly
Lowest Temperature	-12°F	April 1	Antero Reservoir
Greatest Total Precipitation	4.40"		Silver Lake
Least Total Precipitation	0.16"		Guffey 10SE
Greatest Total Snowfall*	48"		Mount Evans Research Center

APRIL 1988 PRECIPITATION

April's precipitation pattern was a direct reflection of the two major precipitation episodes that occurred. Precipitation was above average in southeastern and extreme eastern counties -- those areas hard hit by the April 1-2 storm. More than 3 times the April average was recorded at Walsh and near Timpas southwest of LaJunta. Other wetter than average areas included much of the Western Slope including Rangely (151% of average), Grand Junction (133%), Uravan (122%), Cortez (202%) and Durango (204%). These areas were dampened by frequent showers during the April 14-25th period. Almost all of the areas in between were dry, including most of the mountains, interior valleys, Front Range and northeast plains. Examples of dry areas include Aspen (52% of average), Craig (25%), Green Mountain Reservoir (24%), Greeley (23%) and Colorado Springs (21%).

Greatest		Least	
Silver Lake	4.40"	Guffey 10SE	0.16"
Walsh 1W	3.31"	Blue Mesa Reservoir	0.21"
Mount Evans Research Center	3.23"	Colorado Springs	0.27"
Bonham Reservoir	3.05"	Center 4SSW	0.27"
Campo 7S	2.90"	Eagle FAA	0.28"
		Williams Fork Dam	0.29"



Precipitation amounts (inches) for April 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

1988 WATER YEAR PRECIPITION

A chaotic pattern of moisture anomalies has developed after 7 months of the 1988 water year. The eastern plains have a smattering of both wet, dry and near average conditions. The pattern is a bit more consistent over the west. The central and southern mountains are primarily drier than average while the lower valleys are near normal to somewhat above average. In the north the reverse is true with near or above average precipitation in the mountains but dry in the northwest valleys.

Comparison to Last Year

At the end of April 1987 very dry conditions existed over parts of northern Colorado including the northern and some of the central mountains. Water year precipitation over the southern mountains and southeast plains was much above average.

1988 Water Year to Date through April

Wettest (as % of average)

Akron 1N	213%	8.55"
New Raymer 21N	181%	6.05"
Brush	180%	6.74"

Driest (as % of average)

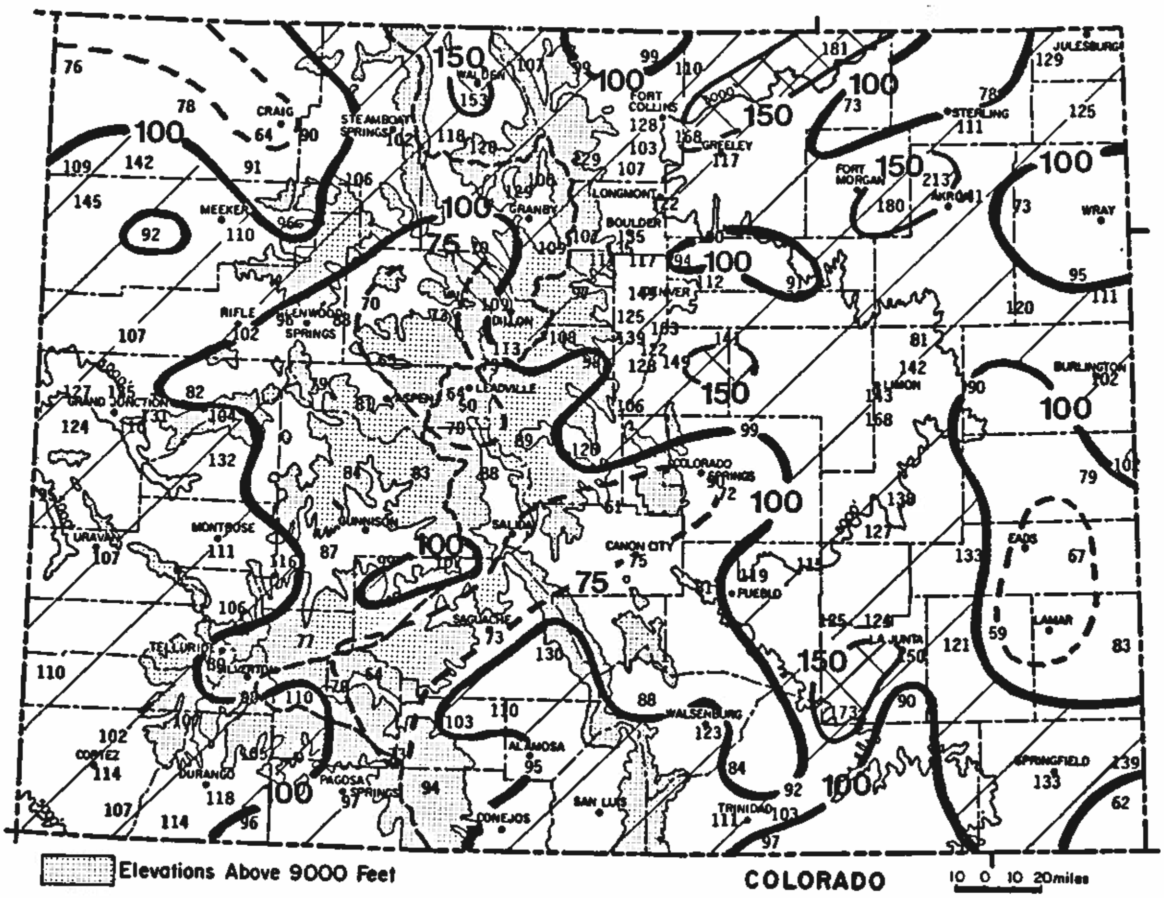
Leadville	50%	4.00"
Creede 2S	54%	3.92"
John Martin Dam	59%	1.91"

Wettest (total precipitation)

Bonham Reservoir	22.84"	104%
Wolf Creek Pass 1E	20.90"	73%
Mount Evans Research Center	18.32"	97%

Driest (total precipitation)

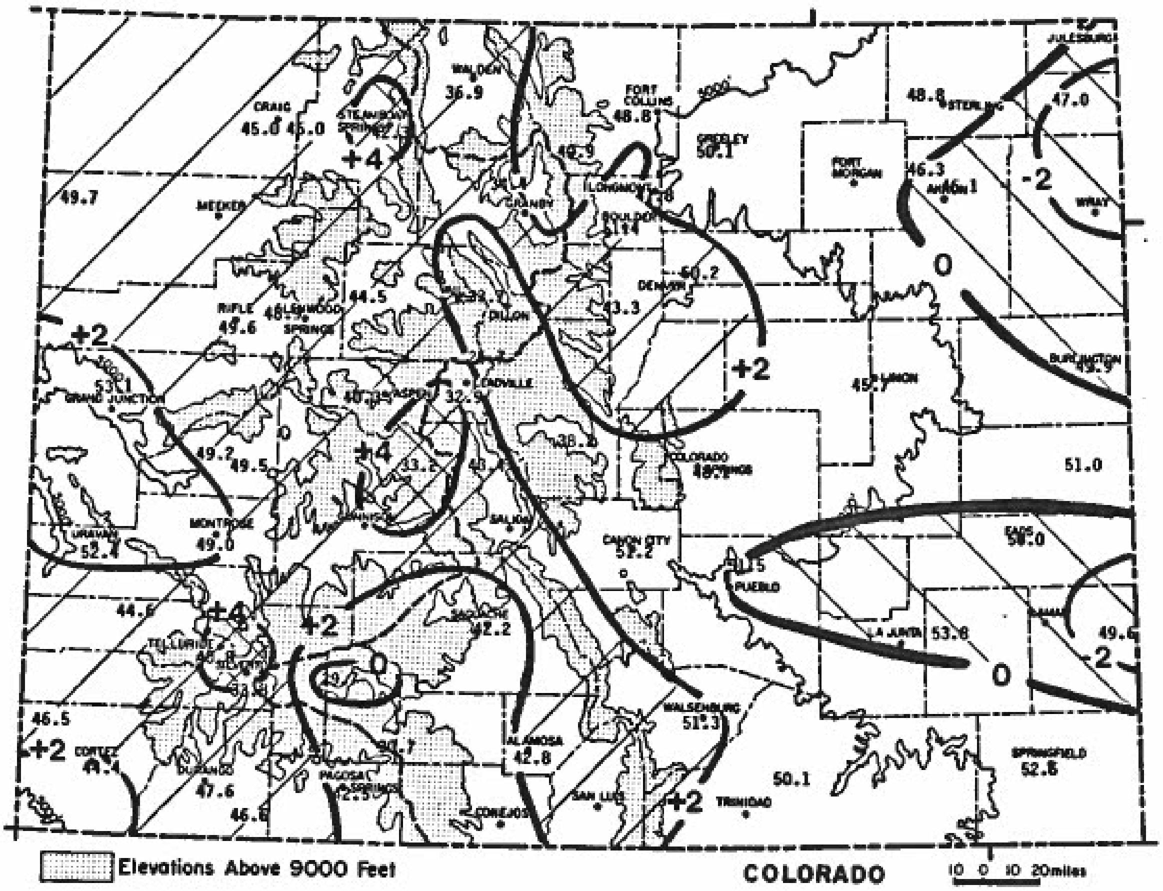
Brandon	1.83"	67%
John Martin Dam	1.91"	59%
Saguache	2.29"	73%



Precipitation for October 1987 through April 1988 as a percent of the 1961-1980 average.

APRIL 1988 TEMPERATURES AND DEGREE DAYS

April temperatures had their normal ups and downs. Over most of the state the "ups" dominated. From the Front Range westward to the Utah border, most areas ended up 1 to 4 degrees Fahrenheit above the 1961-80 average. Local mountain valleys including Steamboat Springs, Telluride and Taylor Park Reservoir were more than 4 degrees above average. Temperatures were closer to average on the eastern plains with a few areas near the Kansas and Nebraska borders below average.



April 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

APRIL 1988 SOIL TEMPERATURES

April soil temperatures climbed erratically and ended up close to average for this time of year. The normal flip-flop has now occurred with near-surface soil temperatures now warmer than at deeper levels.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

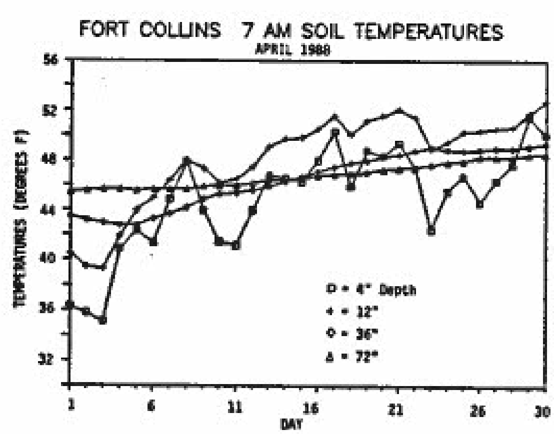


Table 1. Colorado Heating Degree Day Data through April 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130	1556	1867	1381	1031	658			8750
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024	1382	1450	1146	1136	734			8054
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713	1053	1107	842	739	400			5386
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955	1277	1357	1010	1030	639			7296
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724	1037	1221	935	779	449			5617
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668	1007	1144	858	767	407			5359
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767	1108	1256	958	886	499			6160
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860	1179	1351	1008	899	609			6497
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950	1376	1561	1264	1076	593			7732
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737	1102	1300	M	M	M			3612
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745	1125	1227	889	811	437			5786
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145	1491	1629	1376	1379	933			9914
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851	1206	1391	972	859	514			6474
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37	39	314	658	930	1283	1309	925	927	566	384	111	7483
	87-88	54	75	254	509	950	1331	1544	1173	1002	607			7499
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922	1255	1310	1029	992	645			7275
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784	1140	1252	936	821	479			6060
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773	1154	1484	1055	826	M			5873
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754	1147	1469	1031	741	350			5780

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098	1516	1642	1413	1372	907			9569
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762	1157	1363	955	807	437			6060
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M	M	M	M	M	M			0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653	1032	1278	837	638	327			5076
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180	1534	1577	1326	1355	957			10009
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840	1209	1354	1022	943	569			6684
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87	0	0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805	1169	1383	1035	847	509			6416
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	94	7402
	87-88	M	M	M	M	M	M	M	M	M	M			0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849	1160	1332	1003	817	468			6142
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947	1292	1548	1187	996	663			7712
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754	1111	1399	903	777	399			5762
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819	1209	1430	1039	865	454			6365
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033	1448	1619	1336	1167	674			
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742	M	1475	1029	831	476			5117
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992	1269	1354	1109	1092	720			7948
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730	1054	1209	850	803	438			5523
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242	1499	1572	1343	1340	835			9562
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707	977	1109	826	773	401			5259

M = MISSING DATA

APRIL 1988 CLIMATIC DATA

Eastern Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
STERLING	65.0	32.6	48.8	1.0	85	21	476	0	255	1.28	0.00	100.0	6
AKRON FAA AP	62.6	30.0	46.3	-0.4	79	18	554	0	214	1.06	-0.26	80.3	6
AKRON 4E	60.4	31.9	46.1	-0.0	80	20	556	0	197	0.70	-0.57	55.1	6
HOLYOKE	61.2	32.8	47.0	-2.4	85	23	533	0	208	2.14	0.62	140.8	6
BURLINGTON	63.3	36.4	49.9	-0.4	82	26	449	0	227	1.22	0.02	101.7	5
LIMON WSMO	61.9	29.5	45.7	0.6	79	17	569	0	206	0.84	-0.21	80.0	7
CHEYENNE WELLS	66.8	35.2	51.0	1.1	85	25	413	0	272	0.87	-0.01	98.9	5
EADS	66.2	33.9	50.0	-1.8	85	27	441	0	274	0.00	-0.98	0.0	0
LAS ANIMAS	71.5	36.0	53.8	-0.0	88	25	327	0	337	1.74	0.74	174.0	4
HOLLY	69.1	30.0	49.6	-2.9	89	15	457	0	307	1.26	0.29	129.9	3
SPRINGFIELD 7WSW	69.8	35.4	52.6	1.0	86	24	364	0	318	2.87	1.41	196.6	7

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	64.3	33.2	48.8	1.8	81	15	479	0	236	1.02	-0.77	57.0	8
GREELEY UNC	66.7	33.6	50.1	1.4	84	16	437	0	269	0.46	-1.48	23.7	5
ESTES PARK	55.8	26.0	40.9	1.2	68	-2	717	0	113	0.51	-0.79	39.2	5
LONGMONT 2ESE	65.3	30.2	47.8	0.5	80	8	509	0	250	0.58	-1.34	30.2	3
BOULDER	66.3	36.6	51.4	2.7	84	15	400	0	263	1.48	-0.68	68.5	8
DENVER WSFO AP	65.0	35.5	50.2	2.5	81	17	437	1	247	0.65	-1.17	35.7	6
EVERGREEN	60.4	26.1	43.3	2.9	78	7	645	0	170	1.55	-0.72	68.3	5
LAKE GEORGE 8SW	51.9	24.4	38.2	1.7	66	8	798	0	78	0.50	-0.42	54.3	5
COLORADO SPRINGS	63.5	32.8	48.1	1.8	80	18	499	0	225	0.27	-1.01	21.1	4
CANON CITY 2SE	66.1	36.4	51.2	1.4	82	23	407	0	265	0.59	-0.53	52.7	3
PUEBLO WSO AP	69.4	33.6	51.5	-0.1	87	23	399	0	307	0.70	-0.24	74.5	3
WALSENBURG	67.9	34.7	51.3	2.9	83	21	401	0	288	1.15	-0.48	70.6	7
TRINIDAD FAA AP	66.7	33.5	50.1	0.4	83	19	438	0	269	0.57	-0.44	56.4	6

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	52.3	21.6	36.9	2.5	68	1	835	0	86	0.52	-0.27	65.8	4
LEADVILLE 2SW	47.2	18.5	32.9	3.9	63	-5	957	0	30	0.51	-0.89	36.4	11
BUENA VISTA	58.2	28.6	43.4	2.3	72	14	639	0	145	1.60	0.90	228.6	5
SAGUACHE	58.7	25.7	42.2	1.0	70	15	678	0	148	0.35	-0.16	68.6	5
HERMIT 7ESE	44.1	15.4	29.7	-0.8	50	2	1050	0	0	0.80	-0.36	69.0	2
ALAMOSA WSO AP	61.5	24.1	42.8	2.1	73	10	658	0	185	0.35	-0.07	83.3	4
STEAMBOAT SPRINGS	58.2	26.3	42.3	4.3	74	10	674	0	146	1.54	-0.61	71.6	7
GRAND LAKE 6SSW	48.6	20.3	34.4	1.1	64	-3	907	0	45	1.35	0.25	122.7	14
DILLON 1E	49.0	18.3	33.7	0.9	62	1	933	0	51	0.82	-0.30	73.2	11
CLIMAX	40.1	11.3	25.7	-0.0	53	-6	1173	0	2	1.33	-1.07	55.4	10
ASPEN 1SW	54.6	26.0	40.3	2.3	70	10	734	0	99	1.20	-1.10	52.2	6
TAYLOR PARK	47.3	19.2	33.2	9.9	62	5	947	0	32	1.45	0.36	133.0	8
TELLURIDE	56.9	24.7	40.8	4.2	68	7	720	0	120	1.46	-0.44	76.8	9
PAGOSA SPRINGS	60.2	24.8	42.5	1.9	74	14	663	0	175	1.55	0.52	150.5	8
SILVERTON	51.8	15.9	33.8	4.0	65	-5	927	0	70	1.21	-0.23	84.0	10
WOLF CREEK PASS 1	45.7	15.7	30.7	1.7	56	5	1021	0	18	1.89	-1.06	64.1	7

Western Valleys

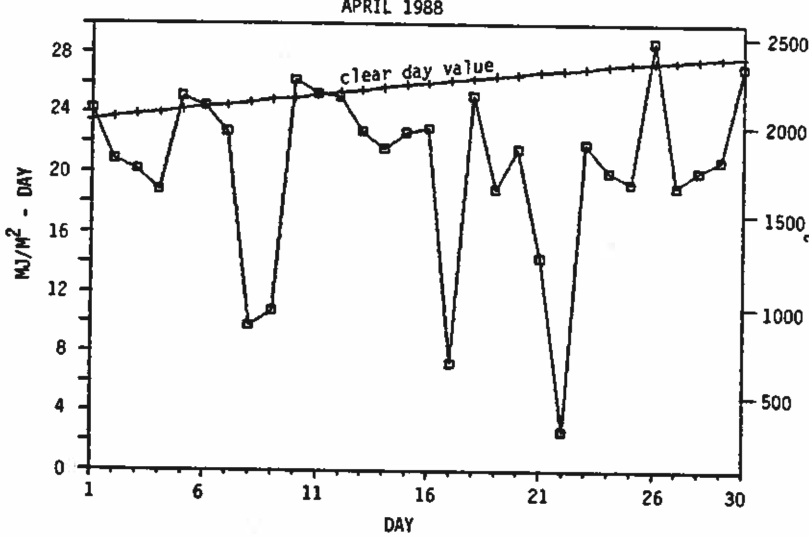
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	60.2	29.8	45.0	3.0	76	15	593	0	171	0.43	-1.37	23.9	6
HAYDEN	60.9	29.2	45.0	3.5	75	13	592	0	179	0.72	-0.77	48.3	5
RANGELY 1E	65.8	33.6	49.7	2.9	77	19	451	0	245	1.42	0.48	151.1	8
EAGLE FAA AP	60.8	28.2	44.5	2.8	73	10	607	0	179	0.28	-0.39	41.8	5
GLENWOOD SPRINGS	64.5	33.3	48.9	3.6	80	20	474	0	224	0.92	-0.56	62.2	11
RIFLE	66.7	32.4	49.6	3.3	80	17	454	0	261	1.11	0.35	146.1	7
GRAND JUNCTION WS	66.8	39.3	53.1	1.7	80	25	350	0	259	0.99	0.25	133.8	8
CEDAREDGE	65.1	33.4	49.2	2.3	79	17	466	0	233	1.34	0.53	165.4	6
PAONIA 1SW	65.0	34.1	49.5	2.4	80	17	456	0	233	1.04	-0.30	77.6	10
MONTROSE NO. 2	63.5	34.6	49.0	1.8	77	21	468	0	213	0.64	-0.10	86.5	8
URAVAN	69.4	35.4	52.4	0.9	84	21	370	0	296	1.29	0.24	122.9	9
NORWOOD	62.7	26.5	44.6	3.1	72	13	242	0	78	0.93	-0.03	96.9	6
YELLOW JACKET 2W	60.5	32.5	46.5	3.2	71	19	547	0	171	1.69	0.84	198.8	10
CORTEZ	61.7	27.2	44.4	-0.4	76	17	609	0	191	1.50	0.76	202.7	10
DURANGO	64.5	30.8	47.6	2.9	76	20	514	0	228	2.15	1.10	204.8	12
IGNACIO 1N	65.5	27.7	46.6	3.1	78	16	547	0	239	1.26	0.47	159.5	9

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

APRIL 1988 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	5	10	15	--	--
Denver	7	11	12	75%	67%
Fort Collins	7	16	7	--	--
Grand Junction	9	8	13	70%	67%
Pueblo	7	11	12	86%	74%

FT. COLLINS TOTAL HEMISPHERIC RADIATION
APRIL 1988



It's Twister Time Again: continued

Are tornadoes really becoming more commonplace? We can't say for sure -- but probably not. If we look at tornado occurrences by county, some interesting patterns appear. Tornado frequencies in several counties including Bent, Kit Carson, Las Animas, Otero, Phillips, Prowers, Sedgwick and Washington have remained about the same since 1950. At the same time, counties like Adams, Arapahoe, Douglas, El Paso and Morgan have seen large increases. For example, no tornadoes were reported in Arapahoe county for the years 1950-1963, while 14 tornadoes occurred from 1982-85. In truth, tornado reports seem to follow population trends and transportation corridors quite nicely. Areas along the Front Range experiencing explosive population growth in the past 15 years also show huge increases in tornadoes, while areas on the Eastern Plains where population has been steady or declining have shown no such tornado increases. It is very likely that Colorado's rapid increase in tornadoes is simply related to greater population in combination with improved communication systems, severe weather spotting networks and media attention. (With the help of enthusiastic remote TV camera crews, most of us have been able to "enjoy" incredible video coverage of Colorado tornadoes in the comfort of our own living room.) Colorado has likely always had its share of tornadoes. In the past most of them went unreported.

Even though tornadoes here in Colorado may not really be increasing in number, and even though our tornadoes aren't as life threatening as the Kansas-Oklahoma-Texas style storm, it is still important to be aware of these monsters. Here is some climatological information on Colorado tornadoes that may be useful.

1) Colorado has averaged 33 reported tornadoes per year during the past 10 years. Frequency, severity and location of tornadoes vary greatly from year to year, but some tornadoes occur in our state every year.

2) Colorado tornadoes tend to be small, short-lived and relatively weak. Statistics indicate that Colorado tornadoes last only a few minutes, are generally only about 100 yards in diameter at the surface and have an average path length of about 1½ miles. Wind speeds appear to average 100 mph or less from Colorado tornadoes, but measurements are not readily available and exceptions certainly exist.

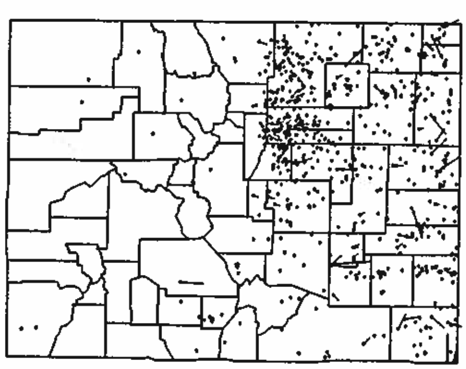
3) 95% or more of Colorado tornadoes occur east of the mountains and are most often east of I-25. Mountain tornadoes are possible, however, as we were clearly reminded last year on June 18 when a twister came within a whisker of causing casualties and great damage at Colorado State University's Pingree Park mountain campus.

4) Colorado tornadoes usually occur during daylight. 68% occur between the hours of 2 pm and 7 pm MST.

5) Be aware that Colorado tornadoes may not have the classic Wizard-of-Oz look of the "Tornado Alley" twisters. Due to our dry atmosphere, a visible tornado cloud extending from cloud base down to ground level often does not appear. A small funnel barely visible at cloud base and a swirling cloud of dust and debris near ground level may be the only visual sign of a tornado in progress.

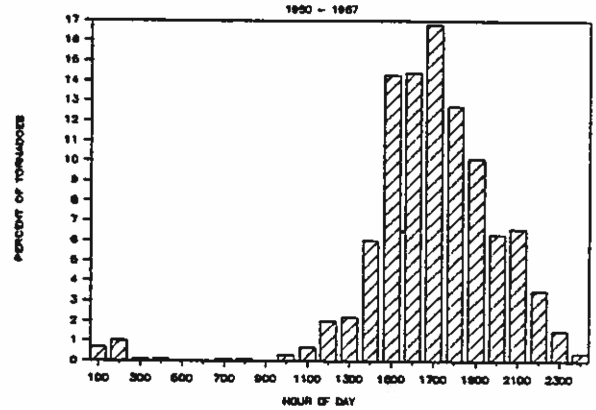
Finally, just because our tornadoes may be small, weak and hard to see compared to Oklahoma's doesn't mean we can take them lightly. Our tornadoes can still do incredible damage. As Front Range urban areas grow, our potential for damage and loss of life increases. And don't be too surprised if the new Denver airport sees its share of twisters. Adams County is second only to Weld in terms of total reported tornadoes since 1950.

LOCATIONS AND PATHS OF COLORADO TORNADOES, 1950-87



DIURNAL TIMING OF COLORADO TORNADOES

1950 - 1987



What are Degree-Days, Anyway?

Degree-days are convenient temperature summaries which describe the difference between the average outside temperature and some base temperature. The most commonly used base temperature is 65°F. The degree-days for one day are found by either (1) multiplying the difference of the daily average temperature and the base temperature by 24 hours or (2) by summing the differences of the hourly average temperatures and the base temperature. Monthly degree-day values are found from the sum of the daily values.

There are two kinds of degree days: heating degree-days (HDD), of concern in the winter when we put energy into our homes, and cooling degree-days (CDD), when we cool our houses by removing heat. The heating season for a particular area is generally defined as the time during which we experience 90% of the heating degree days.

A typical residence has a base load used for water heating and appliances. When the outdoor temperature goes below a certain threshold heating is required, while temperatures above a specific level indicate the need for cooling. Both of these instances will add extra space conditioning energy to the base load. A house which is well insulated will tend to have a lower base temperature than a drafty or non-insulated home; the outside temperature will have to drop lower before the well insulated house begins to "feel" the effects of the cold. Using 65°F as a base temperature, therefore, is not as meaningful as using separate 'balance' temperatures for the HDD and CDD that are residence-specific.

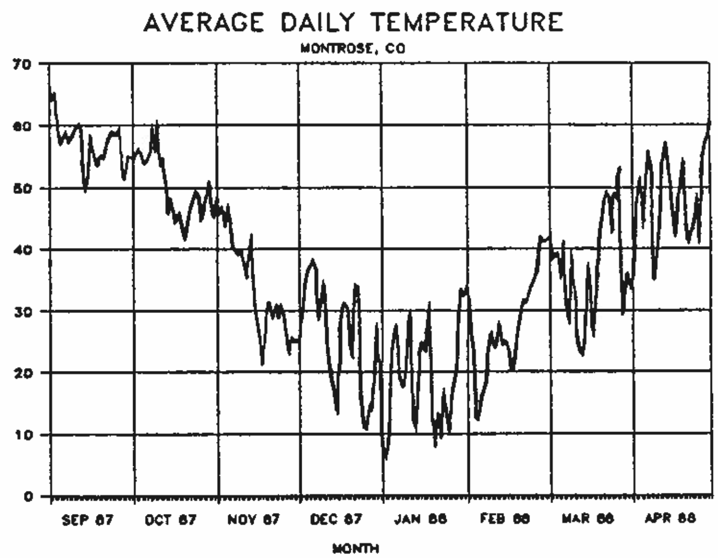
Typically, the heat loss from a building is measured in terms of the "UA value." This is the rate of heat loss from through the building shell per degree difference between the inside and outdoor temperature, and is typically measured in units of Btu/hour·°F or watts/°C. If it were 40° outside and 70° inside, a house with a UA value of 400 Btu/hr·°F would therefore lose

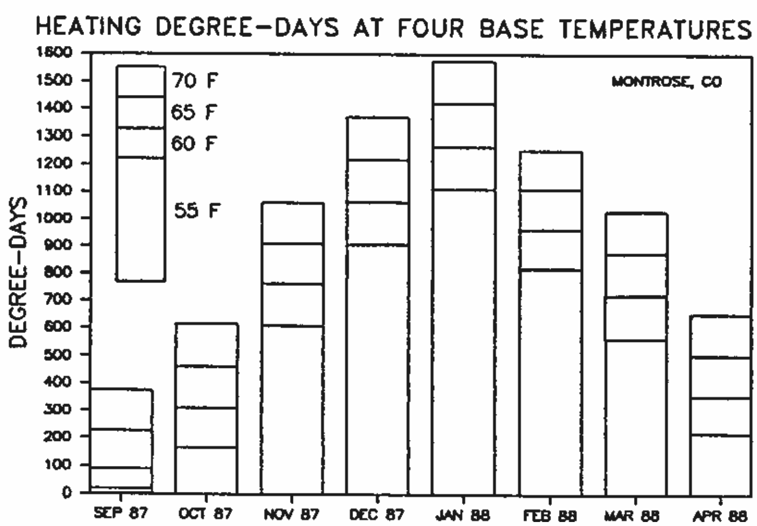
$$400 \text{ Btu/hr}\cdot{}^\circ\text{F} \times (70^\circ\text{F} - 40^\circ\text{F}) = 12{,}000 \text{ Btu per hour.}$$

This is about 3500 watts - the equivalent of running 3 hair dryers continuously. Knowing the degree-days for a specific month can help an architect design the fenestration placement and insulation thicknesses of a building so that it both energy efficient and economical.

An Example of Heating Degree-Day Measurements

The graph on the right shows the daily average temperature for Montrose from September 1987 to April 1988. The degree days for this time will only consider average temperatures which are below the base temperature. That is, if the outdoor temperature is above the base temperature then there are zero degree-days, not a negative number.





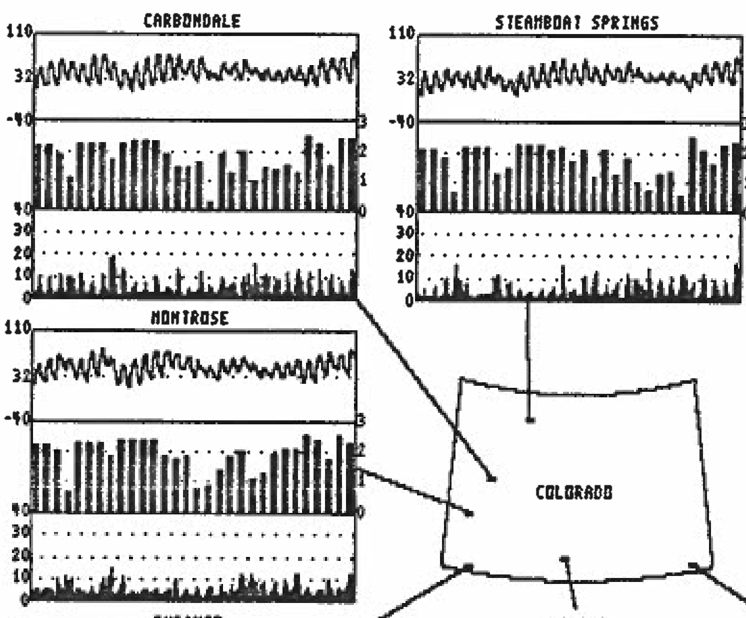
The graph on the left gives the heating degree-days for four different base temperatures over the same time period. Notice that October through April have regular increments of degree-days for temperatures greater than 55°F. This is because it was always colder than the base temperature. Compare these with September, when there were many days when the temperature rose above 55°F.

WTHRNET WEATHER DATA - APRIL 1988

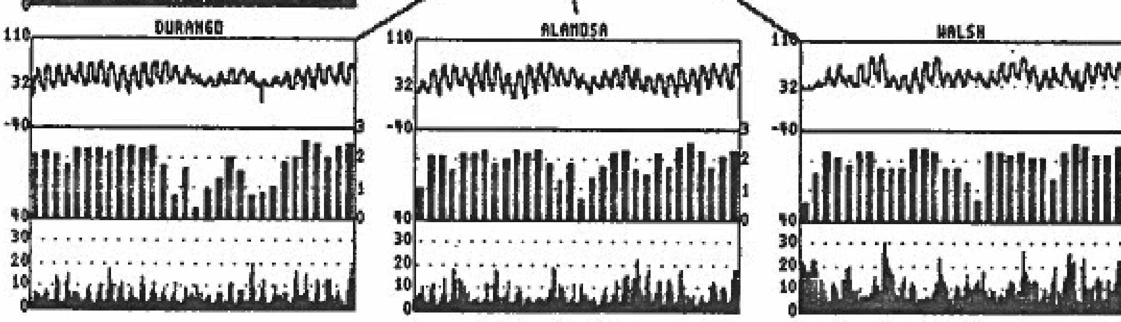
	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
monthly average temperature (°F)						
	43.2	43.6	44.6	48.2	38.3	32.9
monthly temperature extremes and time of occurance (°F day/hour)						
maximum:	72.7 7/16	69.3 7/16	75.0 30/15	76.9 30/14	70.8 30/15	86.1 8/13
minimum:	11.1 10/ 6	3.2 22/ 7	12.0 10/ 6	15.9 10/ 6	5.8 10/ 6	25.8 11/ 2
monthly average relative humidity / dewpoint (percent / °F)						
5 AM	74 / 20	65 / 25	88 / 26	64 / 28	90 / 23	75 / 32
11 AM	26 / 48	39 / 45	37 / 46	32 / 50	52 / 38	39 / 52
2 PM	21 / 55	33 / 51	28 / 54	27 / 55	43 / 43	35 / 57
5 PM	28 / 53	32 / 51	29 / 54	28 / 56	45 / 42	37 / 56
11 PM	45 / 33	56 / 31	54 / 33	44 / 37	76 / 29	67 / 38
monthly average wind direction (degrees clockwise from north)						
day	198	203	263	113	180	163
night	173	91	189	61	135	206
monthly average wind speed (miles per hour)						
	5.41	4.29	4.23	4.40	3.52	9.43
wind speed distribution (hours per month for given mph range)						
0 to 3	237	360	383	253	431	32
3 to 12	423	333	319	458	277	493
12 to 24	60	27	18	9	12	187
> 24	0	0	0	0	0	8
monthly average daily total insolation (Btu/ft²·day)						
	1922	1838	1823	1893	1757	1974
"clearness" distribution (hours per month in specified clearness index range)						
60-80%	206	124	153	180	163	196
40-60%	84	65	81	68	77	70
20-40%	59	71	60	55	77	44
0-20%	18	58	43	33	43	31

The State-Wide Picture

Figure 3 below shows the monthly weather for the eight WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40 degrees to 110 degrees Fahrenheit, the middle one gives the daily total solar radiation on a horizontal plane, up to 4000 Btu per square foot per day, and the bottom graph illustrates the hourly average wind speed from 0 to 40 miles per hour. Continuing problems with the Stratton and Sterling stations have prevented us from retrieving data from these sites.



Data for Stratton and Sterling are unavailable at time of printing.



COLORADO CLIMATE

MAY 1988

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
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This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 8

May in Review:

A major precipitation event in midmonth dropped rain and higher elevation snows on the entire state. This storm rescued much of Colorado from what otherwise would have been an extremely dry month. Several areas east of the mountains ended up with more than double their average May precipitation. Some record high temperatures were set during May, but for the month as a whole temperatures were normal. It was an unusually windy month. Blowing dust was observed on several occasions across the Eastern Plains.

Colorado's July Climate:

Welcome to summer! Our summer climate makes quite an impression on the many visitors who flock to our state each year. Hot on the plains, cool in the mountains, sunny mornings, thundery afternoons, gorgeous sunsets, and calm and pleasant evenings are the parts of our climate that tourists go home remembering. These impressions are quite accurate -- for this time of year, at least.

July produces the most predictable weather of the year. The often heard forecast "partly cloudy with a 20% chance of afternoon and evening thundershowers" is usually pretty close. With weak winds aloft, the weather changes little from day to day. Elevation becomes the dominant climate control and convection (hot air rising) is the main cause of cloud formation and precipitation.

July temperatures are reliably the hottest of the year. Deviations of more than a few degrees from long-term averages are uncommon (see special article below). Daytime temperatures routinely decrease with elevation at a rate of about 4°F per thousand feet. Below 5,000' highs are usually in the 90s with lows near 60°. Between 5,000' and 7,500' expect highs in the 80s and lows in the 50s. From 7,500' to 10,000' highs in the 70s are common with lows in the 40s. Above 10,000 feet highs in the 60s are expected. Even though it's July, nights can be cold in the mountains. Lows in the 30s are normal. Just last year, Silverton had a low of 22° in July. Dry air helps make these cool temperatures possible. It also makes hot afternoons bearable. Afternoon relative humidities are typically 20% to 35%.

Thunderstorms develop somewhere in the state nearly every day in July, but rainfall tends to be spotty and relatively light except in preferred thunderstorm regions such as the Pikes Peak area and some of the San Juan mountains. It is rare to awake to rain on the roof, but afternoon showers are common. Experienced hikers and mountain climbers know to start their treks early to avoid the trauma that afternoon storms can bring. Lightning is a threat to safe outdoor activities across all parts of Colorado. An average of 3 people are killed each year by lightning with more deaths in July than any other month.

Careful observers can detect subtle but significant changes in cloud development as July progresses. The "Southwest Monsoon" (warm, moist wind bringing subtropical moisture northward across Mexico into Colorado) normally strengthens after the middle of the month. As moisture increases, storms develop earlier in the day, cover larger areas and last later into the night. Chances for local flash floods, such as the Big Thompson disaster, are markedly higher in late July than earlier in the month.

News About Summer Temperature Variations:

Throughout much of the year, drastic day-to-day temperature changes can occur in Colorado, especially east of the mountains. Cold fronts, warm fronts, "upslopes," and "chinooks" seem to keep the temperature bobbing up and down like a jack rabbit. But then along comes summer, and with little fanfare these fluctuations stop. In midwinter temperatures are likely to be at least 10 degrees above or below the daily average on about 50% of the days. Come summer, however, and only rarely does the thermometer deviate by more than a few degrees from average. When it does, we really notice it. A deviation of just 10 degrees is likely to come close to breaking all-time records. Such was the case last year on July 12 when snow accumulated in our mountains and daytime temperatures stayed in the 50s at lower elevations of eastern Colorado.

(continued on Page 9)

MAY 1988 DAILY WEATHER

Date	Event
1-3	Some wild spring weather! A very deep low pressure area crossed Colorado on the 1st bringing very strong winds and sharply colder temperatures. Winds gusting to 50-60 mph on the 1st kicked up dust which caused a number of traffic accidents and 2 fatalities. High temperatures soared into the 80s in eastern Colorado on the 1st only to plummet into the 30s behind the front. Severe thunderstorms with hail and local heavy rains accompanied the front. Mountain snows developed late on the 1st and diminished on the 2nd. Much of eastern Colorado awoke to snowflakes on the 2nd. Precipitation and strong winds continued east of the mountains, especially in northeast counties. Several areas including Akron, Holyoke and Julesburg received more than 2" of moisture. Heaviest snow accumulations were actually in southeast Colorado. Springfield reported 7" of snow as did Walsenburg. Our new weather observer south of Kim reported 8" of snow. As skies cleared and winds began to diminish, many areas reported their coldest temperatures of the month. Cortez dipped to 19° on the 3rd. Dillon reported 3° on the morning of the 2nd, the coldest in the state for the month.
4-5	Cool nights but warmer days. Generally sunny and dry statewide with increasing winds. An evening shower on the 5th over parts of SE Colorado.
6-8	A cold front crossed the state on the 6th with another round of very strong winds. Gusts exceeded 60 mph in several areas. Cool and breezy 7-8th with some scattered showers and mountain snows primarily over northern Colorado.
9-10	Generally sunny and warmer on the 9th. The warming trend was interrupted briefly on the 10th as an upper level disturbance triggered an area of showers and thundershowers that developed early near Walden and spread southeastward during the day. Eads got 0.43" from the shower.
11-16	Very warm and dry with lots of sunshine statewide. Mountain temperatures rose into the 50s and 60s which initiated rapid snowmelt. Meanwhile 80s and 90s were the rule at lower elevations. Denver reached 90° on the 16th to set a new record for the date; 94° at Rangely was also a new record.
17-23	Still hot east of the mountains on the 17th, but increasing clouds and moisture from the west as a low pressure trough moved toward us. Las Animas hit 98°, the highest in the state for the month. An upper level storm system organized over the State 18-19th and showers and thunderstorms developed statewide. Temperatures dropped steadily and winds increased. On the 19th many mountain areas were getting snow. The storm moved east of Colorado by the 21st allowing western Colorado to dry out. But some shower activity continued through the 23rd out on the plains and temperatures remained cool statewide. For the entire storm period, precipitation totals ranged from less than 0.25" in extreme northwest Colorado to more than 4" at several locations on the northeastern plains. Much of the rain fell gently making it extremely valuable for agriculture. Mountain snows were also significant. Mount Evans measured 33" of new snow from the storm.
24-28	Warmer and sunnier. Surface air remained humid east of the mountains and some thunderstorms popped up each afternoon. Most rainfall was light, but New Raymer 21N received 0.97" of rain and hail on the 25th.
29-31	A very strong storm system for this time of year moved across the Rockies. Very strong winds developed ahead of the cold front on 29-30th with gusts close to 60 mph in some areas. Rain with mountain snows developed in western Colorado on the 30th. Telluride measured 6" of new snow. Strong storms then exploded late on the 30th out on the plains. Heaviest rains fell on extreme southeast Colorado. 3.05" fell near Campo and Stonington reported 3.06". The month ended on a chilly note. Grand Junction set a new record low of 37° on the 31st.

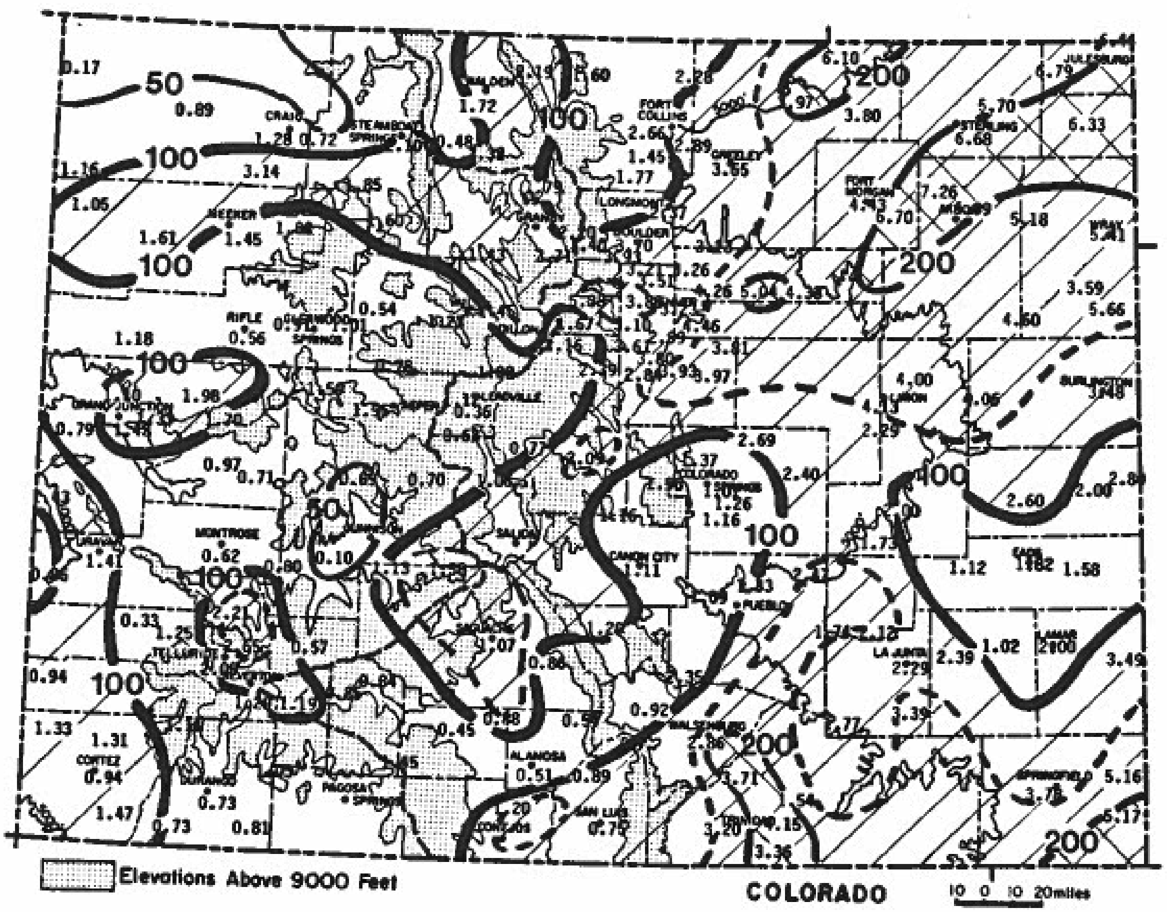
May 1988 Extremes

Highest Temperature	98°F	May 17	Las Animas
Lowest Temperature	3°F	May 2	Dillon 1E
Greatest Total Precipitation	7.26"		Akron Airport
Least Total Precipitation	0.10"		Blue Mesa Lake
Greatest Total Snowfall*	55"		Mount Evans Research Center

MAY 1988 PRECIPITATION

May did not live up to its reputation of having many cloudy and damp periods east of the mountains. There was only one widespread rainy period, but it made up for the lack of many other storms. As a result, much of the state ended up wetter than average. Northeastern counties were especially drenched, and several locations ended up with more than double their May average. Nearly 20 weather stations reported more than 5" of rain for the month. For Colorado, that's a lot. Still there were a number of dry areas. Much of the central and southern mountains were dry -- some areas with only 50% of average. Local dry spots could also be found east of the Continental Divide, such as Estes Park, Colorado Springs, Canon City, Lamar and Cheyenne Wells. This was the 6th consecutive dry month for several locations in the central and southern mountains.

Greatest		Least	
Akron	7.26"	Blue Mesa Lake	0.10"
Sedgwick 5S	6.79"	Browns Park Refuge	0.17"
Brush	6.70"	Norwood	0.33"
Leroy 5WSW	6.68"	Leadville 2SW	0.36"
Julesburg	6.44"	Del Norte	0.45"



Precipitation amounts (inches) for May 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

1988 WATER YEAR PRECIPITION

Substantial portions of the central and southern mountains and adjacent valleys have received between 60% and 90% of the average October to May precipitation. The remainder of western Colorado is near average for the year to date. East of the mountains, moisture has been more abundant, compared to average. Except for small areas along the northern Front Range, the Pikes Peak area and the region from Lamar to Cheyenne Wells, the Eastern Plains are wetter than usual. A number of locations in northeast Colorado have had 150% or more of average.

Comparison to Last Year

At this time a year ago, dry areas covered much of the central and northern mountains while the remainder of Colorado was quite wet. At this point in time, the 1988 water year can be ranked the driest since 1981 for the primary runoff production zones.

1988 Water Year to Date through May

Wettest (as % of average)

Akron 1N	222%	15.81"
New Raymer 21N	213%	12.15"
Brush	207%	13.44"

Driest (as % of average)

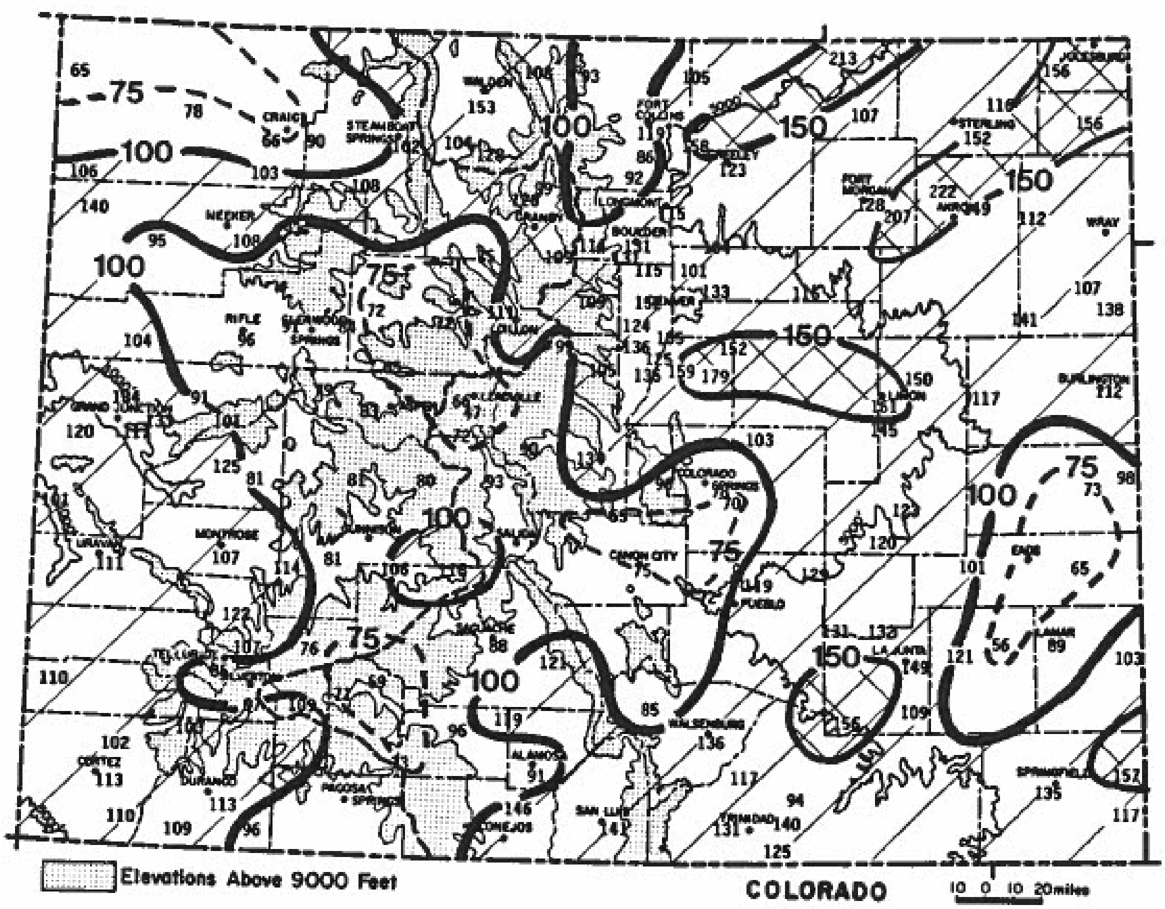
Leadville	47%	4.36"
John Martin Dam	56%	2.93"
Creede 2S	59%	4.76"

Wettest (total precipitation)

Bonham Reservoir	24.54"	101%
Mount Evans Research Center	23.70"	109%
Wolf Creek Pass 1E	22.35"	73%

Driest (total precipitation)

John Martin Dam	2.93"	56%
Antero Reservoir	3.28"	90%
Alamosa WSO AP	3.32"	91%

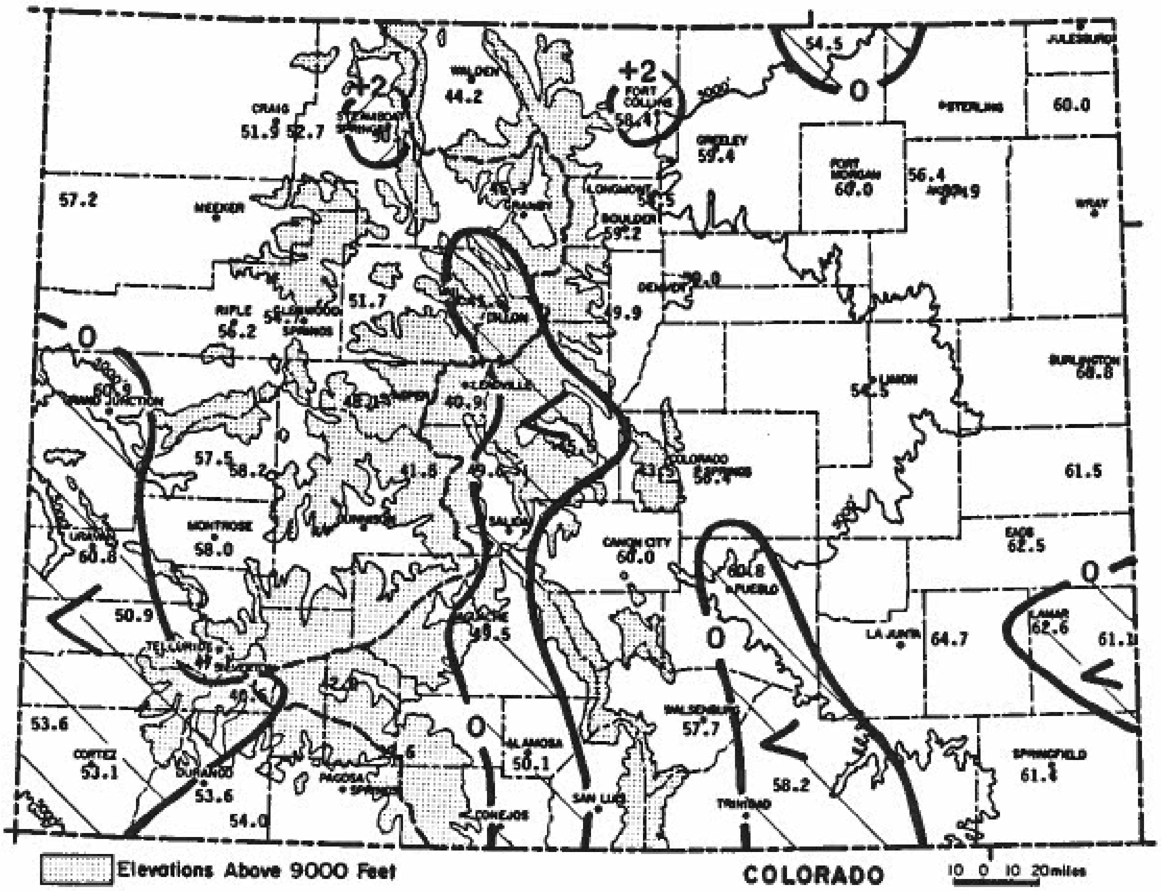


Precipitation for October 1987 through May 1988 as a percent of the 1961-1980 average.

MAY 1988 TEMPERATURES

AND DEGREE DAYS

May temperatures ended up very close to average for the month. More than 80% of all reporting stations were within 1.5 degrees of their long-term May averages. The warmest area compared to average was along the north Front Range where some locations such as Fort Collins were close to 2 degrees warmer than average.



May 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

MAY 1988 SOIL TEMPERATURES

Soil temperatures were rising smartly in mid May in response to strong sunshine and several unusually warm days. Equipment problems curtailed data collection later in the month.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

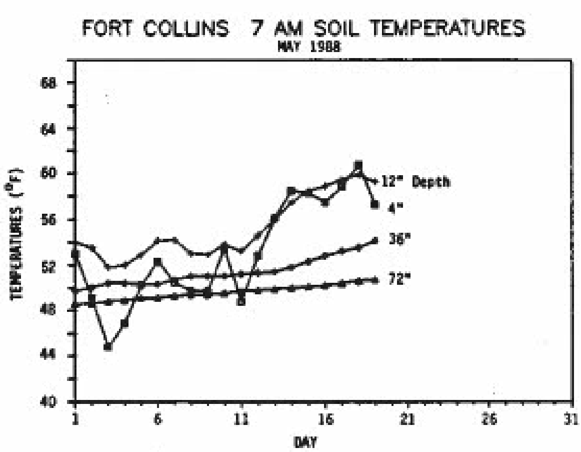


Table 1. Heating Degree Day Data through May 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130	1556	1867	1381	1031	658	454		9204
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024	1382	1450	1146	1136	734	517		8571
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713	1053	1107	842	739	400	203		5589
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955	1277	1357	1010	1030	639	472		7768
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724	1037	1221	935	779	449	178		5795
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668	1007	1144	858	767	407	191		5550
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767	1108	1256	958	886	499	273		6433
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860	1179	1351	1008	899	609	362		6859
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950	1376	1561	1264	1076	593	399		8131
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737	1102	1300	M	M	M	M		3612
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745	1125	1227	889	811	437	215		6001
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145	1491	1629	1376	1379	933	717		10631
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851	1206	1391	972	859	514	346		6820
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37	39	314	658	930	1283	1309	925	927	566	384	111	7483
	87-88	54	75	254	509	950	1331	1544	1173	1002	607	404		7903
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922	1255	1310	1029	992	645	462		7737
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784	1140	1252	936	821	479	217		6277
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773	1154	1484	1055	826	495	206		6574
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754	1147	1469	1031	741	350	172		5952

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1595	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098	1516	1642	1413	1372	907	602		10171
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762	1157	1363	955	807	437	204		6264
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M	M	M	M	M	M	M		0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653	1032	1278	837	638	327	103		5179
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180	1534	1577	1326	1355	957	741		10750
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840	1209	1354	1022	943	569	321		7005
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87	0	0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805	1169	1383	1035	847	509	222		6638
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	94	7402
	87-88	M	M	M	M	M	M	M	M	M	M	M		0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849	1160	1332	1003	817	468	230		6372
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947	1292	1548	1187	996	663	485		8197
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754	1111	1399	903	777	399	167		5929
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819	1209	1430	1039	865	454	268		6633
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033	1448	1619	1336	1167	674	433		8834
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742	M	1475	1029	831	476	197		5314
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992	1269	1354	1109	1092	720	547		8495
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730	1054	1209	850	803	438	234		5757
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242	1499	1572	1343	1340	835	638		10200
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707	977	1109	826	773	401	238		5497

M = MISSING DATA

MAY 1988 CLIMATIC DATA

Eastern Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	68.7	40.3	54.5	-0.5	88	27	327	9	306	6.10	3.73	257.4	10
STERLING	75.2	45.6	60.4	2.4	93	28	197	62	409	6.17	2.98	193.4	10
FORT MORGAN	74.0	45.9	60.0	1.7	92	32	206	56	400	4.43	1.97	180.1	8
AKRON FAA AP	71.2	41.6	56.4	-0.1	90	31	285	24	350	7.26	4.16	234.2	10
AKRON 4E	71.6	44.3	57.9	1.5	91	30	243	31	359	5.09	1.89	159.1	9
HOLYOKE	72.9	47.2	60.0	0.9	91	32	200	53	389	6.33	3.29	208.2	9
BURLINGTON	73.9	47.7	60.8	1.4	92	31	178	54	404	3.48	0.72	126.1	10
LIMON WSMO	69.0	40.0	54.5	1.4	84	28	321	1	312	4.13	1.95	189.4	13
CHEYENNE WELLS	76.2	46.8	61.5	1.8	93	28	174	71	421	2.00	-1.00	66.7	10
EADS	77.6	47.5	62.5	1.3	94	34	149	79	450	1.82	-0.77	70.3	6
LAMAR	80.4	44.8	62.6	-0.5	95	30	134	65	465	2.00	-0.61	76.6	13
LAS ANIMAS	81.2	48.3	64.7	1.4	98	33	103	101	494	2.39	0.44	122.6	8
HOLLY	79.5	42.8	61.1	-1.1	97	25	168	58	440	3.49	0.85	132.2	11
SPRINGFIELD 7WSW	77.0	45.8	61.4	1.1	90	32	151	46	438	3.78	1.09	140.5	12

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	72.3	44.5	58.4	2.1	88	32	217	19	356	2.67	0.04	101.5	7
GREELEY UNC	73.5	45.2	59.4	1.6	91	31	204	37	380	3.65	1.00	137.7	7
LONGMONT 2ESE	75.7	41.4	58.5	1.4	93	24	222	27	394	2.37	0.01	100.4	5
BOULDER	73.5	45.0	59.2	0.8	89	28	203	31	381	3.70	0.66	121.7	10
DENVER WSFO AP	72.8	45.1	59.0	1.9	90	28	215	35	374	4.26	2.07	194.5	7
EVERGREEN	67.1	32.8	49.9	0.9	84	16	462	0	271	3.10	0.52	120.2	7
LAKE GEORGE 8SW	59.7	31.2	45.5	-0.7	75	14	597	0	178	2.09	0.90	175.6	11
RUXTON PARK	57.6	29.3	43.5	0.2	73	14	659	0	155	1.96	-0.57	77.5	8
COLORADO SPRINGS	70.5	42.3	56.4	0.9	86	26	273	12	339	1.01	-0.96	51.3	5
CANON CITY 2SE	74.4	45.5	60.0	1.7	88	25	191	43	404	1.11	-0.32	77.6	5
PUEBLO WSO AP	77.8	43.8	60.8	-0.4	92	30	167	45	430	1.33	0.24	122.0	6
WALSENBURG	72.9	42.4	57.7	0.2	87	27	238	18	377	2.86	1.45	202.8	6
TRINIDAD FAA AP	73.4	42.9	58.2	-0.8	89	27	234	29	382	1.54	-0.00	100.0	10

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	60.4	27.9	44.2	0.1	78	13	638	0	189	1.72	0.60	153.6	11
LEADVILLE 2SW	56.3	25.5	40.9	1.4	70	15	741	0	126	0.36	-0.84	30.0	4
BUENA VISTA	65.0	34.1	49.6	-0.3	80	23	472	0	245	1.06	0.16	117.8	5
SAGUACHE	65.2	33.7	49.5	-0.8	80	23	473	0	249	1.07	0.38	155.1	8
HERMIT 7ESE	59.7	24.3	42.0	0.5	72	13	705	0	167	0.85	-0.16	84.2	3
ALAMOSA WSO AP	68.2	32.0	50.1	-0.4	82	17	454	0	290	0.51	-0.18	73.9	4
STEAMBOAT SPRINGS	67.9	33.6	50.7	3.2	83	23	433	0	289	2.10	0.09	104.5	10
GRAND LAKE 6SSW	59.8	30.8	45.3	1.6	72	17	602	0	173	1.55	0.21	115.7	10
DILLON 1E	56.9	26.3	41.6	-0.7	71	3	717	0	150	1.45	0.25	120.8	12
CLIMAX	46.5	22.8	34.7	-0.9	58	6	934	0	32	1.02	-0.83	55.1	10
ASPEN 1SW	62.6	33.6	48.1	1.1	78	19	517	0	208	1.95	-0.15	92.9	11
TAYLOR PARK	55.0	27.9	41.5	5.2	68	16	720	0	113	0.70	-0.46	60.3	6
TELLURIDE	63.5	30.7	47.1	1.0	78	18	547	0	220	2.05	0.42	125.8	7
PAGOSA SPRINGS	69.0	29.3	49.1	0.0	85	17	485	0	305	0.58	-0.48	54.7	4
SILVERTON	58.2	22.7	40.5	-0.4	72	9	752	0	159	1.29	-0.09	93.5	7
WOLF CREEK PASS 1	53.0	26.1	39.6	0.5	66	11	781	0	81	1.45	-0.48	75.1	7

Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	67.1	36.7	51.9	0.4	83	24	399	0	276	1.28	-0.37	77.6	7
HAYDEN	69.2	36.3	52.7	1.2	84	24	375	0	308	2.11	0.83	164.8	5
RANGELY 1E	74.0	40.5	57.2	0.8	87	31	243	9	383	1.05	0.14	115.4	6
EAGLE FAA AP	69.0	34.4	51.7	0.6	84	26	404	0	303	0.54	-0.13	80.6	6
GLENWOOD SPRINGS	71.6	37.7	54.7	0.2	87	20	232	0	255	0.91	-0.54	62.8	4
RIFLE	73.8	38.6	56.2	0.8	88	29	268	2	374	0.56	-0.40	58.3	4
GRAND JUNCTION WS	75.7	46.0	60.9	-1.1	89	31	172	51	418	1.10	0.28	134.1	6
CEDAREDGE	74.1	40.9	57.5	1.0	88	28	241	18	386	0.97	-0.15	86.6	5
PAONIA 1SW	74.5	41.9	58.2	1.4	88	26	225	23	383	0.71	-0.58	55.0	5
MONTROSE NO. 2	73.3	42.8	58.0	1.2	87	28	230	23	371	0.62	-0.14	81.6	4
URAVAN	77.6	43.9	60.8	-0.5	94	32	165	39	425	1.41	0.40	139.6	7
NORWOOD	67.3	34.5	50.9	-0.2	84	21	430	0	275	0.33	-0.68	32.7	4
YELLOW JACKET 2W	68.8	38.4	53.6	-0.1	82	24	345	0	297	1.33	0.14	111.8	4
CORTEZ	71.1	35.1	53.1	-0.3	85	19	362	0	336	0.94	0.02	102.2	3
DURANGO	71.4	35.9	53.6	0.3	87	25	346	0	338	0.73	-0.39	65.2	5
IGNACIO 1N	73.9	34.2	54.0	1.6	87	19	331	0	377	0.81	-0.05	94.2	3

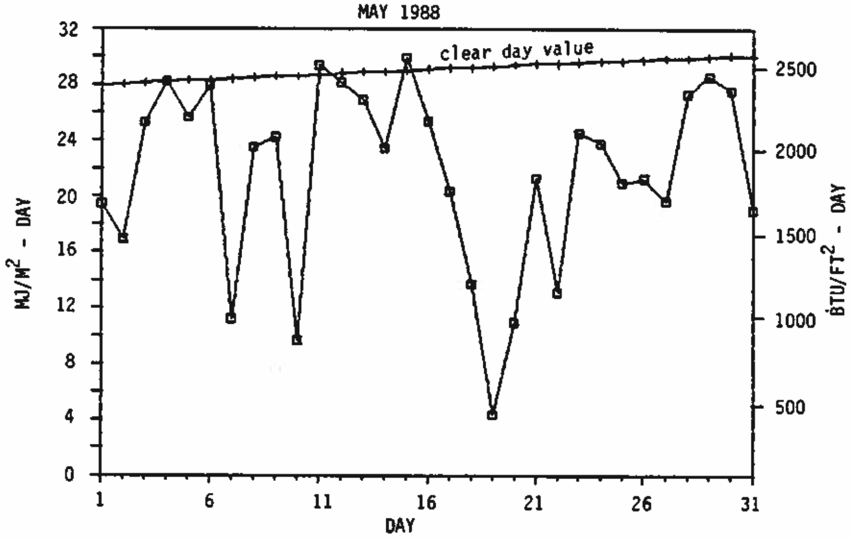
* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

MAY 1988 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	8	10	13	--	--
Denver	7	11	13	72%	65%
Fort Collins	5	15	11	--	--
Grand Junction	12	11	8	75%	71%
Pueblo	11	10	10	82%	73%

FT. COLLINS TOTAL HEMISPHERIC RADIATION

MAY 1988



News About Summer Temperature Variations: (continued)

I've been told by a number of long-time Coloradoans that these cold summer days are occurring more now than they did a few years ago. I didn't have that impression, but I haven't been here as long as some of you. Let's look at some numbers and see what our climate data have to say.

We looked at daily temperatures for Alamosa, Grand Junction, Pueblo and Denver for the summer period for the past several years to determine how often the mean daily temperature was 10 or more degrees Fahrenheit below or above the long-term average. Summer was defined as June 15-August 31 for the purpose of this study. Here are some of the results.

Frequency of Summer Temperature Extremes, 1957-1987

	Alamosa	Denver	Grand Junction	Pueblo
Probability that at least one day each summer will be ≥ 10° above the daily mean for each day	4%	56%	34%	37%
Probability that at least one day each summer will be ≥ 10° below the daily mean for each day	24%	81%	75%	73%

Unusually chilly days (temperature 10 or more degrees below the daily average) occur relatively often. Since 1957, Alamosa has had only 6 such days. However, Grand Junction has had 67 days (an average of 2 per summer) and Denver led the pack with 91 (3 per summer). Hot days that are at least 10 degrees above the daily average occur less frequently. Alamosa has had only 1 such day in the past 3 decades while Grand Junction and Pueblo have each had 22 and Denver 42.

There are obviously some physical reasons for these observations. To get a feel for these we examined unusually warm and cold days to determine their characteristics. Extremely hot days were characterized by highs in the upper 90s and 100s at lower elevations and lows in the 60s (or even 70s at Grand Junction). These days were accompanied by predominantly clear skies, low humidity, light winds (often from the west) and a ridge of high pressure aloft over or just west of Colorado. These conditions occurred most often in late June with a second peak in late August. The unusually cold days were a little harder to characterize and could occur almost anytime during the summer. At Grand Junction, most of their unusually cool days occurred after a cold front brought clear, dry and cooler Pacific airmasses into the area. Occasionally, unusually cool days occurred during the height of the Southwest Monsoon when clouds and precipitation kept daytime temperatures low. Highs in the 70s with lows in the 50s were typical for Grand Junction's coldest summer days. At Pueblo and Denver their coldest days often occurred when high pressure areas moved down across the plains creating moist "upslope" flow east of the mountains. Highs in the 60s or even the 50s characterized these episodes and they were often accompanied by dense clouds and widespread rains.

Northeast Colorado is more susceptible to summer temperature extremes than other parts of the state. This is probably related to the fact that the farther north you go, the more cold fronts and active weather systems there are in the summer. Few of these systems reach into the interior mountain valleys of southern Colorado surrounding Alamosa. That area is left with an incredibly stable summer climate.

Finally, are these episodes of cold (or hot) summer temperatures becoming more frequent? Some long-time residents of Colorado have told me they don't remember any of those gloomy, damp "upslope" weather events during the summer prior to the current decade. Our data suggest that people just don't have very good memories. We looked all the way back to the first decade of weather observations in Denver (in 1870s). Sure enough, 7 out of 10 summers had at least one episode of cloudy, damp weather with highs only in the 60s. It's nothing new. No upward trend is apparent in the frequency of these events. Unusually hot days aren't occurring anymore often either. Perhaps it is our recreation-loving habits and the hyperactive news media that are making us think we're having more of this "bad" weather. My guess is that Colorado old timers cherished those damp cloudy days because it meant good sleeping at night, less irrigation for their crops, and just a nice chance to sit back and rest from their hot summer labors. Let's try the same approach. Instead of complaining about those 2 or 3 chilly days each summer, let's enjoy them.

4/22/90

Odie:

For the record, the WTHRNET Data tables published as <u>May 1988</u> data appear to actually be Feb 1988. However, the data graphs appear OK. <u>Please</u> note this with the original for the Water year series

<u>Wind Energy:</u>

One of the more prominent features of Colorado weather is undoubtedly the wind - gales greater than 100 miles per hour are not uncommon in certain parts of the state. In fact, high winds last January were blamed for the collapse of a bridge under construction in Boulder, and recently the roof was blown off of a hotel on the western slope. While Colorado may not get hurricane-related storms like Florida, our elevation places us closer to the jet stream's associated eddies.

The power of the wind is obvious, and people have been harnessing its kinetic energy for many years. The original windmill was a device which used the power of the wind to turn a grindstone at a grain mill. Water pumping was another early application. In Holland, a country with much land below sea level, wind-powered water pumps still keep many basements dry; wind-powered water pumps punctuate the landscape of much of rural Colorado. The wind's energy can also be converted to electricity.

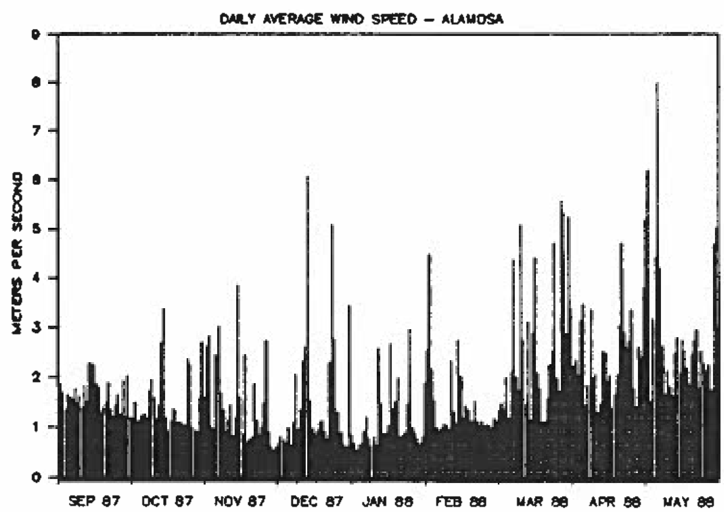
There are, of course, a number of problems associated with utilizing wind energy. Perhaps the most obvious is the lack of wind when you need it, and the presence of wind when you don't. Wind energy has also traditionally been difficult to control. On very windy days, a wind-powered mill operator might have to "put his nose to the grindstone" to see if the grain was burning from the friction of a millstone which was rotating too fast.

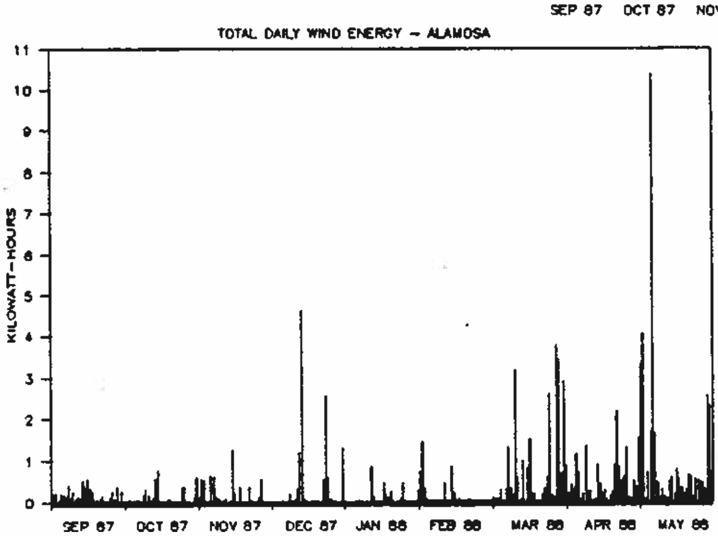
Fortunately, the technology of using wind power has come a long way since then. A number of power authorities have experimented with wind turbines, particularly in coastal regions where steady breezes are often found. The use of advanced blade designs and non-horizontal rotor orientations has shown that wind energy is a feasible, albeit commercially risky, technology. In the U.S., successful wind-to-electricity projects have been established in Florida, New York, New Mexico, Virginia, and along the Pacific coast. The Department of Energy's test site south of Boulder is where many advanced systems have been tested for the past 10 years. In the future, if electricity rates increase, or if the government subsidizes the cost of renewable energy use, as it has other energy sources in the past, Colorado may situate turbines in steady wind areas such as the eastern plains to supplement the electric requirements of many of our communities.

<u>Electricity from the Wind:</u>

Wind energy is a function of the density and velocity of the air, with-the power available increasing proportional to the cube of the speed. The area available for capturing energy is proportional to the square of the radius of the area swept by a wind turbine blade. Like any engine, however, a loss is incurred through the friction of the turbine parts, so any energy calculations must be adjusted by the turbine efficiency (typically 30 to 50 percent).

The graph to the right shows the daily average wind speed for the past nine months in Alamosa. Notice the occasional peaks which indicate particularly windy days. In addition, there is also a yearly trend which reaches a minimum in January and appears to reach a maximum sometime during the summer. Alamosa is in the middle of the San Luis Valley and therefore experiences winds caused by warm air flowing upslope during the day. Warmer air in the summer means that the overall velocity of this air is higher, giving the larger daily average wind speeds. One meter per second is approximately 2.24 miles per hour.





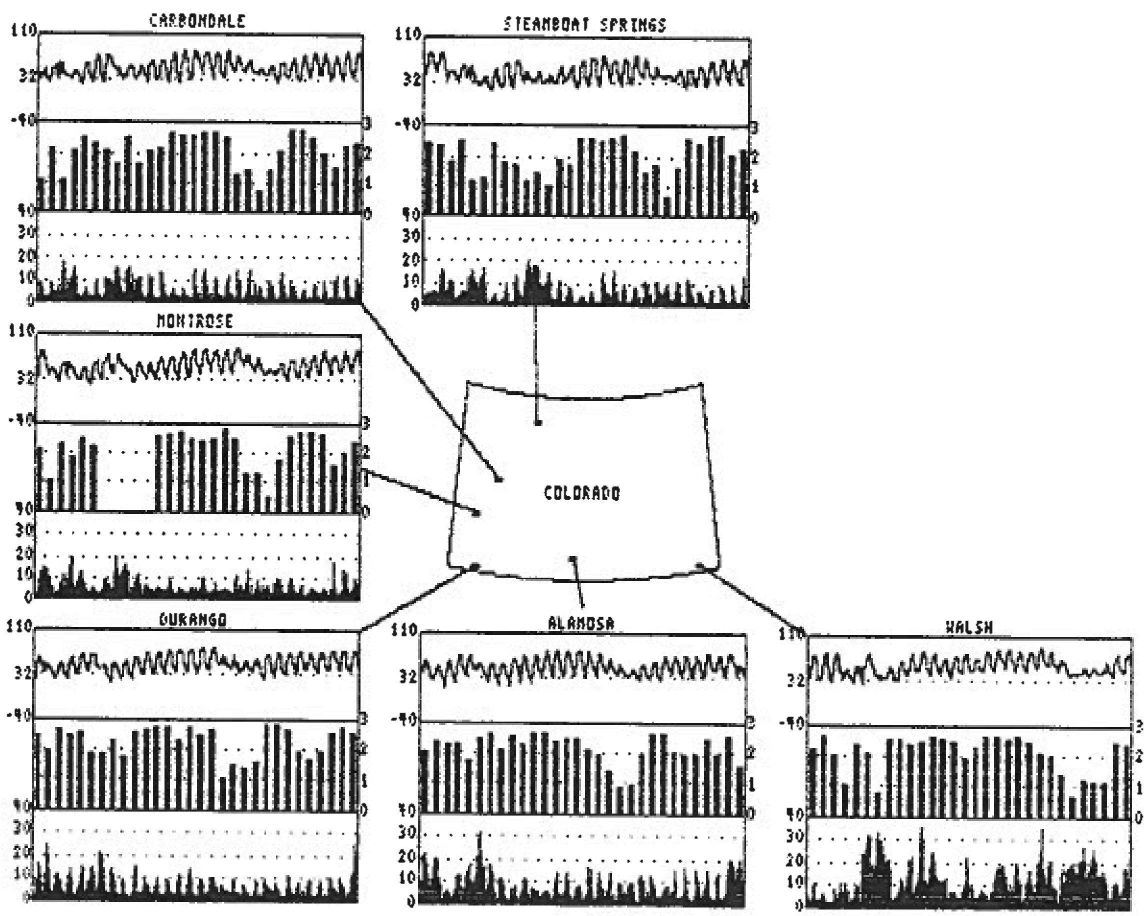
The graph to the left shows the daily wind power (kwh) per vertical square meter in Alamosa. Notice that the power levels are typically very small (less than 200 watt-hours per day). The windy days, on the other hand, show large jumps in the graph and imply that there is a good deal of potential wind energy waiting to be harvested.

WTHRNET WEATHER DATA - MAY 1988

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
monthly average temperature (°F)						
	17.9	26.1	23.6	26.8	13.8	34.0
monthly temperature extremes and time of occurance (°F day/hour)						
maximum:	46.4 28/15	54.2 22/16	58.1 25/16	57.1 29/16	46.4 29/14	71.9 13/15
minimum:	-13.5 5/ 6	0.8 7/ 8	-10.6 5/7	-3.9 5/ 7	-26.0 4/ 6	0.9 11/ 4
monthly average relative humidity / dewpoint (percent / °F)						
5 AM	85 / 1	80 / 11	90 / 8	83 / 12	85 / 2	77 / 20
11 AM	60 / 17	48 / 27	50 / 24	54 / 26	70 / 14	53 / 35
2 PM	48 / 25	47 / 30	37 / 34	45 / 33	58 / 19	44 / 40
5 PM	47 / 24	45 / 31	40 / 32	46 / 31	67 / 18	44 / 38
11 PM	84 / 10	76 / 17	80 / 14	79 / 17	86 / 6	69 / 22
monthly average wind direction (degrees clockwise from north)						
day	205	202	215	204	174	145
night	210	78	175	165	134	220
monthly average wind speed (miles per hour)						
	3.18	3.03	2.52	2.63	2.33	8.30
wind speed distribution (hours per month for given mph range)						
0 to 3	413	473	576	504	573	42
3 to 12	273	217	114	192	109	420
12 to 24	10	5	6	0	14	100
> 24	0	0	0	0	0	8
monthly average daily total insolation (Btu/ft²·day)						
	1314	1262	1157	1234	1016	1163
"clearness" distribution (hours per month in specified clearness index range)						
60-80%	215	153	170	181	133	171
40-60%	69	39	53	57	72	45
20-40%	12	41	66	48	55	37
0-20%	7	36	14	7	36	36

The State-Wide Picture

The figure below shows the monthly weather for the eight WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40 degrees to 110 degrees Fahrenheit, the middle one gives the daily total solar radiation on a horizontal plane, up to 4000 Btu per square foot per day, and the bottom graph illustrates the hourly averge wind speed from 0 to 40 miles per hour. Continuing difficulties with the Stratton and Sterling stations have prevented data retrieval from these sites. Insolation data were not available for Montrose from the 7th to the 11th.



COLORADO CLIMATE

JUNE 1988

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 9

June in Review:

Summer heat set in early, and all of Colorado ended up several degrees warmer than average for the month. With the premature heat came severe weather. Denver area tornadoes were witnessed by thousands of residents on several occasions. Precipitation totals were above average in June across much of southern Colorado but were near average to much below average in northern counties.

Colorado's August Climate:

There's really not much difference between July and August typically. If you liked July, you'll probably be pleased with August.

In early August, look out for heavy local downpours and potential flash flooding statewide. The Southwest Monsoon is normally quite active early in the month pumping moisture into Colorado to fuel thunderstorms. But as the month progresses, monsoon moisture often retreats. By the end of the month only southern parts of the state are prone to routine afternoon thundershower development. State Fair goers in Pueblo should still be alert to the chance of storms. Severe weather is much less a concern in August compared to June and July. Tornadoes only occur about 1/4 as often as they do in June. But still beware of hail. The first 2 weeks of August have dealt some mighty hailstorms to eastern Colorado in recent years.

August precipitation totals average less than 1" in northwest Colorado and less than 1.50" in northeastern Colorado from Longmont and Fort Collins east to Fort Morgan. Totals increase as you go southward and sometimes exceed 4" in the San Juan Mountains. In 1936 Wolf Creek Pass received nearly 10" of rainfall in August. Temperatures are very similar to July's in most years. The main difference is, that by late August, evenings begin to cool off noticeably as the atmosphere becomes less moist and the sun sets earlier. For the month as a whole, expect daily high temperatures near 90° at low elevations decreasing to the 60s and 70s high in the mountains. Lows in the 50s are most common down low with 30s and 40s in the mountains. Don't be surprised, however, to have a few freezing temperatures up high. Last year's lowest August temperature was 22° on the Laramie River. An occasional dusting of snow in the higher mountains is also not unusual.

Drought Rears Its Ugly Head?:

I am pleased to report that Colorado is not experiencing significant drought at this time -- at least not yet. But with the incredible national media focus on this year's drought situation across the country, it may be appropriate for me to make a few comments. I will not elaborate on the current moisture status to the state. Other parts of this report should adequately address that. Instead, let's look at drought from a broader perspective.

The concept of drought seems simple enough. A brief definition could be "insufficient moisture." Webster says, "A prolonged period of dryness." But there is no universally accepted definition that states how dry it has to be and for how long before it qualifies to be called drought. There is not even agreement on how to pronounce or spell the term -- "drought" or "drouth." What we in most of Colorado would consider a wonderfully wet year with perhaps 16" or 18" of precipitation would be classified as horrendous drought for many parts of the country. So it's not surprising that conflicting, misleading and sometimes plain erroneous information appears in the media.

Let me give you a few examples of the complexities of drought here in Colorado. For most of Colorado's water users, it is the total winter snowpack in the mountains that determines how much water there will be for farming, lawn-watering, manufacturing, drinking and even wind surfing. It doesn't matter much when the snow falls as long as enough has accumulated by the end of the winter to send a good torrent of water down the streams throughout the summer. Summer rains may affect how quickly we use up our supply, but they usually don't do much to add to the supply. Others don't care much about the flow in the rivers as long as there is plenty of water in the reservoirs even it if is

(continued on Page 9)

JUNE 1988 DAILY WEATHER

Date	Event
1-3	Remnants of the Memorial Day storm kept Colorado cool and breezy 1-2nd, especially east of mountains. Some showers continued on the 1st with locally significant amounts. Las Animas measured 0.65", but the 1.71" at Karval was the greatest report. Quite chilly on the 1st. Lows dipped to 39° at Grand Junction and 38° at Longmont. 17° at Meredith was the lowest in the state in June. Dry with a warming trend began on the 3rd.
4-8	Generally dry and hot for so early in the summer with SSW winds aloft (associated with the drought-producing high pressure ridge over the Plains states and Midwest). Many 90°+ readings at lower elevations. Campo, in extreme SE Colorado hit 106° on the 8th -- the hottest in the state. An upper level disturbance moved northward across the area triggering strong thunderstorms on the 5th, particularly near the Front Range. Several reports of hail were made and a tornado did some damage north of Denver.
9-12	SSW winds aloft with warmer than average surface temperatures. Increased moisture resulted in more frequent and widespread thunderstorms, especially from the mountains eastward. Storms on the 9th dropped 0.61" at Buena Vista and 0.87" at Limon. Areas just SW of Denver received nearly 2" from the storm system. More small tornadoes were spotted during this period.
13-15	Severe weather erupted as cooler but quite moist air wedged into Colorado accompanied by a series of travelling upper air disturbances. Some strong storms developed on the 13th, heaviest on the southeast plains. Springfield 7WSW got 1.50" of rain late on the 13th. On the 14th, Wheatridge reported 1.51" of rain. Then on the 15th, one of the most widely witnessed and well-photographed tornado outbreaks in the history of the Rocky Mountain west struck Denver. Several tornadoes, visible simultaneously, did considerable property damage to parts of Denver but miraculously caused no deaths and few injuries. Some heavy rains and hail were also reported.
16-24	A major heatwave developed that covered all of Colorado. Low elevation daytime temperatures soared into the 90s and 100s and didn't drop below 60° at night for most of the period. Six or more locations including Eads, Sterling and Palisade saw the mercury hit 105° at least once during the period. Temperatures of 90° or above were even noted at Pagosa Springs and Steamboat Springs. Denver set a new record high on the 24th with 99°. Humidity was low at first but increased during the period contributing to increased thunderstorm activity. Thunderstorms developed each day, especially over the central mountains. Precipitation was generally light, and several small forest fires were ignited by lightning. However, some daily rainfall amounts of 0.50" or greater were reported. The Air Force Academy received 1.26" on the 23rd. Storms on the 24th kept lightning dancing across the sky well into the night.
25-30	An unusual period of persisting SE winds aloft brought lots of moisture into Colorado and sent storm cells moving toward the NW (catching some weather watchers by surprise). Temperatures returned to near normal, but rain fell over most of the state at a time of year when rainfall is normally sparse, especially in western Colorado. A number of large rainfall amounts were reported such as 2.38" at Nunn on the 25th, 1.91" at Pueblo Reservoir on the 27th, 1.48" at Twin Lakes Reservoir and 1.12" at Cortez on the 28th. Hugh slow-moving cells formed over the foothills of Larimer County on the 28th but broke up before significant flooding could occur. Glen Comfort, in the Big Thompson Canyon, did get 2.75" of rain in a short while. An ususual late morning storm dumped nearly 1" of rain on New Raymer and Briggsdale on the 29th. Finally on the 30th, a Pacific cool front moved in to end this unusual period of warm, stormy weather.

June 1988 Extremes

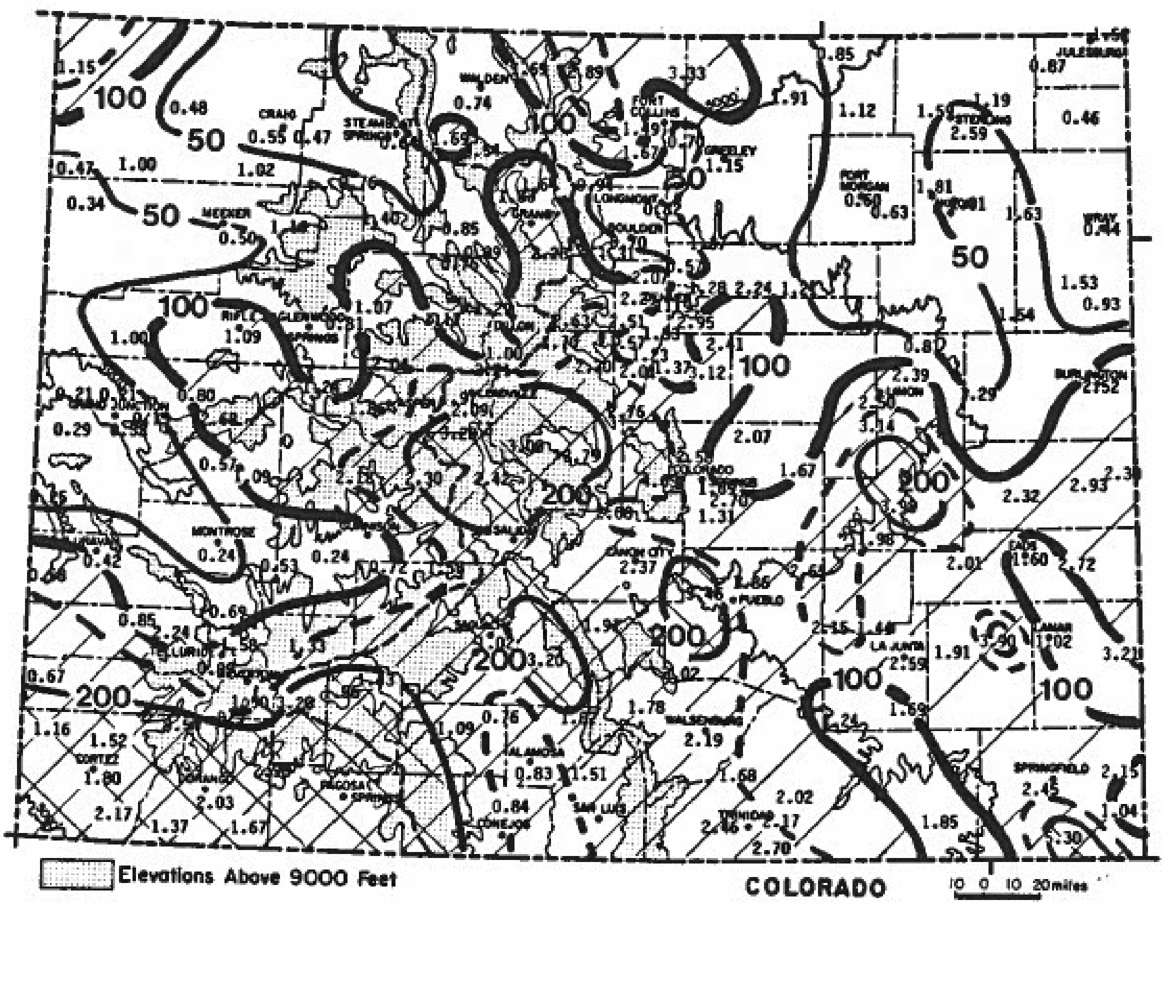
Highest Temperature	106°F	June 8 and 19	Campo 7S
Lowest Temperature	17°F	June 1	Meredith
Greatest Total Precipitation	8.54"		Rico
Least Total Precipitation	0.15"		Palisade

Several locations reported 20 or more days with thunder.

JUNE 1988 PRECIPITATION

The unusual weather patterns of June 1988 helped produce a very dramatic distribution of precipitation. Much of northern and some of western Colorado was considerably drier than average. Fort Morgan, Boulder, Steamboat Springs, Meeker and Grand Junction were just a few of the many locations to receive less than 50% of average rainfall. Holyoke's 0.46" total was only 13% of average. But at the same time, much of central and southern Colorado was much wetter than average. At least 25 stations received 200% or more of their average June precipitation. Cortez, for example, had it's 3rd wettest June on record, and at Twin Lakes Reservoir near Leadville this was the wettest June in 40 years of record. The wet areas were typically locations on the eastern and southern slopes of the mountains with good exposure to moist southeasterly flow.

Greatest		Least	
Rico	8.54"	Palisade	0.15"
Campo 7S	5.30"	Fruita	0.21"
Ruxton Park	4.09"	Grand Junction WSO	0.21"
Karval	3.98"	Blue Mesa Lake	0.24"
John Martin Dam	3.90"	Montrose	0.24"



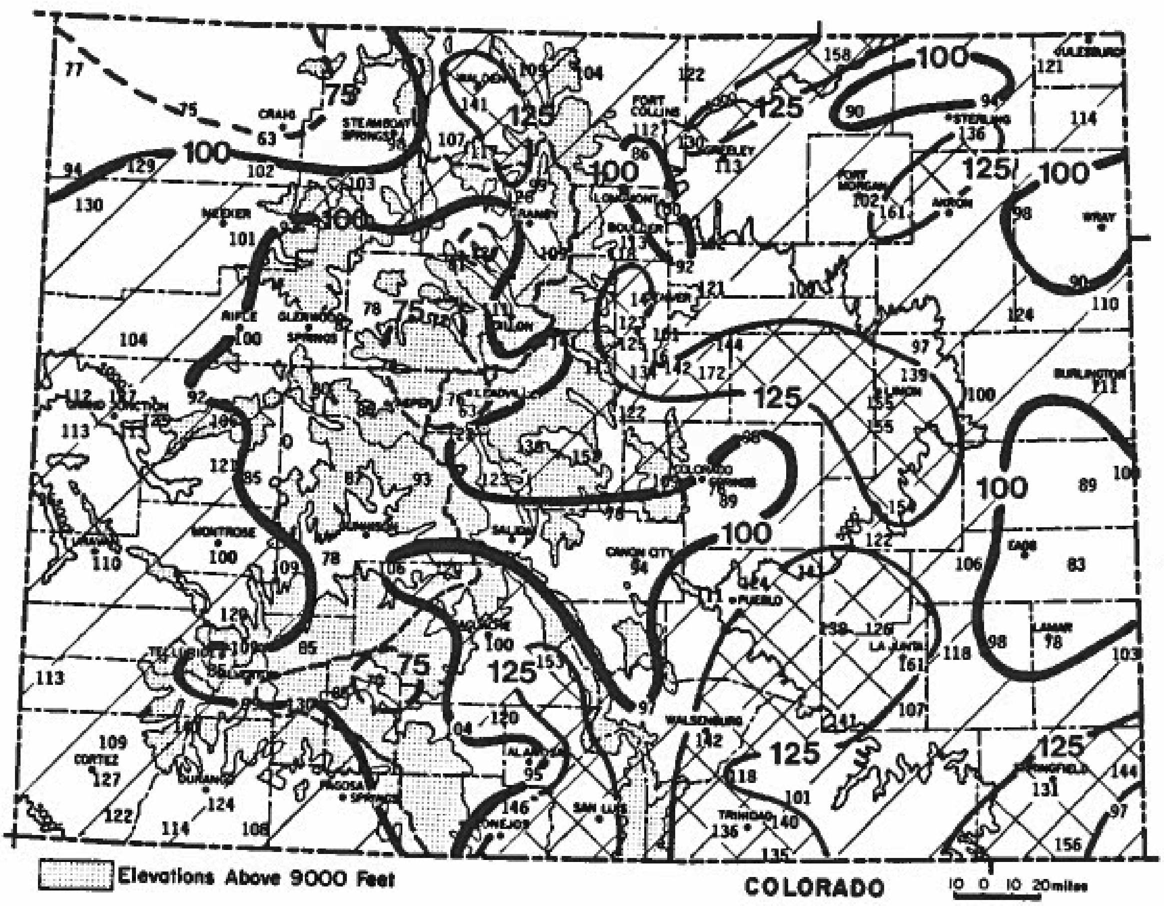
Precipitation amounts (inches) for June 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

1988 WATER YEAR PRECIPITION

June precipitation tended to move much of Colorado closer to average for the first 9 months of the 1988 water year. In general, the central and southern mountains and parts of the northwest plateau area of Colorado are drier than average for the year while the rest of the state is near or above average. The wettest locations, compared to average are a few small areas east of the mountains.

Portions of the Colorado mountains are drier now than they have been since 1981. Nevertheless, precipitation values are not exceptionally low and Colorado is fairing much better than the drought-effected areas that surround us on nearly all sides.

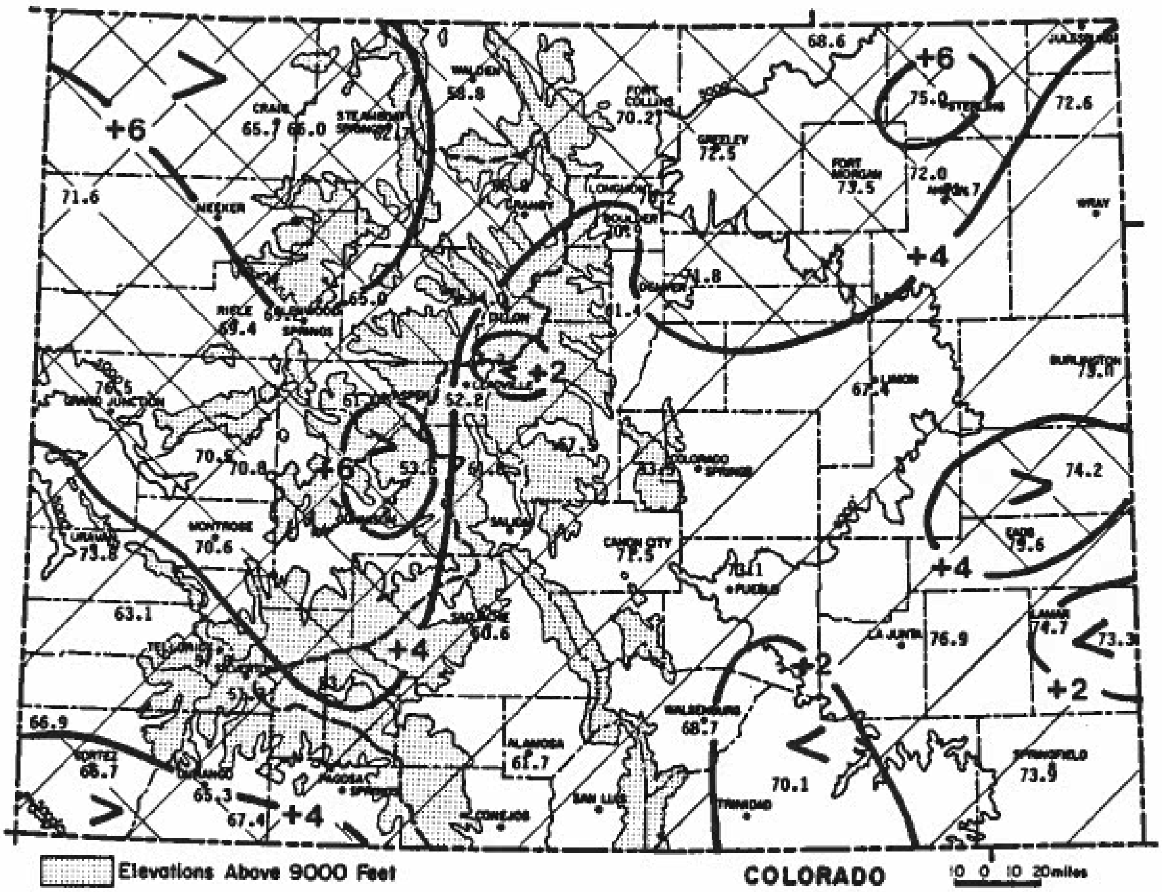
Beginning next month, we will be changing this comparative section to show precipitation graphs for different regions of Colorado. The intent of these graphs will be to show trends in precipitation over the past few years and how we compare to long-term averages. For example, these graphs will show that much of Colorado has been experiencing favorably moist conditions since about 1981 but recently we have begun a downward slide toward drier conditions.



Precipitation for October 1987 through June 1988 as a percent of the 1961-1980 average.

JUNE 1988 TEMPERATURES AND DEGREE DAYS

The entire state experienced substantially above average temperatures in June. For a few cities, mostly in northern Colorado, this was the warmest June on record. These included Steamboat Springs, Dillon and Walden (tied). Curiously, Climax (11,350 feet above sea level) indicate temperatures very close to average. For most of the northwestern half of the state temperatures ended up 4 to 7 degrees F above average. In southeastern half, temperatures were more normal, typically 2 to 4 degrees above average. The warm temperatures were a result of consistent heat throughout the month rather than episodes of extreme record-breaking heat.



June 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

JUNE 1988 SOIL TEMPERATURES

Equipment problems in the soil temperature apparatus were corrected during June. Temperature levels are indicative of the unusually warm June.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

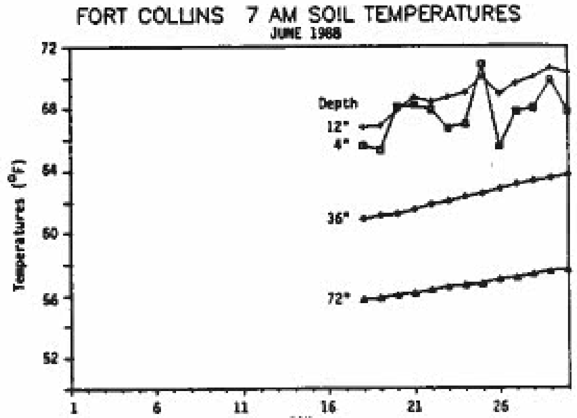


Table 1. Heating Degree Day Data through June 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	86-87	63	75	366	728	1004	1377	1593	1160	1049	662	436	115	8628
	87-88	66	96	364	601	1130	1556	1867	1381	1031	658	454	102	9306
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	86-87	147	132	428	735	1009	1307	1398	1063	1067	701	508	202	8697
	87-88	112	152	355	563	1024	1382	1450	1146	1136	734	517	123	8694
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	86-87	1	0	175	450	714	970	947	779	776	375	191	10	5388
	87-88	7	33	122	370	713	1053	1107	842	739	400	203	14	5603
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	86-87	79	69	388	730	970	1316	1280	1011	1071	650	433	113	8110
	87-88	49	117	313	549	955	1277	1357	1010	1030	639	472	102	7870
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	86-87	0	0	76	406	745	984	980	746	816	385	127	10	5275
	87-88	5	20	72	375	724	1037	1221	935	779	449	178	14	5809
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	86-87	4	2	132	422	724	952	976	793	M	M	177	15	4197
	87-88	11	36	87	374	668	1007	1144	858	767	407	191	16	5566
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	86-87	4	14	174	519	813	1081	1096	888	912	491	271	50	6313
	87-88	17	74	150	445	767	1108	1256	958	886	499	273	25	6458
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	86-87	10	6	214	541	813	1041	1224	888	953	534	302	36	6562
	87-88	6	35	154	396	860	1179	1351	1008	899	609	362	56	6915
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	86-87	31	15	338	654	967	1234	1473	1059	1055	589	368	107	7890
	87-88	55	96	227	534	950	1376	1561	1264	1076	593	399	52	8183
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	86-87	0	0	145	414	M	984	M	764	759	326	154	5	3551
	87-88	0	11	108	354	737	1102	1300	M	M	M	M	M	3612
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	86-87	0	0	145	477	775	1045	1012	804	805	392	170	22	5647
	87-88	11	21	110	410	745	1125	1227	889	811	437	215	14	6015
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	86-87	322	318	580	883	1125	1473	1542	1244	1286	914	667	387	10741
	87-88	296	346	556	763	1145	1491	1629	1376	1379	933	717	322	10953
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	86-87	23	9	295	559	844	1055	1204	895	906	478	346	36	6650
	87-88	14	44	188	435	851	1206	1391	972	859	514	346	42	6862
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	86-87	37	39	314	658	930	1283	1309	925	927	566	384	111	7483
	87-88	54	75	254	509	950	1331	1544	1173	1002	607	404	52	7955
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	86-87	75	90	380	699	927	1186	1178	995	1009	652	442	168	7801
	87-88	69	118	333	602	922	1255	1310	1029	992	645	462	111	7848
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	86-87	0	0	178	500	809	1091	1042	830	850	413	206	21	5940
	87-88	12	37	146	453	784	1140	1252	936	821	479	217	8	6285
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	86-87	0	4	138	495	874	1193	1148	842	937	443	150	14	6238
	87-88	12	29	110	430	773	1154	1484	1055	826	495	206	17	6591
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	86-87	0	0	130	414	718	1001	1159	785	765	314	143	0	5429
	87-88	0	6	34	248	754	1147	1469	1031	741	350	172	8	5960
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	86-87	245	242	488	777	1051	1450	1612	1265	1265	876	593	328	10192
	87-88	207	257	480	677	1098	1516	1642	1413	1372	907	602	238	10409
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	86-87	0	0	142	484	825	1085	1054	797	844	382	163	13	5789
	87-88	10	26	119	424	762	1157	1363	955	807	437	204	6	6270
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	86-87	123	146	420	734	1064	1430	1539	1187	1148	698	502	M	8991
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	86-87	0	0	32	280	668	991	937	685	700	295	65	0	4653
	87-88	0	3	35	273	653	1032	1278	837	638	327	103	1	5180
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	86-87	372	369	626	920	1188	1482	1510	1276	1349	955	719	440	11206
	87-88	346	393	578	763	1180	1534	1577	1326	1355	957	741	360	11110
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	86-87	4	8	171	551	873	1190	1132	931	961	513	284	62	6680
	87-88	21	66	158	502	840	1209	1354	1022	943	569	321	35	7040
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	86-87	0	0	154	498	852	1135	1155	848	872	435	165	20	6134
	87-88	12	33	159	464	805	1169	1383	1035	847	509	222	20	6658
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	86-87	41	28	402	623	894	1147	1262	957	999	579	376	94	7402
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	86-87	1	6	183	532	809	1085	1190	876	856	426	233	12	6209
	87-88	5	30	129	349	849	1160	1332	1003	817	468	230	26	6398
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	86-87	98	45	385	668	927	1182	1326	1013	1063	648	466	163	7984
	87-88	104	105	347	523	947	1292	1548	1187	996	663	485	143	8340
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	86-87	0	0	94	428	741	1069	1082	768	756	358	119	10	5425
	87-88	4	17	43	355	754	1111	1399	903	777	399	167	8	5937
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	86-87	1	3	226	499	795	1081	1216	839	826	431	243	27	6187
	87-88	9	24	125	391	819	1209	1430	1039	865	454	268	14	6647
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	86-87	120	119	M	M	M	M	M	M	1059	608	377	171	2454
	87-88	77	127	330	590	1033	1448	1619	1336	1167	674	433	95	8929
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	86-87	0	4	105	427	847	1193	1072	762	974	395	123	15	5917
	87-88	12	31	108	413	742	M	1475	1029	831	476	197	12	5326
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	86-87	200	129	434	716	1018	1297	1304	1091	1156	719	540	250	8854
	87-88	161	222	426	603	992	1269	1354	1109	1092	720	547	208	8703
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	86-87	1	0	90	421	719	1022	998	775	778	400	206	8	5418
	87-88	4	25	80	330	730	1054	1209	850	803	438	234	13	5770
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	86-87	225	224	530	825	1126	1388	1449	1127	1162	800	576	293	9725
	87-88	215	281	495	740	1242	1499	1572	1343	1340	835	638	184	10384
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	86-87	0	0	84	420	682	984	958	796	789	397	207	6	5323
	87-88	3	30	101	332	707	977	1109	826	773	401	238	25	5522

M = MISSING

JUNE 1988 CLIMATIC DATA

Eastern Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	84.0	53.2	68.6	4.2	98	41	30	145	548	0.85	-1.65	34.0	7
STERLING	91.0	59.0	75.0	6.8	105	49	12	321	656	1.59	-1.14	58.2	8
FORT MORGAN	88.4	58.6	73.5	5.1	101	45	17	278	640	0.60	-1.42	29.7	6
AKRON FAA AP	87.2	56.8	72.0	5.1	99	45	19	239	613	1.81	-0.83	68.6	6
AKRON 4E	87.6	55.7	71.7	5.1	100	46	22	228	589	2.01	-0.70	74.2	9
HOLYOKE	86.2	59.1	72.6	3.5	101	51	17	241	605	0.46	-2.90	13.7	4
BURLINGTON	86.5	59.5	73.0	3.3	100	49	14	262	640	2.52	0.20	108.6	6
LIMON WSMO	82.0	52.8	67.4	3.4	92	43	35	115	521	2.50	0.70	138.9	10
CHEYENNE WELLS	89.4	59.0	74.2	4.7	102	49	8	290	643	2.93	0.78	136.3	10
EADS	91.5	59.7	75.6	4.6	105	49	0	325	678	1.60	-0.44	78.4	7
LAMAR	92.4	57.0	74.7	1.5	103	44	6	303	644	1.02	-1.30	44.0	8
LAS ANIMAS	94.1	59.7	76.9	3.5	103	48	1	367	682	1.91	0.17	109.8	8
HOLLY	92.4	54.2	73.3	0.7	105	45	5	261	596	3.21	0.14	104.6	6
SPRINGFIELD 7WSW	89.8	57.9	73.9	3.8	99	44	7	270	620	2.45	0.34	116.1	7

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	84.8	55.6	70.2	4.8	98	43	8	172	588	1.49	-0.35	81.0	7
GREELEY UNC	88.2	56.7	72.5	4.6	101	42	6	236	621	1.15	-0.66	63.5	6
LONGMONT 2ESE	87.5	53.0	70.2	4.3	101	38	20	186	569	0.82	-1.18	41.0	5
BOULDER	85.7	56.1	70.9	3.7	98	40	14	199	610	0.70	-1.56	31.0	10
DENVER WSFO AP	86.0	57.7	71.8	5.4	99	42	14	225	624	1.28	-0.59	68.4	8
EVERGREEN	77.5	45.4	61.4	3.7	89	31	111	11	423	2.51	0.40	119.0	14
LAKE GEORGE 8SW	72.3	42.8	57.5	2.5	81	27	215	0	343	2.79	1.51	218.0	15
RUXTON PARK	69.0	37.9	53.5	2.1	78	26	338	0	293	4.09	1.73	173.3	18
COLORADO SPRINGS	82.7	54.7	68.7	3.5	93	38	25	143	552	1.69	-0.63	72.8	10
CANON CITY 2SE	85.1	58.0	71.5	3.8	94	40	16	221	626	2.37	1.07	182.3	10
PUEBLO WSO AP	90.6	55.7	73.1	2.2	100	37	8	261	627	1.86	0.54	140.9	12
WALSENBURG	84.0	53.4	68.7	2.1	91	35	25	142	562	2.19	0.97	179.5	12
TRINIDAD FAA AP	86.1	54.2	70.1	1.7	95	38	13	174	581	2.02	0.49	132.0	8

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	78.0	39.5	58.8	5.6	89	25	184	2	425	0.74	-0.28	72.5	6
LEADVILLE 2SW	69.5	35.0	52.2	3.7	78	25	360	0	290	2.09	1.09	209.0	18
BUENA VISTA	77.5	46.1	61.8	3.1	87	39	102	15	422	2.42	1.61	298.8	18
SAGUACHE	75.5	45.6	60.6	2.2	84	35	131	3	397	1.02	0.45	178.9	12
HERMIT 7ESE	71.8	35.7	53.7	4.3	80	20	332	0	337	1.95	1.23	270.8	6
ALAMOSA WSO AP	80.3	43.2	61.7	2.6	90	26	102	13	463	0.83	0.11	115.3	12
STEAMBOAT SPRINGS	82.5	42.8	62.7	7.9	91	35	95	34	490	0.64	-0.81	44.1	4
GRAND LAKE 6SSW	72.5	41.1	56.8	4.9	78	28	238	0	345	1.83	0.53	140.8	16
DILLON 1E	70.6	37.4	54.0	3.4	80	27	322	0	316	1.29	0.13	111.2	12
CLIMAX	54.2	36.4	45.3	0.2	67	20	586	0	103	2.21	0.73	149.3	12
ASPEN 1SW	76.3	45.7	61.0	6.0	86	29	123	9	406	1.86	0.45	131.9	11
TAYLOR PARK	68.7	38.5	53.6	6.6	77	28	334	0	289	2.30	1.24	217.0	12
TELLURIDE	75.2	40.3	57.8	3.7	87	27	208	1	386	0.99	-0.23	81.1	11
PAGOSA SPRINGS	80.3	41.1	60.7	3.6	91	26	143	23	453	1.61	0.84	209.1	10
SILVERTON	70.7	32.0	51.3	3.3	82	19	401	0	316	1.50	0.25	120.0	14
WOLF CREEK PASS 1	65.2	35.6	50.4	3.0	73	29	431	0	236	2.34	0.70	142.7	15

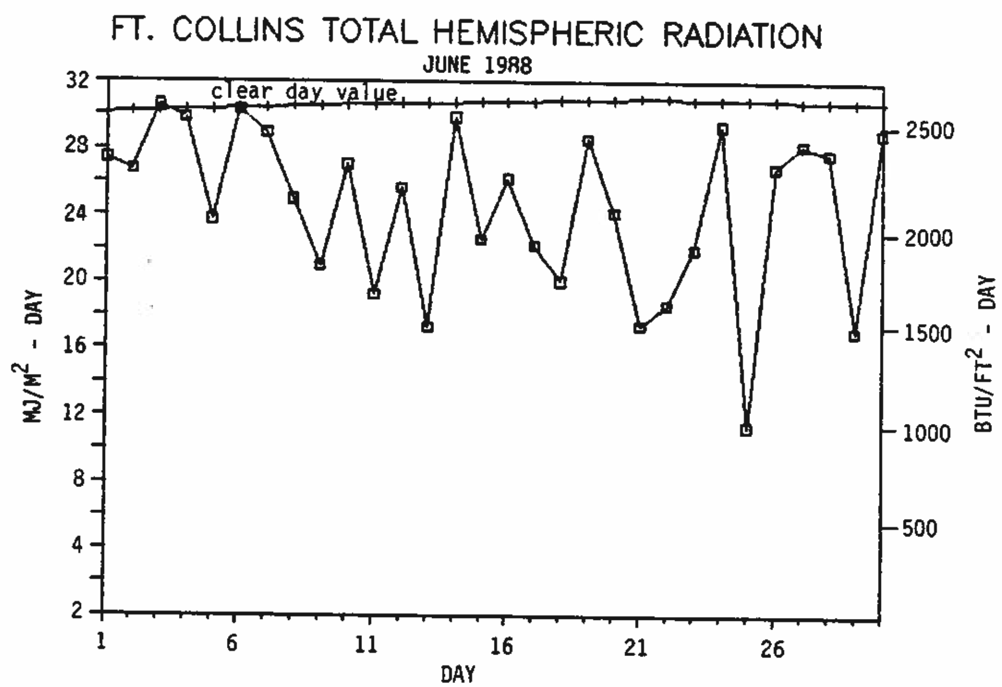
Western Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
CRAIG 4SW	82.5	49.0	65.7	6.4	94	37	52	82	498	0.55	-0.80	40.7	2
HAYDEN	83.3	48.7	66.0	6.1	91	40	32	67	512	0.47	-0.75	38.5	4
RANGELY 1E	89.2	54.1	71.6	5.5	100	38	11	218	613	0.34	-0.39	46.6	4
EAGLE FAA AP	84.0	46.1	65.0	5.6	94	29	52	62	511	1.07	0.22	125.9	6
GLENWOOD SPRINGS	86.8	51.5	69.2	6.1	9999	43	15	111	411	0.22	-1.09	16.8	6
RIFLE	88.0	50.8	69.4	5.8	97	34	14	156	568	1.09	0.26	131.3	6
GRAND JUNCTION WS	91.4	61.6	76.5	4.5	101	39	8	360	715	0.21	-0.29	42.0	4
CEDAREDGE	88.1	52.8	70.5	5.0	97	35	14	185	584	0.57	-0.16	78.1	6
PAONIA 1SW	87.7	53.9	70.8	5.3	100	37	25	193	541	1.09	0.29	136.2	7
MONTROSE NO. 2	86.4	54.8	70.6	4.7	95	38	26	201	588	0.24	-0.37	39.3	6
URAVAN	91.6	56.1	73.8	3.6	103	40	12	285	627	0.42	-0.00	100.0	4
NORWOOD	80.1	46.2	63.1	3.1	92	29	76	29	458	0.85	-0.01	98.8	4
YELLOW JACKET 2W	82.3	51.5	66.9	3.6	95	35	34	101	522	1.16	0.67	236.7	7
CORTEZ	83.6	49.9	66.7	4.2	95	30	56	118	533	1.80	1.39	439.0	6
DURANGO	83.5	47.1	65.3	3.9	94	30	42	57	472	2.03	1.46	356.1	10
IGNACIO 1N	88.8	46.1	67.4	6.2	101	29	27	108	540	1.67	1.14	315.1	9

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

JUNE 1988 SUNSHINE AND SOLAR RADIATION

	Number of Days				
Station	clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	7	16	7	--	--
Denver	8	13	9	64%	71%
Fort Collins	5	17	8	--	--
Grand Junction	12	8	10	80%	79%
Pueblo	10	14	6	82%	79%



Drought Rears Its Ugly Head?: (continued)

"old" water stored up from previous wet years. If the rivers and reservoirs are low, we're in a drought. To the ski industry, however, what matters most is the early winter snowfall. If it hasn't snowed much by Christmas, we're having a drought. The Christmas holiday is so important to profit margins that it has been well worth it for several ski areas to invest millions of dollars into snow-making equipment. Dryland farmers have a totally different view of drought. For wheat growers, any deficits in precipitation that lead to reduced crop yields can be called a drought. Spring and early summer precipitation is most important for wheat, but winter snows contribute to soil moisture, and late summer-early fall rains are needed for seed germination and establishment. From forest fire potential and fish reproduction to statewide tax revenues, life in Colorado can be affected by drought.

When it's all said and done, the definition of drought that seems to make the most sense can be derived from the following equation:

WATER SUPPLY = WATER DEMAND

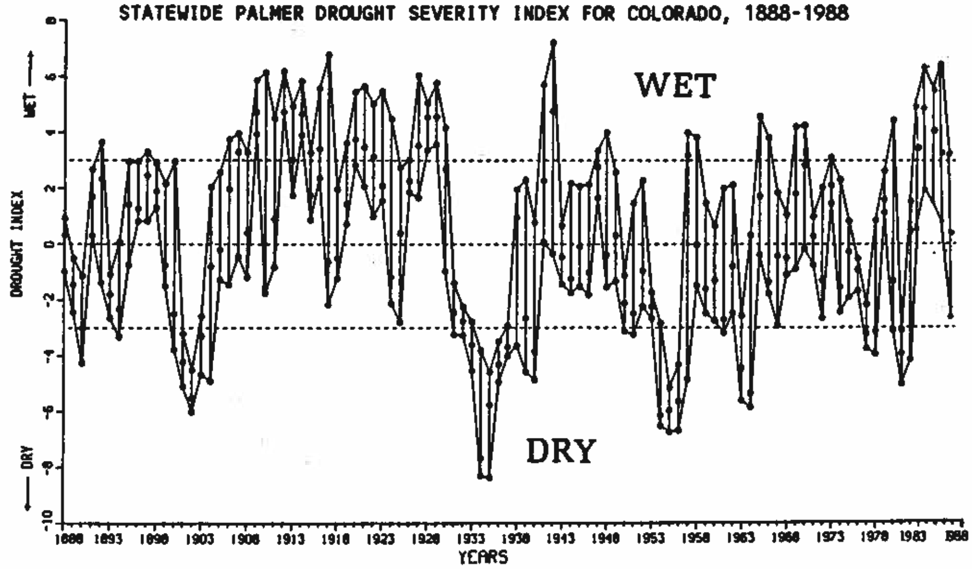
When supply falls short of demand, and the shortfall begins to result in problems and impact, then it is safe to say we have a drought. The worrisome thing about this definition is that it means that we, by increasing the demand for water, can have drought even when we are receiving average or above precipitation. As climatologists, we keep track of the supply -- all of which can be traced back to precipitation. The supply varies greatly from place to place, season to season and year to year. We can quote all sorts of fascinating statistics about dry periods and precipitation deficits, but it's still only part of the story. Population, economy, industry, agriculture and our own water use habits all effect the demand. That's even harder to keep track of than the supply.

We have learned how to adjust to some of the natural and often extreme variations in our precipitation climate. Stabilizing and even increasing local water supplies have been accomplished by building dams and reservoirs, by diverting water from one basin to another and possibly by using weather modification technology (cloud seeding). But these adjustments sometimes lead to higher demand for water. It wasn't all that long ago that much of the runoff from the Upper Colorado River made its way to the Gulf of California. Very few people cared if the Rockies had a dry year. Times have changed, and that water is now consumed for agriculture and diverted toward growing cities in the sunny southwest. Drought is increasingly a topic of urgent conversation. The other options are decreasing demand and increasing reuse of water resources. Improved irrigation techniques, low-water use landscaping, new hybrids and alternate crops are just a few items on the long list of opportunities that we have to reduce water demand.

Climatologists will continue to get better at monitoring water supplies and assessing variations. We may even develop some skill at predicting precipitation a few weeks and months in advance. We can tell you with confidence that there will be periods in the future when precipitation will be low -- much lower than this year in Colorado. But the planners, the policy makers, the researchers, the educators, the developers and all of the people who choose Colorado as their home will determine if these dry periods will result in a drought. Let's work together now, to make sure that they don't.

A display on drought is presently being developed by the Colorado Climate Center and several cooperating groups for the 1988 State Fair. I hope you'll be there.

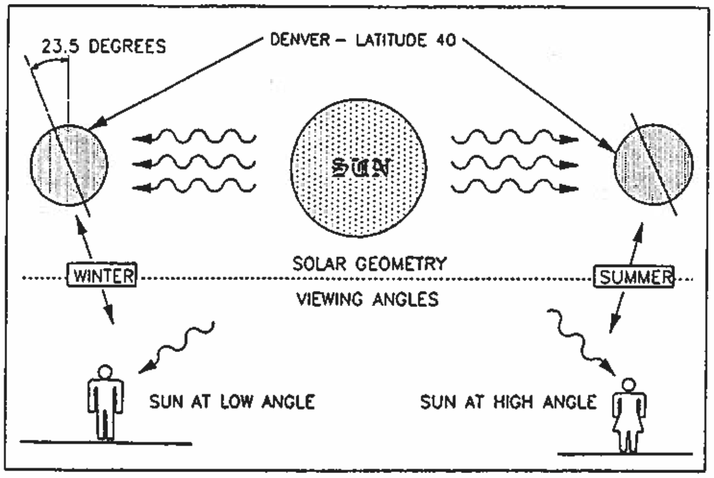
STATEWIDE PALMER DROUGHT SEVERITY INDEX FOR COLORADO, 1888-1988



Solar Geometry

Interest in the motion of the heavenly bodies has been with us for thousands of years. One of the first attempts to quantify the movement of the sun and stars goes back as far as the second century A.D. and the theories of the Greco-Egyptian mathematician Ptolmey. The Ptolmaic system puts a stationary earth at the center of the universe, with the sun, moon and stars revolving about it in circular orbits at a uniform rate.

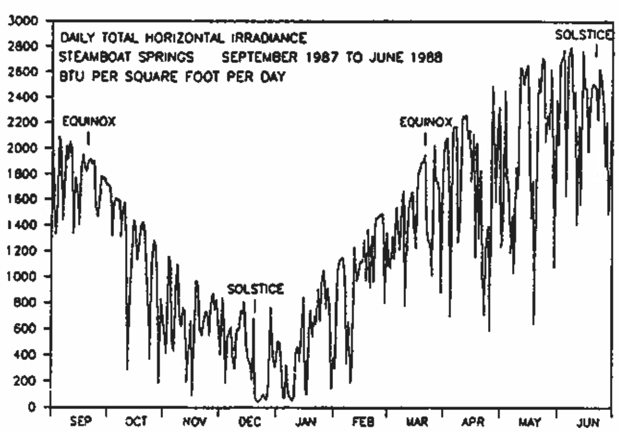
Now, of course, we understand that the sun is low in the sky in the winter and high in the summer due to the rotation of the earth around the sun (see the picture below). The solar intensity is greatest at the summer solstice which usually occurs on June 21. This being a leap year, however, the solstice is shifted by a day; summer arrived on June 20th in 1988.



Solar Architecture

By knowing the position of the sun during various seasons of the year and at specific times of the day, it is possible to design buildings which are solar heated in the winter but do not overheat during the summer. The early Greeks were well acquainted with the sun's motion as attested by their use of sun dials, and in the 5th century B.C. the town of Olynthus became one of the first planned solar communities. This town was located atop a large plateau, with the houses all oriented to face south and placed sufficiently far apart to allow for direct access to the sun's energy. Clever use of overhangs to block solar radiation in the summer when the sun was high in the sky, and minimizing openings on north walls to reduce heat loss caused by prevailing winds from the north, kept these homes comfortable throughout the year. The Romans also used solar energy to heat their famous bath houses. A south facing bath room would usually be enclosed by walls on the north, east, and west sides and mica glazing on the south - in the summer these baths often doubled as steam rooms!

One of the tricks when utilizing the sun's heat is to capture as much of the winter sun as possible while at the same time excluding the summer sun. Perhaps the biggest complaint about sun spaces is that they get too hot in the summer or not hot enough in the winter. This, more often than not, is the fault of a designer who did not pay enough attention to the solar geometry for that particular location. If you live in a house surrounded by deciduous trees you have probably noticed that there is more light coming in your windows in winter than in summer. This scheme is used for solar energy applications, often by placing a vine-covered trellis above the window where the heat collection is taking place. During the winter the vines are leafless and allow light to pass through, while during the summer the leaves provide needed shading and can, providing you are using a fruit vine of some sort, provide a tasty snack as well!



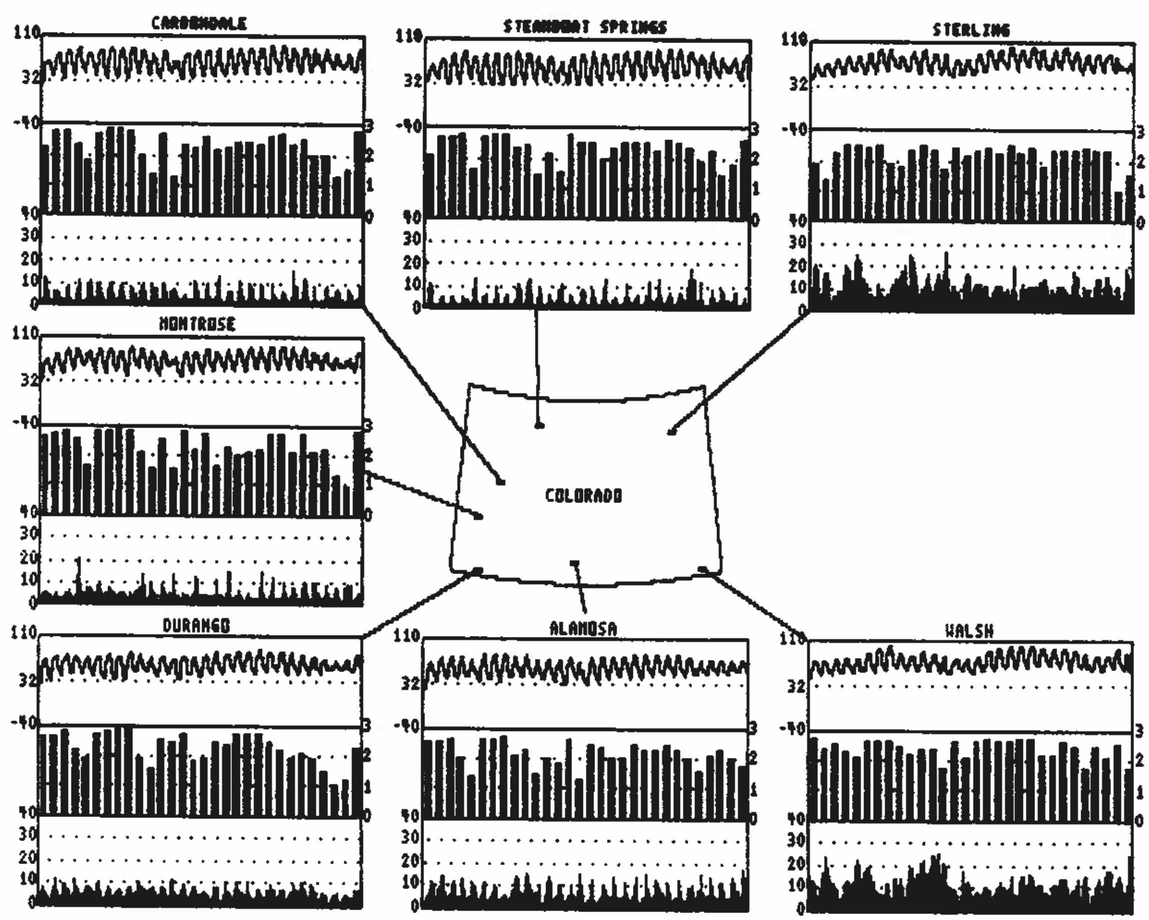
The graph to the left shows the total daily solar radiation incident on a horizontal surface in Steamboat Springs from September 1987 through June 1988. The winter solstice occured on December 21, right before the Christmas blizzard. You can see that almost no radiation passed through the clouds and snow for the five days of this storm, although there were probably few complaints from skiers.

WTHRNET WEATHER DATA - JUNE 1988

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
monthly average temperature (°F)						
	60.4	61.6	63.9	68.1	60.6	74.1
monthly temperature extremes and time of occurance (°F day/hour)						
maximum:	84.6 21/15	84.9 21/15	90.8 23/15	91.6 22/16	89.3 24/15	99.4 21/15
minimum:	26.3 1/ 3	29.6 1/ 5	29.6 1/ 5	33.8 1/ 5	30.7 9/ 4	46.1 1/ 5
monthly average relative humidity / dewpoint (percent / °F)						
5 AM	87 / 41	76 / 41	92 / 42	58 / 43	96 / 39	77 / 55
11 AM	37 / 61	36 / 63	28 / 69	25 / 71	35 / 64	35 / 76
2 PM	25 / 69	30 / 68	22 / 75	20 / 79	26 / 72	29 / 81
5 PM	31 / 65	32 / 66	23 / 74	21 / 76	28 / 70	32 / 80
11 PM	59 / 48	57 / 48	54 / 50	36 / 56	73 / 48	61 / 60
monthly average wind direction (degrees clockwise from north)						
day	177	192	225	236	182	n/a
night	172	92	169	151	34	n/a
monthly average wind speed (miles per hour)						
	4.89	3.72	3.60	3.86	3.27	9.34
wind speed distribution (hours per month for given mph range)						
0 to 3	235	343	424	310	441	35
3 to 12	457	376	293	397	268	498
12 to 24	28	0	3	12	11	183
> 24	0	0	0	0	0	4
monthly average daily total insolation (Btu/ft²·day)						
	2171	2261	2286	2281	2311	2395
"clearness" distribution (hours per month in specified clearness index range)						
60-80%	211	180	220	208	252	264
40-60%	89	66	86	80	76	84
20-40%	71	59	52	52	43	38
0-20%	42	47	31	39	38	26

The State-Wide Picture

The figure below shows the monthly weather for the eight WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40 degrees to 110 degrees Fahrenheit, the middle one gives the daily total solar radiation on a horizontal plane, up to 3000 Btu per square foot per day, and the bottom graph illustrates the hourly average wind speed from 0 to 40 miles per hour. Date continues to be unavailable from the Stratton station.



COLORADO CLIMATE

JULY 1988

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 10

July in Review:

July temperatures were warm but very close to average -- a bit warmer than average west of the continental divide and just a bit cooler than average to the east. Thunderheads developed almost every day, but total rainfall for the month was below average over most of the state.

Colorado's September Climate:

September has a well-deserved reputation for being a tranquil and enjoyable month. Sunshine is abundant, and September often has more clear days than any other month of the year (see special feature below). Humidity decreases, thunderstorms diminish and winds are light -- you have to be pretty grouchy to dislike most of what September weather has to offer.

September marks the end of summer in Colorado. Daylength shortens rapidly -- faster than any other month. With longer nights come cooler temperatures, but bright sunshine helps keep daytime temperatures quite warm. Highs in the 70s and 80s are common at elevations below about 7,000 feet. Nighttime temperatures begin to get quite chilly. While low elevation temperatures are generally in the 40s and 50s at night, some 30s are possible by the end of the month. Mountain temperatures may even drop into the teens. Climax had one of the coldest temperatures ever reported in September in Colorado, 6°F on September 18, 1971.

September tends to be a dry month. There have been a few years, such as 1978, when almost no precipitation fell anywhere in the state. On the average, September precipitation totals about 1.00" to 1.50" across the majority of the state and is quite uniformly distributed. Drier areas include the San Luis Valley, the Arkansas Valley from Pueblo to LaJunta and extreme western valleys including Grand Junction. The wettest area is the San Juan mountains where 2"-4" rains are normal.

September weather is pleasant, but it may sound boring. There can, however, still be some pretty exciting events. The northern mountains will often get one or two dustings of snow. Even the lower elevations can get snow and dramatic temperature drops although it is uncommon. Some very heavy rains have also fallen in September, especially in the southwest mountains and along parts of the Front Range. The culprit for these rains are often deceased Pacific hurricanes which spread copious moisture northeastward into the area as they decay. Even with these possible interruptions, September is still an incredible month to get out and enjoy Colorado.

Clear Weather Ahead?

One thing I've learned over the years, which applies both to climate and to other part of life, is don't count on your recollections and perceptions -- stick with facts. At least this once, though, I think my perceptions are correct. I've always thought that September sunshine was brighter, and the sky bluer than other times of the year. Here are a few statistics and graphs to back it up. The graph of average number of clear days (clear days are defined as days on which 0 to 3/10 of the sky is covered by cloud averaged over the period from sunrise to sunset) shows two distinct peaks at all of Colorado's five First-Order National Weather Service observing stations. Grand Junction, Pueblo and Denver all have more clear days in September than in any other month. At Alamosa and Colorado Springs the best is yet to come since October is their clearest month. In all cases, the autumn peak in clear days surpasses the normal but briefer June clear day peak. With 17 clear days in an average October, Alamosa is Colorado's blue sky capital city. You can certainly see by looking at this graph how the summer thunderstorm season in July and August cut-down on our sunshine.

(continued on page 9)

JULY 1988 DAILY WEATHER

Date	Event
1-6	Normal hot summer weather. Afternoon and evening scattered thundershowers with some gusty winds and reports of hail. Akron had nearly 1" rain late on the 2nd with hail. Pueblo reported 0.93" on the 6th. A fine 4th of July, but lightning injured several people in the Denver area.
7-10	A weak cold front pushed across Colorado early on the day of the 7th. Cooler but moist air moved into eastern Colorado and helped fuel some very heavy thunderstorms late in the day. A number of areas reported heavy rains on the 7th with some local flooding. Examples included 1.41" at Denver, 3.09" at Windsor and 3.30" near Flagler. While it remained warm and mostly dry west of the mountains, humid and stormy weather continued east of the mountains on the 8th and 9th. Crestone reported 0.86" of rain on the 8th. Heavy hail fell along parts of the southern Front Range on the 9th. Snowplows were used near Colorado Springs to clear I-25. Walsenburg totalled 1.15" of moisture and the Kim 10SSE station (Las Animas county) reported 1.80". Convection decreased on the 10th as drier air returned to most of Colorado.
11-15	A typical mid-summer heatwave baked Colorado. Most low elevation areas had hot high temperatures in the 90s and 100s. Pueblo hit a record high of 104° on the 14th and Campo and Eads each hit 106°. Wray and Las Animas tied for the state's hot spot with 107° readings on the 13th and 15th, respectively. Thunderstorms developed each day, especially near the mountains, but precipitation was minimal.
16-22	Humidities began to increase again on the 16th and a round of thunderstorms developed over the eastern plains that dropped some locally heavy rains. Arapahoe and Otis 11NE reported 1.40" and 1.98" of rain, respectively, on the 17th, but Julesburg's 4.40" report was the greatest in the state. Cooler air pushed in from the northeast on the 18th and more storms rumbled across the plains. Akron picked up 1.42" of rain and Yuma had 1.23". Meanwhile, the mountains and Western Slope enjoyed some lovely sunny weather with warm days and cool nights. On the 19th moist upslope conditions developed along the Front Range with light rain and drizzle. Denver's high temperature on the 19th was only 65° and some foothills locations stayed in the 50s. More scattered rains on the plains. Lamar got 0.86". Skies cleared on the 20th but temperatures remained cool. Silverton and Fraser each had a low of 27° on the 21st, the coldest in the state. On the 22nd morning lows were chilly but afternoon temperatures soared. Alamosa had both its coldest and warmest temperature of the month on the same day (low 38°, high 90°). Palisade hit 105° on the 22nd, their warmest reading of the month.
23-31	Typical late July weather. Increasing daily thunderstorm activity, especially 26th-31st as monsoon moisture moved into the state from the south. Rainfall was not as heavy as it often is at this time of year, though, and northern portions of the state remained dry. Examples of daily rainfall totals included 0.80" at Fowler on the 26th, 0.72" at Altenbern on the 27th, 0.78" at Evergreen on the 28th, 0.47" at Creede on the 29th and 0.54" at Buena Vista on the 30th.

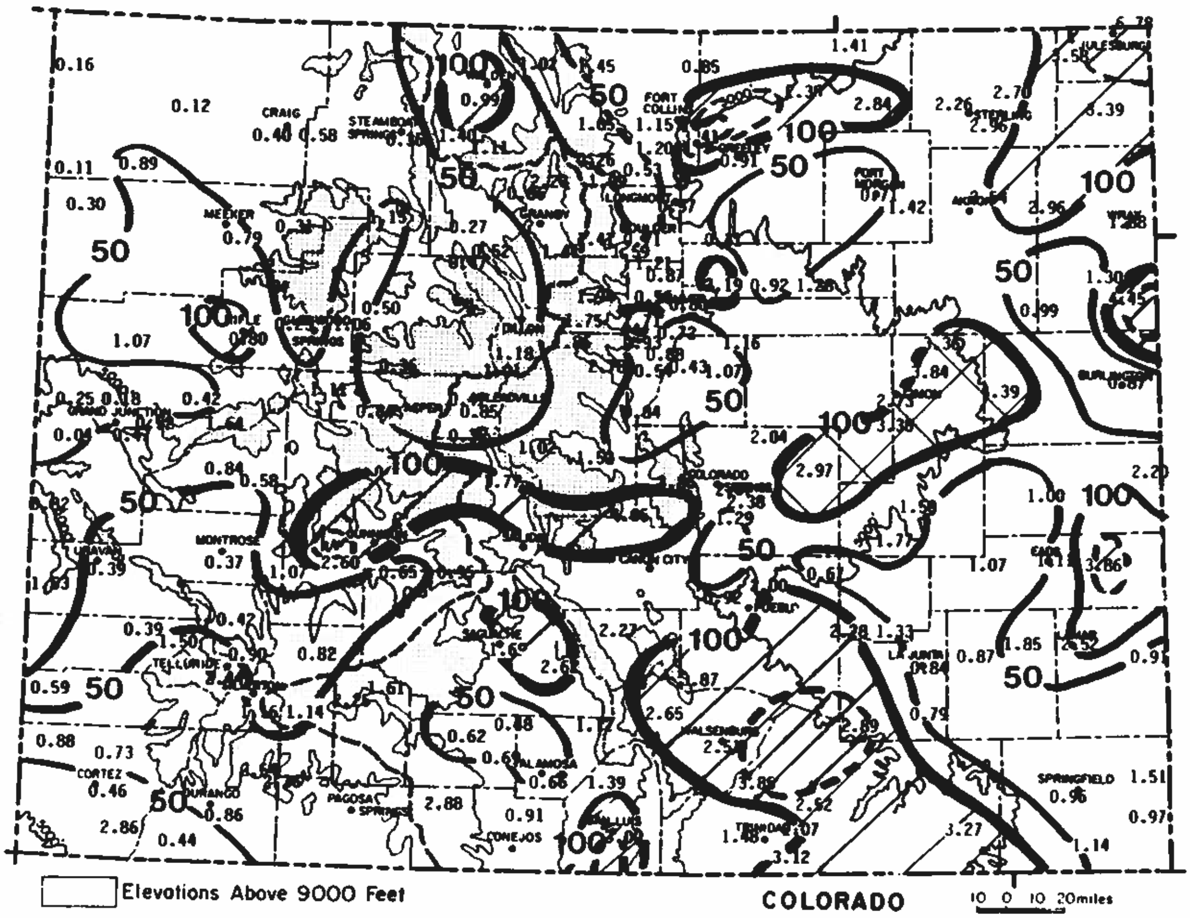
July 1988 Extremes

Highest Temperature	107°F	July 13 July 15	Wray Las Animas
Lowest Temperature	27°F	July 21	Silverton, Fraser
Greatest Total Precipitation	6.78"		Julesburg
Least Total Precipitation	0.04"		Colorado National Monument

JULY 1988 PRECIPITATION

Thunderstorms rumbled across parts of Colorado on almost every day in July. But the storms didn't drop as much moisture as they usually do. There were a few places that got drenched, but the majority of the state was considerably drier than average. A number of areas including portions of the Eastern Plains and much of northwestern and southwestern Colorado received less than 50% of the July average. At Craig this was the 11th consecutive month with below average precipitation. Wet areas included a narrow band in central Colorado from west of Gunnison to near Pikes Peak, the southern Front Range from Pueblo to east of Trinidad and parts of central and northeast Colorado. With the help of one 3" deluge, Windsor more than doubled their July average.

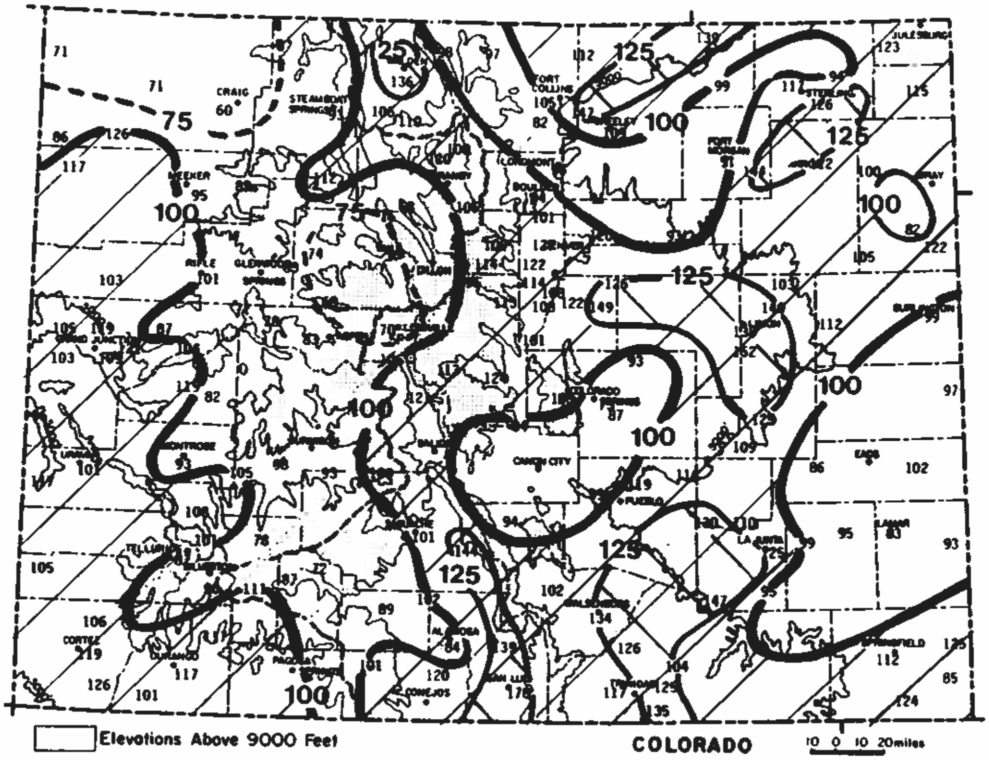
Greatest		Least	
Julesburg	6.78"	Colorado Natl Mon.	0.04"
Bonny Lake	4.45"	Dinosaur Natl Mon.	0.11"
Flagler 2NW	4.39"	Maybell	0.12"
Guffey 10SE	4.05"	Browns Park Refuge	0.16"
Rye	3.87"	Grand Junction NWS	0.18"



Precipitation amounts (inches) for July 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

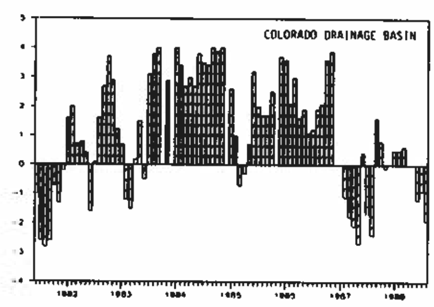
1988 WATER YEAR PRECIPITION

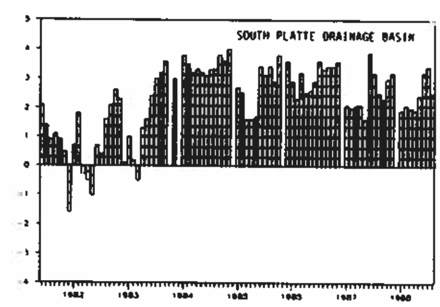
Dry areas expanded in July. For the first 10 months of the 1988 water year most of the mountains are below their 1961-80 average. Drier than average conditions are also expanding on the Eastern Plains. However, the only extremely dry areas are in Moffat and Eagle counties where precipitation has been less than 75% of average. A few areas persist with precipitation totals of at least 125% of average. These areas include Windsor, Akron, Limon, Castle Rock, Walsenburg, Fowler and Crestone.

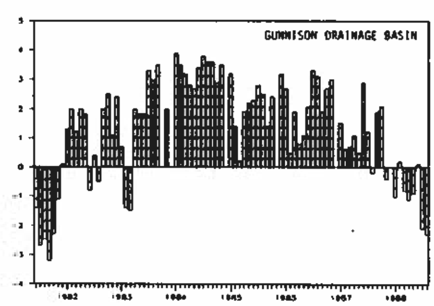


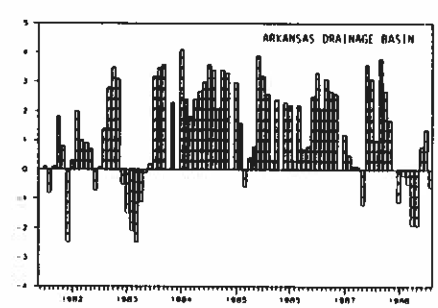
Precipitation for October 1987 through July 1988 as a percent of the 1961-1980 average.

Below are graphs showing an index of surface water supplies in various Colorado basins since 1981. The Surface Water Supply Index combines information on precipitation, snowpack, streamflow and reservoir levels. Positive values denote wetter than average conditions.



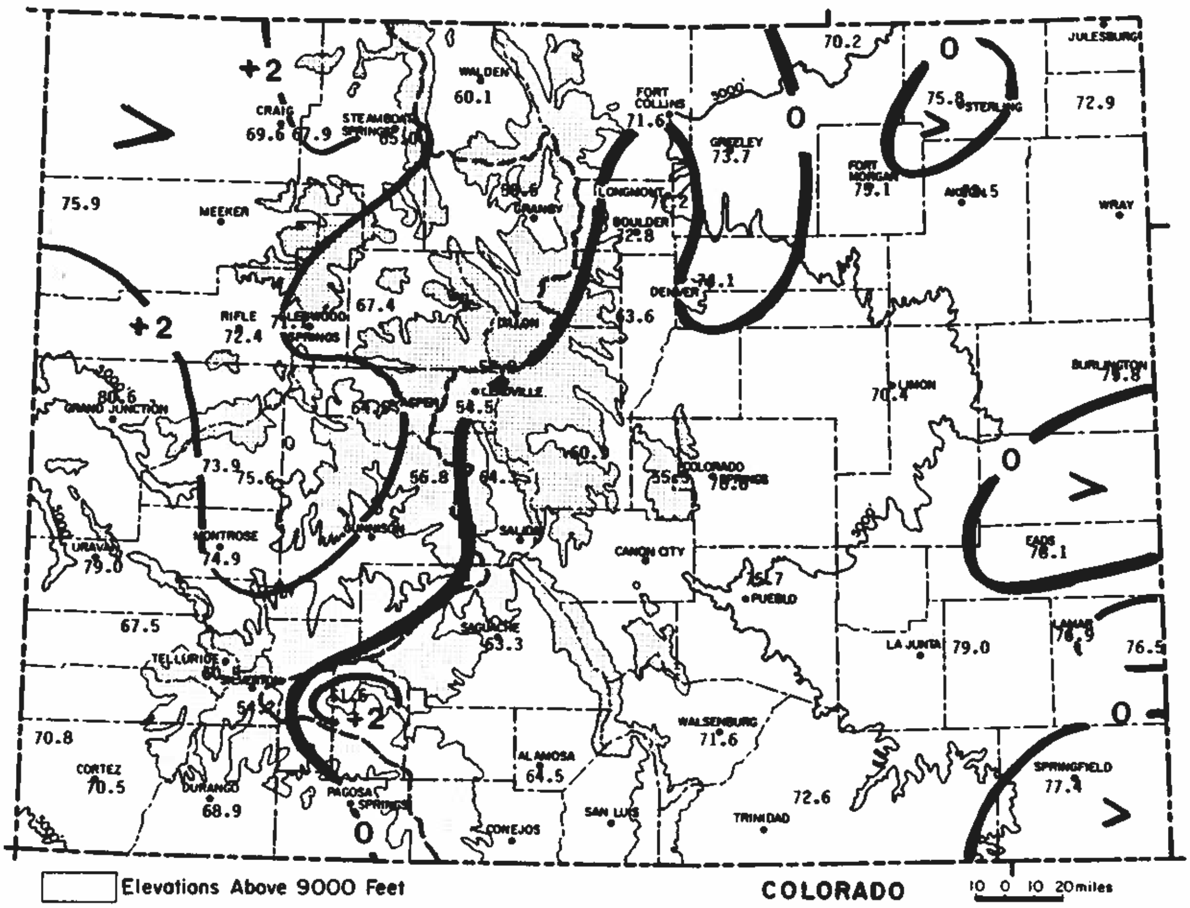






JULY 1988 TEMPERATURES AND DEGREE DAYS

July temperatures were close to average statewide. West of the continental divide temperatures were mostly 1 or 2 degrees above average while east of the mountains most areas were slightly colder than average. There were no unusual persisting episodes of hot or cool weather although a handful of records were set.



July 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

JULY 1988 SOIL TEMPERATURES

Near surface soil temperatures were unusually high early in July but leveled off and were close to average by the end of the month.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

FORT COLLINS 7 AM SOIL TEMPERATURES
JULY 1988

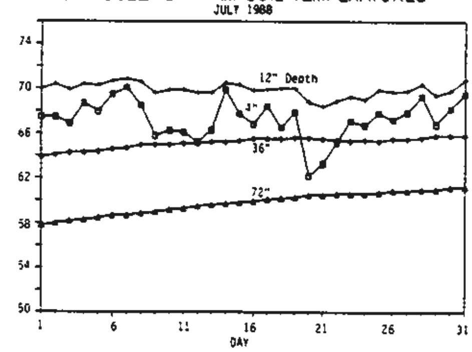


Table 1. Heating Degree Day Data through June 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	87-88	66	96	364	601	1130	1556	1867	1381	1031	658	454	102	9306
	88-89	28												28
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	87-88	112	152	355	563	1024	1382	1450	1146	1136	734	517	123	8694
	88-89	34												34
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	87-88	7	33	122	370	713	1053	1107	842	739	400	203	14	5603
	88-89	1												1
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	87-88	49	117	313	549	955	1277	1357	1010	1030	639	472	102	7870
	88-89	37												37
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	87-88	5	20	72	375	724	1037	1221	935	779	449	178	14	5809
	88-89	4												4
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	87-88	11	36	87	374	668	1007	1144	858	767	407	191	16	5566
	88-89	M												0
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	87-88	17	74	150	445	767	1108	1256	958	886	499	273	25	6458
	88-89	7												7
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	87-88	6	35	154	396	860	1179	1351	1008	899	609	362	56	6915
	88-89	0												0
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	87-88	55	96	227	534	950	1376	1561	1264	1076	593	399	52	8183
	88-89	1												1
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	87-88	0	11	108	354	737	1102	1300	M	M	M	M	M	3612
	88-89	M												0
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	87-88	11	21	110	410	745	1125	1227	889	811	437	215	14	6015
	88-89	7												7
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	87-88	296	346	556	763	1145	1491	1629	1376	1379	933	717	322	10953
	88-89	M												0
DURANGO	AVE	9	34	193	495	837	1153	1218	958	862	600	366	125	6848
	87-88	14	44	188	435	851	1206	1391	972	859	514	346	42	6862
	88-89	1												1
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	87-88	54	75	254	509	950	1331	1544	1173	1002	607	404	52	7955
	88-89	3												3
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	87-88	69	118	333	602	922	1255	1310	1029	992	645	462	111	7848
	88-89	60												60
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	87-88	12	37	146	453	784	1140	1252	936	821	479	217	8	6285
	88-89	3												3
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	87-88	12	29	110	430	773	1154	1484	1055	826	495	206	17	6591
	88-89	6												6
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	87-88	0	6	34	248	754	1147	1469	1031	741	350	172	8	5960
	88-89	0												0

M = MISSING

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	87-88	207	257	480	677	1098	1516	1642	1413	1372	907	602	238	10409
	88-89	191												191
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	87-88	10	26	119	424	762	1157	1363	955	807	437	204	6	6270
	88-89	5												5
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
	88-89	M												0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	87-88	0	3	35	273	653	1032	1278	837	638	327	103	1	5180
	88-89	0												0
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	87-88	346	393	578	763	1180	1534	1577	1326	1355	957	741	360	11110
	88-89	318												318
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	87-88	21	66	158	502	840	1209	1354	1022	943	569	321	35	7040
	88-89	9												9
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	87-88	12	33	159	464	805	1169	1383	1035	847	509	222	20	6658
	88-89	10												10
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
	88-89	M												0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	87-88	5	30	129	349	849	1160	1332	1003	817	468	230	26	6398
	88-89	0												0
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	87-88	104	105	347	523	947	1292	1548	1187	996	663	485	143	8340
	88-89	30												30
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	87-88	4	17	43	355	754	1111	1399	903	777	399	167	8	5937
	88-89	1												1
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	87-88	9	24	125	391	819	1209	1430	1039	865	454	268	14	6647
	88-89	0												0
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	87-88	77	127	330	590	1033	1448	1619	1336	1167	674	433	95	8929
	88-89	27												27
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	87-88	2	31	108	413	742	M	1475	1029	831	476	197	12	5326
	88-89	1												1
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	87-88	161	222	426	603	992	1269	1354	1109	1092	720	547	208	8703
	88-89	131												131
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	87-88	4	25	80	330	730	1054	1209	850	803	438	234	13	5770
	88-89	8												8
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	87-88	215	281	495	740	1242	1499	1572	1343	1340	835	638	184	10384
	88-89	144												144
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	87-88	3	30	101	332	707	977	1109	826	773	401	238	25	5522
	88-89	2												2

M = MISSING

JULY 1988 CLIMATIC DATA

Eastern Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	86.4	54.1	70.2	-0.9	95	46	13	175	576	1.41	-0.75	65.3	7
STERLING	91.9	59.8	75.8	1.1	102	49	1	344	707	2.26	-0.31	87.9	8
FORT MORGAN	91.5	58.7	75.1	-0.1	99	49	6	329	687	0.71	-0.99	41.8	4
AKRON FAA AP	89.9	57.2	73.5	-0.1	100	49	6	277	661	3.01	0.38	114.4	9
AKRON 4E	89.0	55.9	72.5	-0.9	100	46	12	251	635	2.54	-0.03	98.8	11
HOLYOKE	86.5	59.3	72.9	-2.1	97	53	6	262	678	3.39	0.61	121.9	6
BURLINGTON	90.5	61.0	75.8	-0.0	100	50	4	347	718	0.87	-1.10	44.2	6
LIMON WSMO	86.2	54.6	70.4	-0.3	95	48	9	183	600	2.73	-0.17	94.1	11
CHEYENNE WELLS	90.5	60.0	75.2	-0.2	100	52	0	325	706	4.67	2.20	189.1	8
EADS	94.3	61.9	78.1	1.1	106	55	2	414	736	1.11	-1.72	39.2	1
LAMAR	94.9	58.9	76.9	-2.0	105	52	0	375	695	2.52	0.12	105.0	8
LAS ANIMAS	97.2	60.8	79.0	-0.3	107	54	0	439	732	0.87	-1.38	38.7	3
HOLLY	95.9	57.1	76.5	-2.2	108	48	0	367	674	0.91	-1.16	44.0	7
SPRINGFIELD 7WSW	95.3	59.5	77.4	2.1	106	53	0	390	708	0.96	-1.48	39.3	5

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	86.2	57.1	71.6	0.1	93	47	3	219	651	1.15	-0.62	65.0	8
GREELEY UNC	89.8	57.7	73.7	0.2	98	48	5	283	669	0.91	-0.30	75.2	4
ESTES PARK	79.9	45.9	62.9	0.6	87	36	68	19	416	0.19	-1.98	8.8	4
LONGMONT 2ESE	89.5	53.0	71.2	-1.2	98	45	10	212	598	0.57	-0.49	53.8	4
BOULDER	88.4	57.2	72.8	-0.7	96	48	1	250	670	0.71	-1.18	37.6	10
DENVER WSFO AP	89.0	59.3	74.1	0.8	96	50	7	300	687	2.19	0.29	115.3	8
EVERGREEN	80.6	46.5	63.6	-0.2	90	39	60	22	481	2.71	0.46	120.4	14
LAKE GEORGE 8SW	74.3	45.8	60.1	-1.2	83	42	146	3	386	1.52	-1.01	60.1	17
RUXTON PARK	72.2	38.8	55.5	-0.8	80	33	288	0	350	3.86	-0.38	91.0	20
COLORADO SPRINGS	85.3	55.9	70.6	-0.6	95	50	7	190	611	2.07	-0.83	71.4	10
PUEBLO WSO AP	93.6	57.7	75.7	-1.5	104	48	1	342	671	2.00	0.06	103.1	12
WALSENBURG	87.1	56.2	71.6	-0.6	93	50	2	215	640	2.51	0.11	104.6	10
TRINIDAD FAA AP	88.5	56.7	72.6	-1.4	97	52	8	252	648	2.52	0.35	116.1	15

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	80.9	39.3	60.1	1.2	86	29	144	0	487	0.99	0.06	106.5	5
LEADVILLE 2SW	72.3	36.6	54.5	-0.0	79	32	318	0	356	0.85	-1.45	37.0	11
BUENA VISTA	81.1	47.5	64.3	-0.6	88	41	37	23	491	1.77	0.20	112.7	12
SAGUACHE	79.0	47.6	63.3	-0.7	87	44	57	12	461	1.69	0.08	105.0	9
HERMIT 7ESE	65.7	37.2	51.5	-4.3	73	31	413	0	250	2.25	-0.07	97.0	7
ALAMOSA WSO AP	83.7	45.3	64.5	-0.6	90	38	28	17	525	0.66	-0.68	49.3	7
STEAMBOAT SPRINGS	85.9	44.0	65.0	3.4	92	36	27	32	543	0.36	-0.92	28.1	7
GRAND LAKE 6SSW	74.9	42.2	58.5	0.4	80	35	191	0	392	0.86	-0.49	63.7	16
CLIMAX	64.1	40.0	52.0	0.3	71	33	393	0	225	1.01	-1.07	48.6	11
ASPEN 1SW	81.1	47.9	64.5	2.5	86	42	34	24	492	0.84	-0.86	49.4	10
TAYLOR PARK	72.7	40.8	56.8	3.4	80	34	246	0	359	1.90	0.36	123.4	7
TELLURIDE	78.1	42.9	60.5	0.5	86	38	131	0	442	2.44	0.02	100.8	18
PAGOSA SPRINGS	84.0	44.7	64.3	0.2	89	40	30	17	524	3.15	1.41	181.0	12
SILVERTON	74.5	33.9	54.2	0.3	81	27	327	0	387	1.16	-1.57	42.5	15

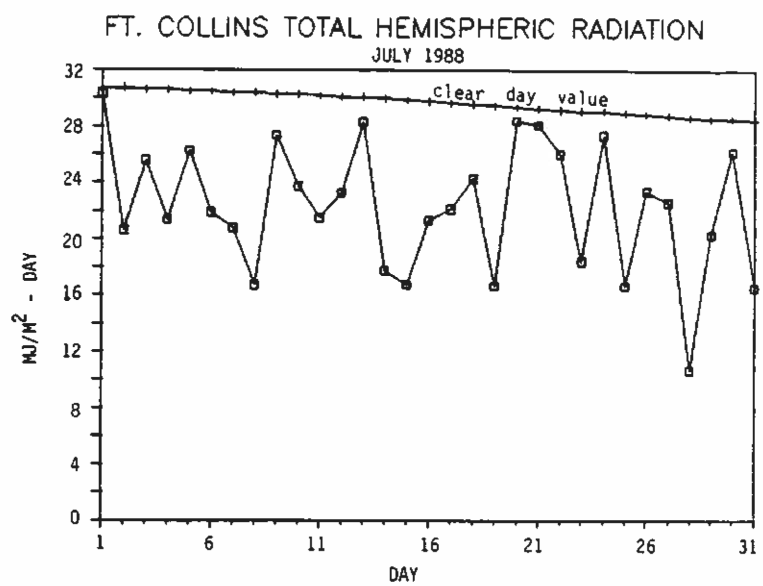
Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	88.2	51.0	69.6	2.9	94	45	1	150	582	0.40	-0.90	30.8	6
HAYDEN	86.5	49.2	67.9	1.1	92	42	3	102	561	0.58	-0.50	53.7	3
RANGELY 1E	93.5	58.3	75.9	2.6	98	53	0	345	691	0.30	-0.64	31.9	3
EAGLE FAA AP	87.4	47.3	67.4	0.9	93	40	3	83	558	0.50	-0.53	48.5	7
GLENWOOD SPRINGS	89.6	52.6	71.1	1.2	96	48	0	198	598	0.25	-1.02	19.7	1
RIFLE	91.6	53.1	72.4	2.1	97	47	0	235	617	0.80	0.11	115.9	7
GRAND JUNCTION WS	95.5	65.6	80.6	1.5	101	61	0	489	806	0.18	-0.38	32.1	3
CEDAREDGE	92.3	55.5	73.9	2.0	98	50	0	284	649	0.84	-0.00	100.0	6
PAONIA 1SW	93.4	57.9	75.6	3.2	99	54	0	336	686	0.58	-0.55	51.3	8
MONTROSE NO. 2	91.4	58.4	74.9	2.6	97	51	0	316	697	0.37	-0.51	42.0	6
URAVAN	98.2	59.8	79.0	1.8	103	54	0	443	717	0.39	-0.77	33.6	7
NORWOOD	84.7	50.5	67.5	1.2	90	43	3	89	537	0.39	-1.37	22.2	4
YELLOW JACKET 2W	87.1	54.6	70.8	0.3	93	50	0	183	602	0.88	-0.42	67.7	7
CORTEZ	88.0	52.9	70.5	1.7	95	45	0	177	606	0.46	-0.57	44.7	4
DURANGO	87.2	50.7	68.9	0.1	94	45	1	128	564	0.86	-0.65	57.0	7
IGNACIO 1N	91.5	50.0	70.8	2.6	99	44	0	188	578	M	M	M	M

* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

JULY 1988 SUNSHINE AND SOLAR RADIATION

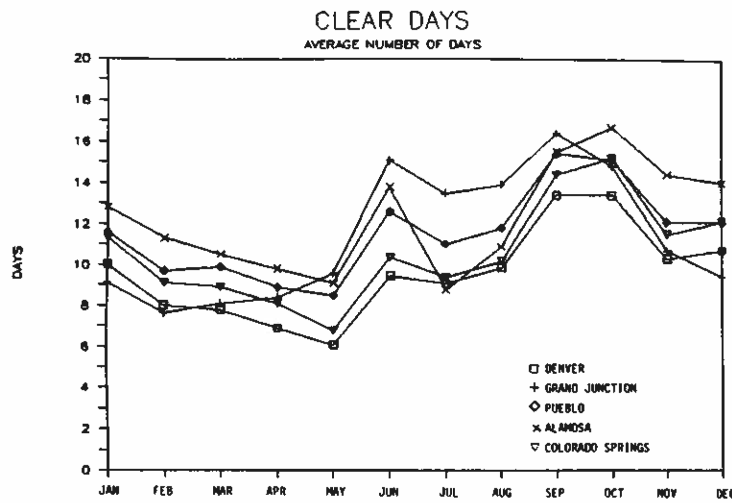
Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	7	17	7	--	--
Denver	8	15	8	64%	71%
Fort Collins	6	20	5	--	--
Grand Junction	12	14	5	82%	78%
Pueblo	12	14	5	77%	78%

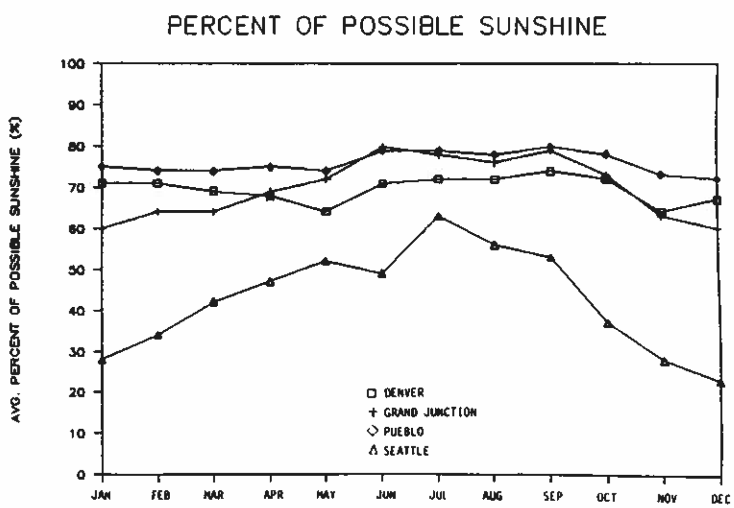


Clear Weather Ahead? (continued from page 1)

The second graph shows the percent of possible sunshine that some Colorado cities receive. We often get calls for this kind of data for all parts of Colorado, but Denver, Pueblo and Grand Junction are the only three locations where "percent of possible sunshine" is measured. Month to month variations are not so dramatic, but again the June and September peaks are visible. Of these three cities, Pueblo wins the sunshine award with 76% of possible sunshine for the whole year. From this graph one of the characteristics of the Western Slope stands out. While sunshine remains high east of the mountains, during the winter the west side of the Rockies is much cloudier. This is a result of moisture from the Pacific brought eastward by the prevailing westerly winds aloft which strengthen during the winter. This same pattern in cloudcover holds true for almost all of the western U.S. The Rockies act as a barrier for this moisture, thus helping Front Range areas to see more winter sunshine. Just for fun, we added Seattle, Washington, to give you something to think about.

Have a pleasant autumn and enjoy the sunshine. It's not just your imagination that makes you think fall in Colorado is mighty nice.





Drought Comes to the State Fair:

Please stop by the Science and Technology Pavilion at the 1988 State Fair August 26 to September 5. Colorado State University will have a number of different displays showing progress of many decades of agricultural research in our state. The Colorado Climate Center's display on drought will hopefully be interesting and educational. Nearly a dozen organizations have contributed materials for this display. I hope you make an effort to take a look.

WTHRNET - JULY 1988

The Underground Movement...?

Earth sheltered homes have been around a long time. The earliest humans sought warmth and protection by residing in caves - a history which appears in the drawings they left us. During the last few millenia people from Tunisia to China inhabited underground dwellings as protection from the hot summers and bitter winters. Even in the American Midwest farmers built sod houses to protect them from the elements.

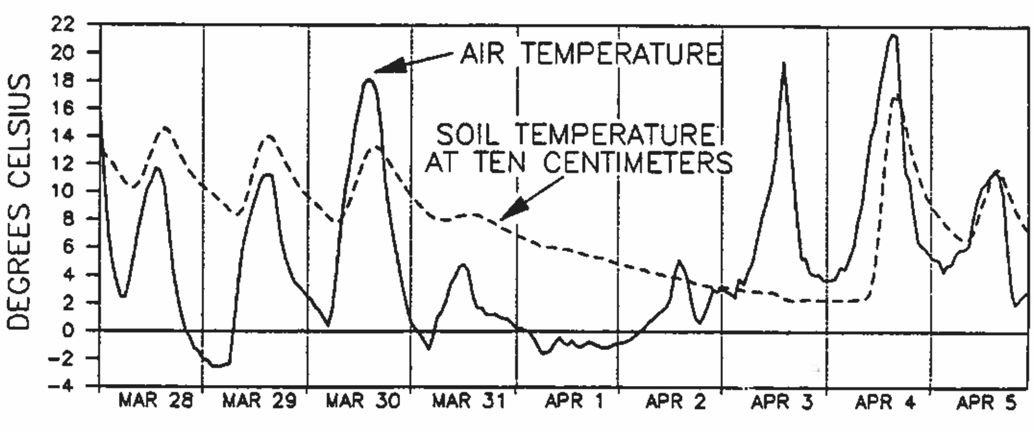
Despite the effectiveness of this type of housing, it is easy to see why it has fallen from grace. These early shelters were not the most comfortable or amenable places to live. The more primative building techniques did not allow the architect to fully use natural lighting or ventilation. A dwelling near a water source (or even near the water table) might flood during a storm, and in the dry periods the dust would coat everything. In addition, insects and rodents found that humans make good, if unwilling, hosts. No wonder that with the advent of modern building techniques, people were more than willing to give up the earth for above-ground houses.

Recently, however, more and more people have been interested in returning to the ground. The reason for this is twofold: first, in the early sixties many became concerned with rapid urbanization of rural lands. Many argued that underground houses are more aesthetically benign to the landscape. Then, in 1973, the 'energy crisis' forced not only homeowners but state and federal governments to investigate and promote alternative, less energy-wasteful lifestyles. Another unwitting sponsor of underground housing was the push for fallout shelters, but that's a whole 'nother story.

Today there are more than 5000 underground homes in the United States, from New Hampshire to North Carolina, from New Mexico to Oregon. There's even a series of underground townhouses in Minneapolis. The success of these residences lies in the energy efficiency of living underground. Earth is a very good insulator, only about a third worse than the insulation in the walls in your house, and is much less expensive. While it may cost you several hundred dollars to insulate your home, soil is, well, dirt cheap. Most underground houses use 50% to 80% less energy than their above-ground counterparts. In addition to the insulating effect, the soil also acts as thermal storage which damps out daily variations in the living space temperature and keeps the rooms at a comfortably constant temperature. You can experience this effect by walking from your basement to your attic on a very cold or hot day and noticing the temperature change.

Sample Soil Data

The graph below shows air and soil temperatures for Walsh, Colorado from 28 March to 5 April of this year. There was a snowstorm which started on the 31st of March. Snow, like soil, is a very good insulator. Note how the ground temperature stops following the daily air temperatures; indeed it seems completely independent. After the snow melts on the 4th, however, the ground temperature again follows the air temperature.



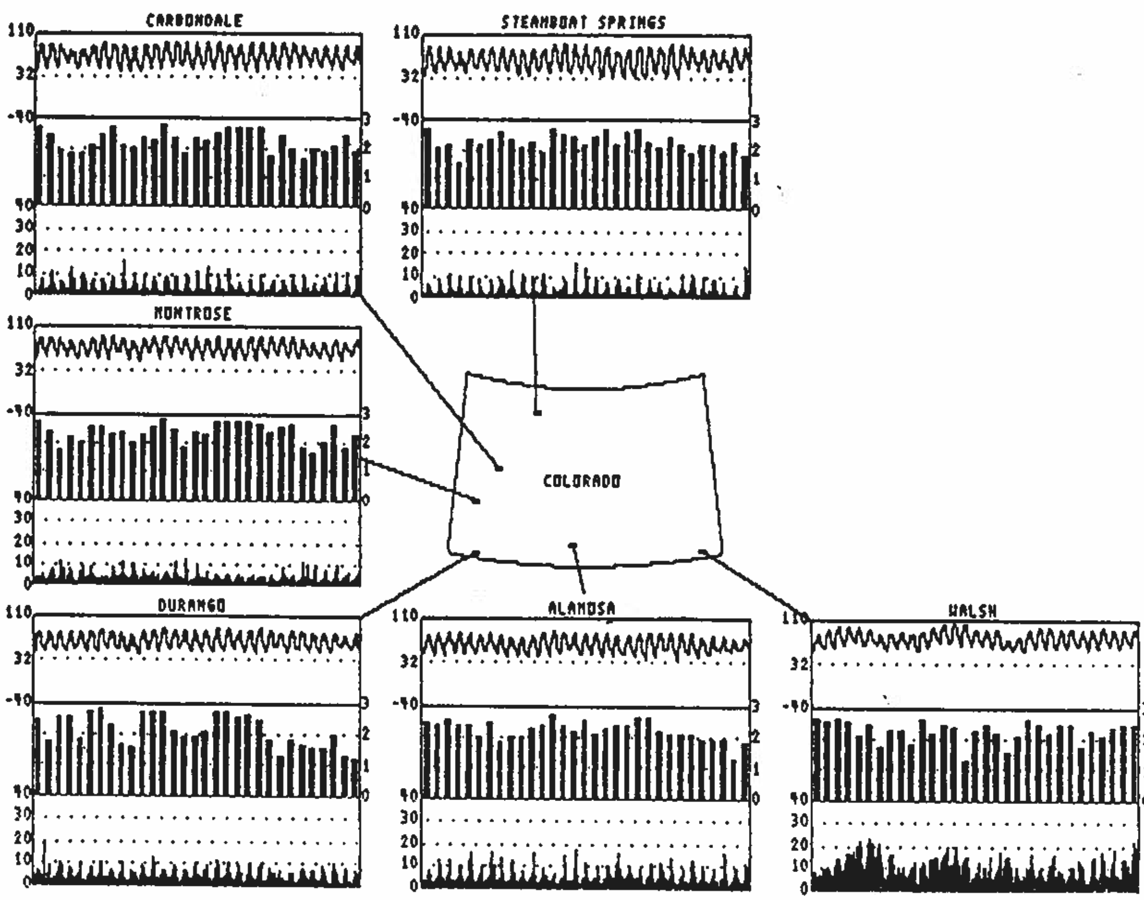
This report prepared by Peter Curtiss, Research Assistant at the Joint Center for Energy Management. The JCEM, a collaboration between Colorado State University and the University of Colorado at Boulder, performs energy studies for the state.

WTHRNET WEATHER DATA - JULY 1988

	Alamosa		Durango		Carbondale		Montrose		Steamboat Springs		Walsh	
monthly average temperature (°F)												
	62.8		64.3		66.9		71.3		62.8		76.6	
monthly temperature extremes and time of occurance (°F day/hour)												
maximum:	86.6	13/16	87.5	13/15	92.1	14/16	92.8	13/17	90.0	25/15	102.8	14/14
minimum:	39.5	25/ 5	43.1	11/ 5	41.3	21/ 5	47.7	11/ 5	33.9	22/ 5	54.8	11/ 5
monthly average relative humidity / dewpoint (percent / °F)												
5 AM	87 / 43		78 / 44		91 / 44		64 / 46		96 / 41		82 / 57	
11 AM	38 / 64		35 / 67		26 / 73		26 / 75		34 / 67		38 / 76	
2 PM	24 / 73		32 / 68		20 / 83		20 / 83		24 / 73		28 / 83	
5 PM	26 / 66		31 / 68		23 / 79		20 / 81		30 / 72		28 / 80	
11 PM	62 / 50		65 / 49		50 / 53		36 / 56		74 / 49		58 / 61	
monthly average wind direction (degrees clockwise from north)												
day	177		172		247		242		145		76	
night	173		86		178		149		83		127	
monthly average wind speed (miles per hour)												
	4.13		3.42		3.43		3.29		3.06		8.98	
wind speed distribution (hours per month for given mph range)												
0 to 3	340		410		454		393		475		50	
3 to 12	383		332		288		349		264		509	
12 to 24	21		2		2		1		5		185	
> 24	0		0		0		0		0		0	
monthly average daily total insolation (Btu/ft²·day)												
	2200		2120		2229		2321		2243		2263	
"clearness" distribution (hours per month in specified clearness index range)												
60-80%	237		178		242		224		245		255	
40-60%	91		73		87		91		95		83	
20-40%	60		91		48		41		50		54	
0-20%	35		36		26		27		28		33	

The State-Wide Picture

The figure below shows the monthly weather for the eight WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40 degrees to 110 degrees Fahrenheit, the middle one gives the daily total solar radiation on a horizontal plane, up to 4000 Btu per square foot per day, and the bottom graph illustrates the hourly average wind speed from 0 to 40 miles per hour. Continuing problems with the Stratton and Sterling stations have prevented us from retrieving data from these sites.



COLORADO CLIMATE

AUGUST 1988

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 11

August in Review:

The entire state was warmer than average in August. Precipitation was highly variable, both east and west of the mountains. Many locations, especially on the Eastern Plains had less than half of the average August rainfall. At the same time, several areas scattered across Colorado had more than double the average. Smoke-filled skies late in the month were vivid reminders of forest fires raging in nearby states.

Colorado's October Climate:

October is a month of beauty and invigoration in Colorado. But the progression toward winter is obvious and irreversible. Long periods of sunny days are common in October in all parts of the state, and daytime temperatures are comfortably mild. But daylength continues to shorten. With the longer nights come colder temperatures, frosty mornings and stronger surface temperature inversions that begin to trap our pollution over cities and in valleys. The puffy convective clouds of summer are replaced by flatter altocumulus and cirrus clouds -- another indication of a more stable atmosphere. Interesting wave-like formations in the clouds occur more frequently near the mountains -- a signal of the strengthening jet stream associated with winter's approach. While sunshine dominates in October, periods of dense cloudiness, sometimes lasting several days, should also be expected. And don't forget to get ready for snow. October marks the beginning of a new water year when new snow begins to accumulate in the high mountains. Don't expect a lot of snow, but at least one major snowstorm usually blasts the mountains, often during the peak of hunting season. October is also the month when the first snowflakes are usually spotted down in the lower elevations. Last year we enjoyed lovely weather on Halloween, but cold rain and wet snow occurs with a remarkably high frequency the last 3 days of the month.

Temperatures tend to cool steadily through the month. Lower elevations enjoy many days with temperatures in the 70s early in the month, but by late October 50s and low 60s are more common. Nights are chilly with 30s common early in the month dropping into the 20s later on. In the mountains, conditions are noticeably cooler. By the end of the month, temperatures on the passes struggle to reach 40° during the day and dip into the teens at night. After a good snow, temperatures may even fall below zero.

With strengthening westerly winds aloft, precipitation patterns begin to shift. Precipitation out on the plains decreases noticeably, while parts of western and southwestern Colorado can be quite wet (at least in a relative sense). October precipitation is not very consistent from year to year. Often, very little rain or snow falls during the month. But occasionally the skies open up and we get drenched. Pueblo received nearly 5" of moisture in 1957. Ninety inches of snow fell on Berthoud Pass in October 1969. Durango measure 11.72" of precipitation in October 1972. When you average over the past few decades, total October precipitation is normally just 0.50-0.75" on the Eastern Plains, about 1" along the Front Range, increases to 1"-2.5" in the northern and central mountains and then drops back to about 1" on the Western Slope. The mountains of southwestern Colorado are the wettest in the state with a 2"-4" average.

Big Storms Make the Difference:

All summer I've heard one complaint after another about how dry our weather has been. It is true in some parts of the state that this has been a pretty dry year. But for most of Colorado, when you add up the figures, the 1988 water year has delivered average or above average moisture. "How can that be?" some have asked, but upon brief reflection they've answered their own question. "Oh yeh, I remember that storm back in March, and that big one in May, and then there was that big thunderstorm in August ...."

(continued on page 9)

AUGUST 1988 DAILY WEATHER

Date	Event
1-2	Hot weather. 90s with 70s and 80s in the mountains. Scattered thunderstorms both days, especially over and near the mountains and across southwestern Colorado.
3-5	A cool front and upper level disturbance crossed Colorado from the northwest. Heavy storms developed late on the 3rd and pushed southward continuing into the 4th. Much of the Front Range was affected. More than 1" of rain fell on many communities from Fort Collins to Colorado Springs. Fort Collins was hit by severe winds, hail and over 1" of rain in 10 minutes. Wheatridge totalled 2.58". Other scattered areas were also affected. Meeker was drenched by 1.89" and near Idalia 3.35" of rain was reported. Much cooler temperatures followed on the 4th. Even some fog and low clouds lingered east of the mountains, but more thunderstorms developed in the afternoon. Widespread sunshine reappeared on the 5th as showers were limited to southern parts of the state.
6-9	Warmer moist air again pushed into southwest Colorado and some heavy monsoon rains ensued. Vallecito Reservoir and Lemon Dam both received close to 3", most falling on the 6th. Lower elevation areas also got wet. Cortez received 0.96", for example. A cool front and disturbance aloft then pushed across Colorado 8-9th triggering active thunderstorms primarily east of the mountains. Local downpours and severe hail were reported on the eastern plains on the 9th. Genoa received 1.33" of rain. Behind the cold front nighttime temperatures dipped in the mountains. It was 28° in Silverton early on the 9th.
10-12	Warm and dry on the 10th but increased moisture from the southwest. Showers developed in the southwest on the 11th and pushed across parts of the state on the 12th. Several mountain areas were dampened but heaviest rains fell in extreme northeast Colorado. Julesburg measured 1.55" and Holyoke had 1.00".
13-15	Hot and dry as high pressure built in east of Colorado. Wray had the hottest reading in the state, 106° on the 14th, but many communities reached 100°. Brighton, Longmont and Greeley all hit the 100° mark on the 15th.
16-20	Moisture began moving northward again late on the 15th as cooler air approached from the north. Scattered storms developed on the 16th and were more widespread on the 17th especially in central Colorado. Antero Reservoir picked up 0.90" on the 17th. South Denver was soaked by more than 2" of rain right at the evening rush hour causing some damage and disrupting travel. Quite pleasant on the 18th, but a local storm poured 1.73" of rain on the town of Holly. Then hot temperatures moved back in 19-20th with only a few light afternoon thunderstorms.
21-25	Another cool front brought relief to the state on the 21st. Grand Junction and Glenwood Springs received 0.83" and 1.00" of rain, respectively. Then northwest winds brought dry and warm weather back to northern Colorado. But with it came smoke from the huge Yellowstone forest fires which made for milky white skies but eerie sunrises and sunsets. Southern Colorado was spared the smoke and instead had daily showers. Wootton Ranch south of Trinidad got 1.57" of rain on the 23rd and Durango added 0.83" on the 24th.
26-31	Very hot on the 26th with near record high temperatures in some areas. Sterling reached 101°F. Then thunderstorms developed as cooler air approached. Normally dry portions of southern and western Colorado were drenched. Montrose picked up 1.16" of rain and Colorado National Monument received 1.47". Alamosa's 0.34" total was actually one of their heavier showers so far this year. Then much cooler temperatures embraced the state 27-29th. Daytime temperatures stayed in the 70s on the plains and nighttime lows were chilly. The 25° reading at Hohnholz Ranch (Laramie River) on the 30th was the coldest in the state. Forest fire smoke still lingered across the state but cleared somewhat 30-31st as hotter weather with more showers returned to end up the month.

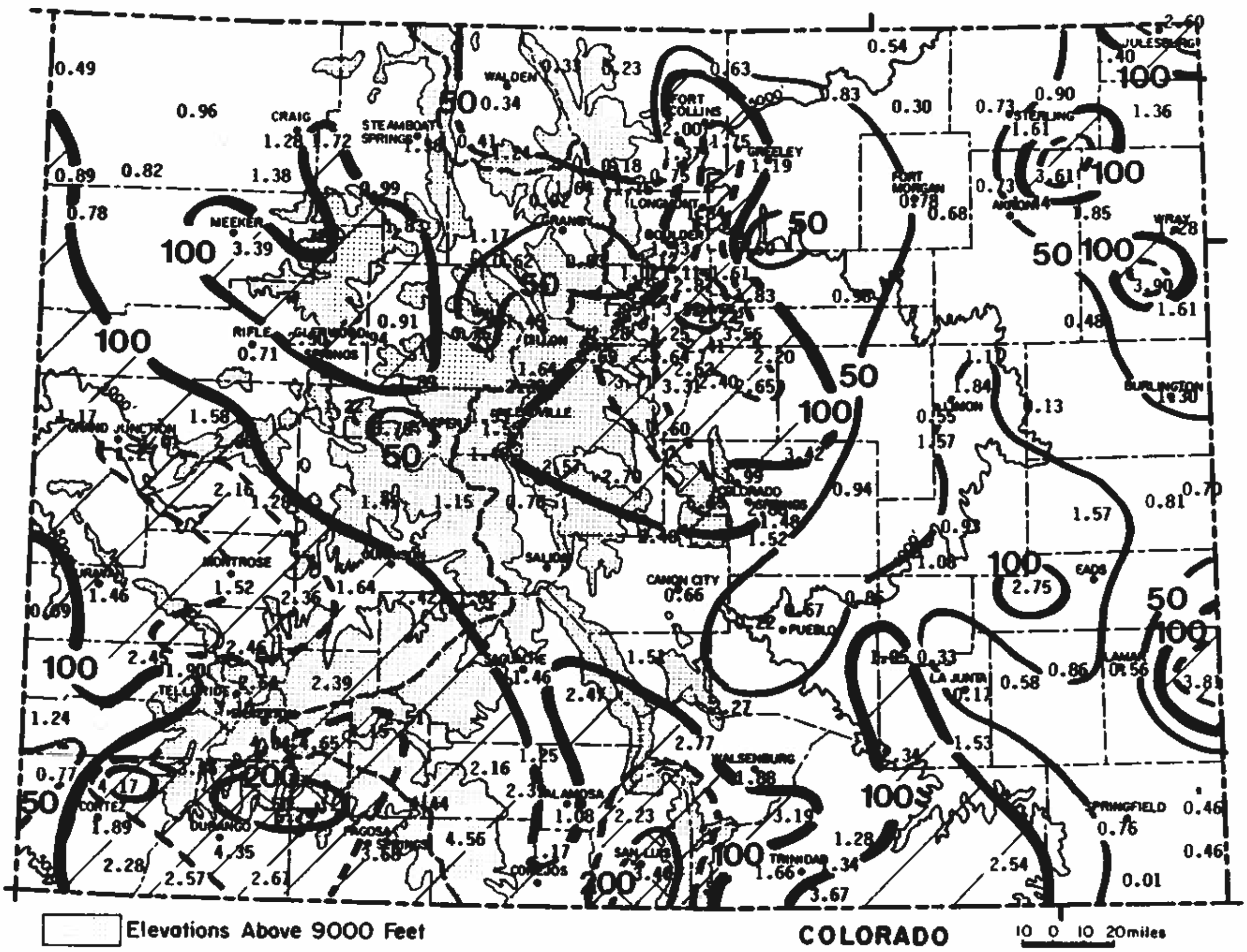
August 1988 Extremes

Highest Temperature	106°F	August 14	Wray 1E
Lowest Temperature	25°F	August 30	Hohnholz Ranch
Greatest Total Precipitation	7.50"		Lemon Reservoir
Least Total Precipitation	0.01"		Campo 7S

A U G U S T   1 9 8 8   P R E C I P I T A T I O N

Due to the nature of summer thunderstorm precipitation, a typically variable pattern of rainfall was observed. In general, very wet conditions were noted across southwest Colorado. However, the monsoon moisture did not reach much farther north this year. Much above average precipitation also occurred along the I-25 corridor from Fort Collins to Colorado Springs. Most of the rain there came from a single storm late on the 3rd. Elsewhere, it was very dry in August across north central Colorado and over quite a bit of the Eastern Plains. Fifteen weather stations received less than 25% of the August average.

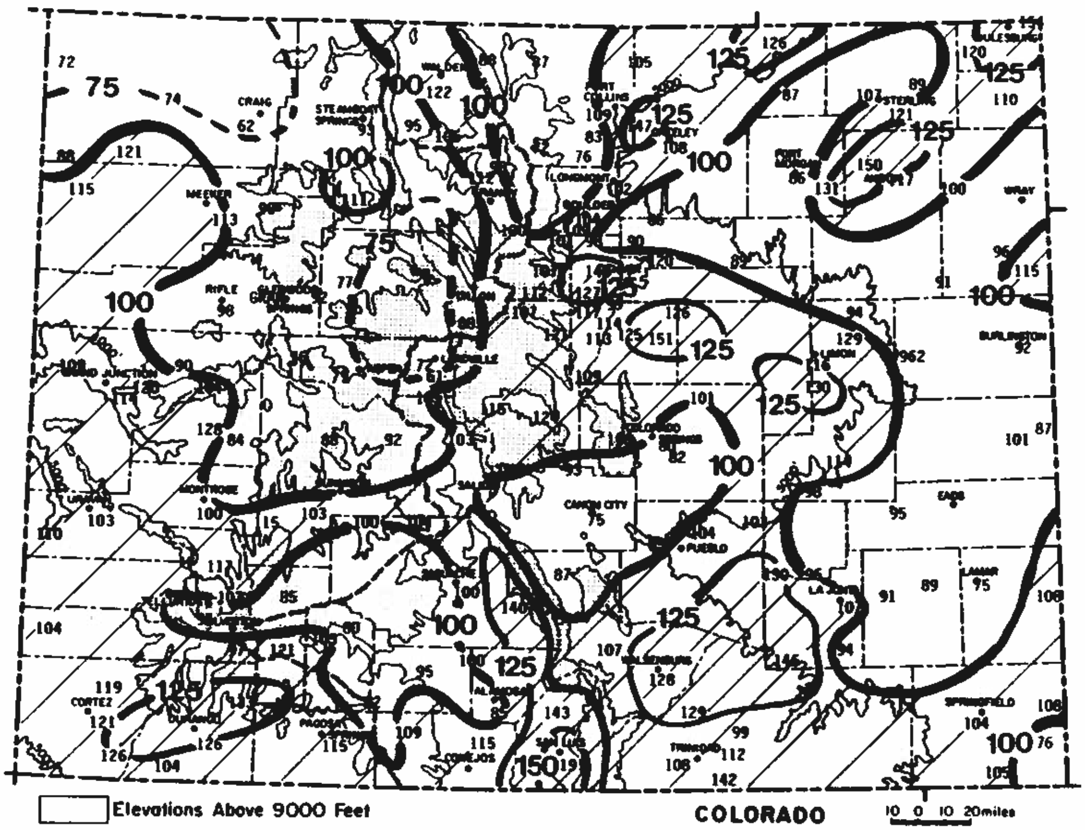
Greatest		Least	
Lemon Dam	7.50"	Campo 7S	0.01"
Vallecito Dam	6.79"	Flagler 2NW	0.13"
Ruxton Park	6.15"	La Junta 1S	0.17"
Rio Grande Reservoir	4.65"	Estes Park	0.18"
Platoro	4.56"	Pueblo Reservoir	0.22"



Precipitation amounts (inches) for August 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

1988 WATER YEAR PRECIPITION

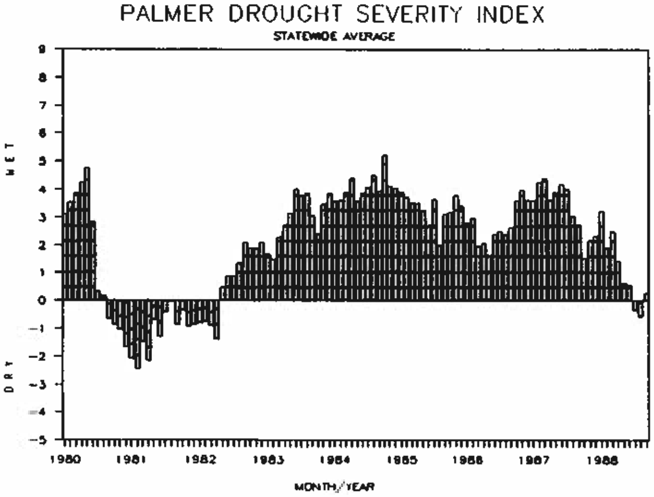
With just one month left in the 1988 water year, precipitation totals are close to average over much of the state. Drier than average conditions remain in northwest Colorado (Moffat County), through the central mountains from Crested Butte to Leadville and northward to Kremmling, the northeast portion of the San Juan Mountains, and scattered areas east of the Continental Divide. There are also several small wet areas including the east edge of the San Luis Valley, the Durango area, Jefferson and Douglas counties, and a few other areas on the plains.



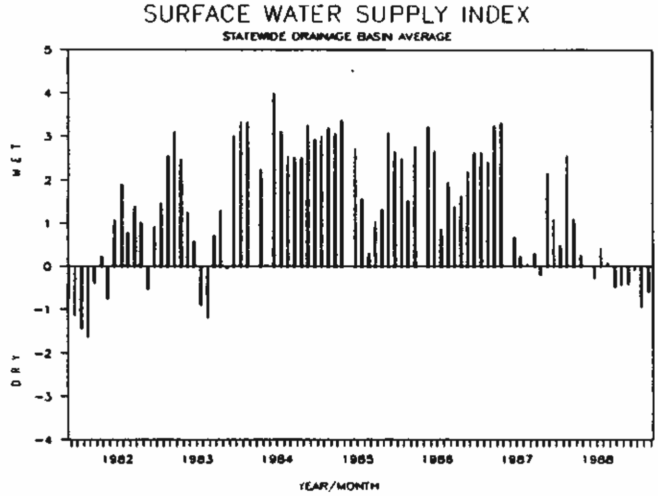
Precipitation for October 1987 through August 1988 as a percent of the 1961-1980 average.

Statewide averages of two indexes of water supplies are shown below for the past several years. The Palmer Drought index has been used for over twenty years for operational drought monitoring on a national scale. The Surface Water Supply Index was developed here in Colorado back in 1981 to track fluctuations in water resources in mountainous regions where most water supplies originate as mountain snowpack. Both indexes show that Colorado has recently returned to near normal after an extended wet period.

PALMER DROUGHT SEVERITY INDEX

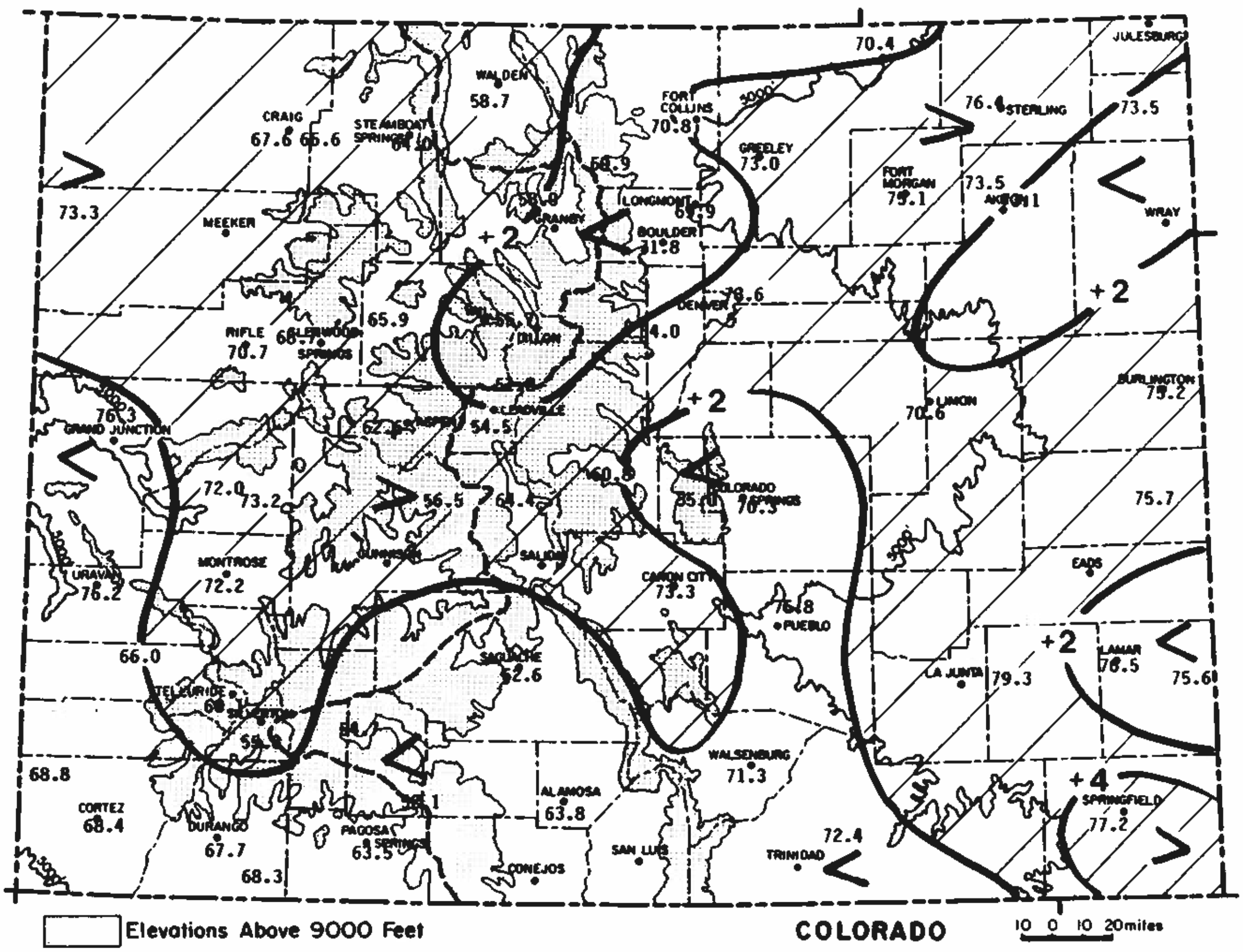


SURFACE WATER SUPPLY INDEX



AUGUST 1988 TEMPERATURES AND DEGREE DAYS

Temperatures were above average across all of Colorado. Departures from average were modest -- averaging about +2 degrees Fahrenheit. Both daytime and nighttime temperatures were warmer than usual. There were no extraordinary heatwaves during the month. Instead, temperatures remained slightly but consistently above average for most of August. Despite several cold fronts crossing the state, cool periods were short lived.



August 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

AUGUST 1988 SOIL TEMPERATURES

Deep soil temperatures continued to rise, as usual, during August. But nearer the surface, some cooling was already noted. Overall, soil temperatures at all depths are a bit warmer than average.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

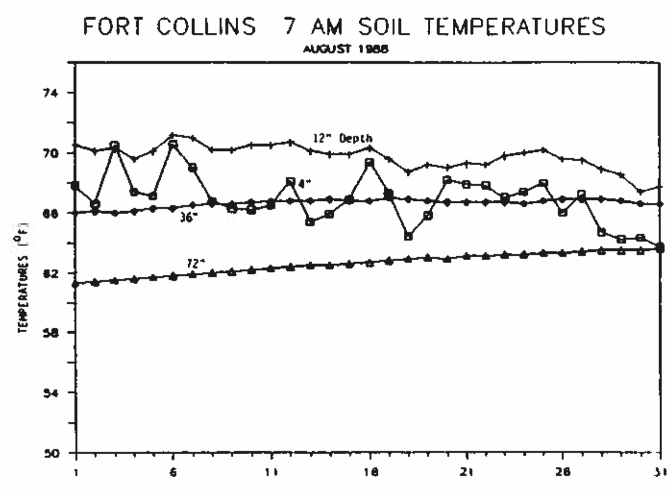


Table 1. Heating Degree Day Data through June 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	87-88	66	96	364	601	1130	1556	1867	1381	1031	658	454	102	9306
	88-89	28	50											78
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	87-88	112	152	355	563	1024	1382	1450	1146	1136	734	517	123	8694
	88-89	34	79											113
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	87-88	7	33	122	370	713	1053	1107	842	739	400	203	14	5603
	88-89	1	4											5
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	87-88	49	117	313	549	955	1277	1357	1010	1030	639	472	102	7870
	88-89	37	41											78
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	87-88	5	20	72	375	724	1037	1221	935	779	449	178	14	5809
	88-89	4	5											9
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	87-88	11	36	87	374	668	1007	1144	858	767	407	191	16	5566
	88-89	M	9											9
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	87-88	17	74	150	445	767	1108	1256	958	886	499	273	25	6458
	88-89	7	10											17
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	87-88	6	35	154	396	860	1179	1351	1008	899	609	362	56	6915
	88-89	0	1											1
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	87-88	55	96	227	534	950	1376	1561	1264	1076	593	399	52	8183
	88-89	1	14											15
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	87-88	0	11	108	354	737	1102	1300	M	M	M	M	M	3612
	88-89	M	M											0
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	87-88	11	21	110	410	745	1125	1227	889	811	437	215	14	6015
	88-89	7	0											7
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	87-88	296	346	556	763	1145	1491	1629	1376	1379	933	717	322	10953
	88-89	M	283											283
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	87-88	14	44	188	435	851	1206	1391	972	859	514	346	42	6862
	88-89	1	5											6
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	87-88	54	75	254	509	950	1331	1544	1173	1002	607	404	52	7955
	88-89	3	11											14
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	87-88	69	118	333	602	922	1255	1310	1029	992	645	462	111	7848
	88-89	60	50											110
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	87-88	12	37	146	453	784	1140	1252	936	821	479	217	8	6285
	88-89	3	2											5
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	87-88	12	29	110	430	773	1154	1484	1055	826	495	206	17	6591
	88-89	6	3											9
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	87-88	0	6	34	248	754	1147	1469	1031	741	350	172	8	5960
	88-89	0	0											0

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	87-88	207	257	480	677	1098	1516	1642	1413	1372	907	602	238	10409
	88-89	191	208											399
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	87-88	10	26	119	424	762	1157	1363	955	807	437	204	6	6270
	88-89	5	1											6
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
	88-89	M	M											0
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	87-88	0	3	35	273	653	1032	1278	837	638	327	103	1	5180
	88-89	0	0											0
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	87-88	346	393	578	763	1180	1534	1577	1326	1355	957	741	360	11110
	88-89	318	306											624
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	87-88	21	66	158	502	840	1209	1354	1022	943	569	321	35	7040
	88-89	9	7											16
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	87-88	12	33	159	464	805	1169	1383	1035	847	509	222	20	6658
	88-89	10	8											18
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
	88-89	M	M											0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	87-88	5	30	129	349	849	1160	1332	1003	817	468	230	26	6398
	88-89	0	1											1
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	87-88	104	105	347	523	947	1292	1548	1187	996	663	485	143	8340
	88-89	30	61											91
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	87-88	4	17	43	355	754	1111	1399	903	777	399	167	8	5937
	88-89	1	0											1
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	87-88	9	24	125	391	819	1209	1430	1039	865	454	268	14	6647
	88-89	0	0											0
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	87-88	77	127	330	590	1033	1448	1619	1336	1167	674	433	95	8929
	88-89	27	45											72
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	87-88	12	31	108	413	742	M	1475	1029	831	476	197	12	5326
	88-89	1	1											2
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	87-88	161	222	426	603	992	1269	1354	1109	1092	720	547	208	8703
	88-89	131	147											278
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	87-88	4	25	80	330	730	1054	1209	850	803	438	234	13	5770
	88-89	8	5											13
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	87-88	215	281	495	740	1242	1499	1572	1343	1340	835	638	184	10384
	88-89	144	189											333
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	87-88	3	30	101	332	707	977	1109	826	773	401	238	25	5522
	88-89	2	3											5

M = MISSING

A U G U S T 1 9 8 8 C L I M A T I C D A T A

Eastern Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	86.7	54.1	70.4	1.8	98	39	19	197	607	0.54	-0.92	37.0	7
STERLING	92.4	60.5	76.4	4.9	102	47	1	362	719	0.73	-1.10	39.9	7
FORT MORGAN	90.7	59.5	75.1	3.2	100	49	3	323	697	0.78	-0.72	52.0	5
AKRON FAA AP	88.9	58.1	73.5	2.4	99	46	5	279	672	0.73	-1.05	41.0	8
AKRON 4E	89.2	57.1	73.1	1.5	99	46	11	270	651	1.44	-0.33	81.4	5
HOLYOKE	87.1	59.9	73.5	1.1	95	48	7	278	690	1.36	-0.57	70.5	7
BURLINGTON	88.7	61.6	75.2	2.5	99	51	5	329	718	1.30	-0.89	59.4	3
LIMON WSMO	86.6	54.5	70.6	2.1	95	43	7	187	612	0.55	-1.90	22.4	9
CHEYENNE WELLS	91.1	60.3	75.7	3.0	100	50	1	342	705	0.81	-1.11	42.2	5
LAMAR	94.2	58.8	76.5	0.6	102	44	2	367	703	0.56	-1.38	28.9	5
LAS ANIMAS	96.7	61.9	79.3	3.3	105	50	0	451	744	0.58	-0.85	40.6	6
HOLLY	94.2	57.1	75.6	0.4	103	40	7	346	675	3.81	1.94	203.7	6
SPRINGFIELD 7WSW	94.5	59.9	77.2	4.4	104	44	2	389	718	0.76	-0.92	45.2	6

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	85.4	56.3	70.8	2.1	95	49	2	190	625	2.00	0.63	146.0	8
GREELEY UNC	88.7	57.3	73.0	2.1	101	50	1	256	653	1.19	0.04	103.5	6
ESTES PARK	79.5	42.3	60.9	0.7	85	35	115	4	443	0.18	-1.88	8.7	3
LONGMONT 2ESE	87.9	52.0	69.9	0.2	100	46	8	168	575	1.84	0.67	157.3	7
BOULDER	86.9	56.8	71.8	0.8	97	46	4	225	645	1.33	0.07	105.6	7
DENVER WSFO AP	87.7	59.5	73.6	2.6	97	51	0	277	688	1.83	0.30	119.6	8
EVERGREEN	80.0	47.9	64.0	2.5	90	41	50	24	485	3.25	1.25	162.5	9
LAKE GEORGE 8SW	74.2	47.5	60.8	2.0	82	39	125	4	394	2.70	0.51	123.3	13
RUXTON PARK	70.4	39.6	55.0	0.7	80	34	301	0	324	6.15	2.57	171.8	17
COLORADO SPRINGS	84.5	56.1	70.3	1.7	92	48	10	181	617	2.88	0.07	102.5	12
CANON CITY 2SE	87.1	59.5	73.3	2.2	93	48	9	273	686	0.66	-1.05	38.6	9
PUEBLO WSO AP	93.1	58.5	75.8	1.6	100	49	0	342	689	0.67	-1.13	37.2	6
WALSENBURG	86.4	56.3	71.3	1.9	93	47	3	208	646	1.88	-0.15	92.6	10
TRINIDAD FAA AP	87.4	57.4	72.4	0.9	95	49	5	244	655	1.28	-0.57	69.2	10

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	79.5	37.8	58.7	2.8	87	29	189	1	464	0.34	-0.86	28.3	8
LEADVILLE 2SW	70.6	38.5	54.5	2.1	77	31	306	0	314	1.55	-0.45	77.5	14
BUENA VISTA	79.9	48.8	64.4	2.3	85	40	41	32	486	0.76	-1.22	38.4	11
SAGUACHE	76.7	48.4	62.6	1.3	83	43	74	11	401	1.46	-0.08	94.8	15
HERMIT 7ESE	69.5	39.8	54.7	0.9	78	31	313	0	310	4.15	2.03	195.8	10
ALAMOSA WSO AP	80.4	47.3	63.8	1.5	87	36	50	22	489	1.08	-0.16	87.1	10
STEAMBOAT SPRINGS	84.2	43.8	64.0	4.4	90	37	45	23	536	1.38	-0.12	92.0	10
GRAND LAKE 6SSW	74.2	41.8	58.0	1.8	82	35	208	0	387	0.92	-0.67	57.9	10
DILLON 1E	72.7	38.7	55.7	1.0	81	28	283	0	359	1.45	-0.19	88.4	11
CLIMAX	62.8	39.7	51.2	1.9	72	33	420	0	204	2.30	-0.01	99.6	12
ASPEN 1SW	78.0	47.2	62.6	3.1	88	42	79	11	444	0.75	-1.15	39.5	9
TAYLOR PARK	71.1	42.0	56.5	5.1	78	35	256	0	333	1.15	-0.70	62.2	4
TELLURIDE	76.3	43.9	60.1	2.2	84	36	147	4	415	3.10	0.40	114.8	19
PAGOSA SPRINGS	80.2	46.9	63.5	1.6	88	41	61	23	484	3.68	1.19	147.8	19
SILVERTON	72.3	38.3	55.3	2.8	79	28	292	0	353	4.04	1.06	135.6	20
WOLF CREEK PASS 1	65.4	38.8	52.1	0.9	70	34	397	0	244	4.44	0.52	113.3	17

Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	85.2	50.0	67.6	2.7	93	44	14	99	548	1.28	-0.32	80.0	8
HAYDEN	84.5	48.7	66.6	2.4	89	42	7	65	544	1.72	0.23	115.4	6
RANGELY 1E	90.2	56.4	73.3	3.3	96	50	0	247	618	0.78	-0.03	96.3	6
EAGLE FAA AP	84.6	47.3	65.9	2.1	92	40	11	47	544	0.91	0.03	103.4	8
GLENWOOD SPRINGS	86.5	51.0	68.7	1.4	94	40	6	125	546	2.50	1.17	188.0	12
RIFLE	89.5	51.9	70.7	2.7	97	42	0	185	599	0.71	-0.33	68.3	6
GRAND JUNCTION WS	90.6	61.9	76.3	0.3	97	58	0	358	745	1.37	0.61	180.3	8
CEDAREDGE	89.2	54.9	72.0	2.6	95	50	0	224	636	2.16	1.09	201.9	10
PAONIA 1SW	89.4	57.0	73.2	3.3	96	53	0	254	642	1.28	0.06	104.9	10
MONTROSE NO. 2	86.9	57.6	72.2	2.6	95	52	1	234	659	1.52	0.48	146.2	5
URAVAN	93.9	58.5	76.2	1.6	100	47	0	352	698	1.46	0.27	122.7	8
NORWOOD	82.3	49.8	66.0	2.0	89	44	17	56	521	2.45	0.82	150.3	6
YELLOW JACKET 2W	84.0	53.7	68.8	1.0	91	48	5	132	585	0.77	-0.93	45.3	8
CORTEZ	84.4	52.5	68.4	1.0	91	48	1	114	573	1.89	0.54	140.0	11
DURANGO	83.7	51.7	67.7	1.6	92	44	5	99	557	4.35	2.04	188.3	14
IGNACIO 1N	85.5	51.2	68.3	2.6	92	44	4	117	568	2.67	0.97	157.1	11

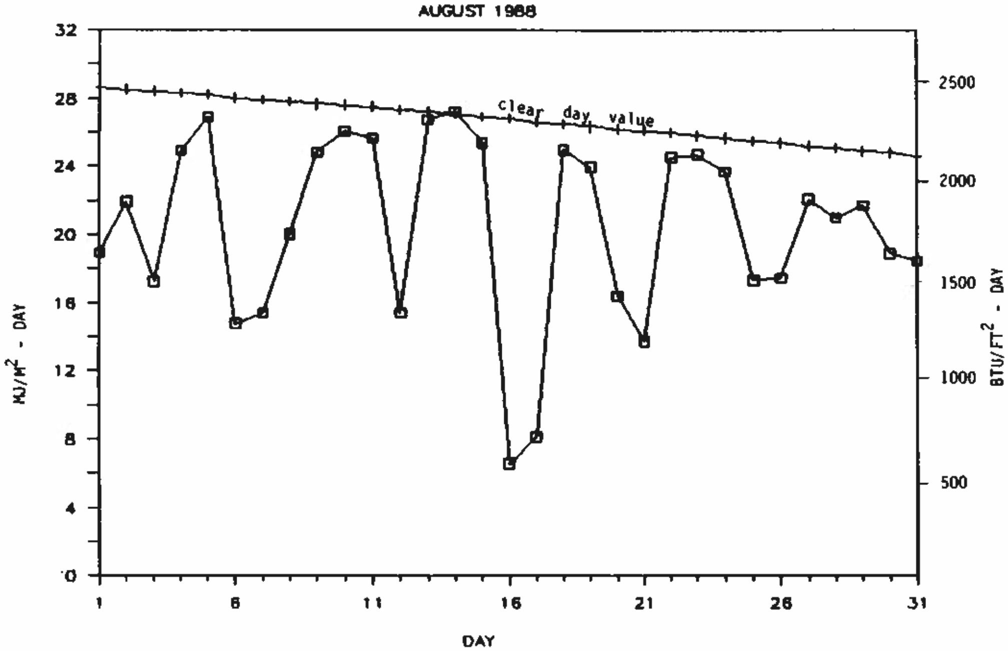
* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

AUGUST 1988 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	8	14	9	--	--
Denver	9	14	8	73%	73%
Fort Collins	12	12	7	--	--
Grand Junction	11	13	7	80%	76%
Pueblo	15	9	7	85%	78%

FT. COLLINS TOTAL HEMISPHERIC RADIATION

AUGUST 1988



<u>Big Storms Make the Difference:</u> (continued)

The fact of the matter is that in many parts of the world, most of the year's precipitation falls from a small number of storms. This is especially true in dry (arid and semiarid) climates and that covers much of Colorado. The frequency of measurable precipitation in Colorado ranges from a low of less than 60 days per year in parts of southeast Colorado to as many as 180 days or more per year in the highest mountains of northern and central Colorado. Only a few of those days contribute sizeable amounts of moisture, however.

Here in Colorado, any precipitation total of 0.40" or greater in a day is a sizeable amount. The table below shows the average annual frequency of occurrence of daily precipitation amounts greater than or equal to 0.40" for a number of locations in Colorado. Also shown is the average frequency of smaller events of at least 0.01" and 0.10". Comparisons of amounts of 0.01" or greater can be misleading as experience has shown that some weather stations do not keep accurate information on those very light precipitation events. Therefore, data on these small amounts are not included here for all stations.

Station	Average Annual Precipitation (inches)	Average Number of Days Per Year with Precip: ≥0.01"	≥0.10"	≥0.40"	% of Total Precip from events ≥0.40" Annual	WY 1988*
Akron FAA	15.66	81	41	11	58%	59%
Alamosa WSO	7.13	68	25	5	E24%	0%
Berthoud Pass	38.03	187	112	25	42%	
Boulder	18.12		49	12	55%	51%
Climax	23.16	157	82	12	29%	23%
Colorado Springs WSO	15.42	90	43	10	E56%	44%
Crested Butte	24.52		74	15	E42%	35%
Denver WSFO AP	15.31	88	42	10	51%	55%
Durango	18.61	85	51	16	E49%	50%
Eagle FAA AP	10.24	87	39	5	30%	10%
Fort Collins	14.47	80	40	9	54%	66%
Grand Junction WSO	8.00	72	31	4	28%	35%
Grand Lake 1NW	20.02		75	11	32%	31%
Julesburg	17.07		43	13	60%	77%
Lamar	14.53	60	34	10	E61%	38%
Limon	14.02		43	10	E55%	53%
Pueblo WSO AP	10.87	69	28	7	E57%	47%
Springfield 7WSW	14.98	67	34	11	E60%	55%
Steamboat Springs	23.30		78	15	38%	39%
Telluride	21.57		74	14	E40%	27%
Trinidad FAA AP	12.30	71	37	9	E58%	34%

E = values estimated
* = October 1987 through August 1988

Except for snowier parts of the mountains, most of Colorado averages less than a dozen days per year with at least 0.40" of precipitation. But those few days drop there share of moisture. East of the mountains, those few days account for 50%-60% of the annual precipitation. Variations are greater in the mountains and western parts of Colorado where smaller and more frequent winter snowfall events make up a larger portion of the year's total precipitation. But even in those areas 30% to 50% of the year's moisture comes from those few storms.

Of the states listed above, 7 locations reported more days than average with ≥ 0.40" precipitation so far this year. Six of those 7 have received more total precipitation than average. Out at Julesburg as of early September there had only been 35 days this year with ≥ 0.10" precipitation. But the 14 days with ≥ 0.40" had already contributed 18.14" of moisture -- well above average. For stations with fewer days with large precipitation amounts compared to average, most are drier than average for the 1988 water year. Statewide, the frequency of precipitation this year has been normal.

There are, perhaps, no dramatic conclusions to draw from this analysis. Precipitation does vary from year to year. We have wet years and we have dry ones. Likewise, the size and frequency of storms varies from year to year. In the end, the exact amount of precipitation that falls each year probably isn't all that important. What may matter most to our well-being here in Colorado is how well we use the moisture we get. This analysis suggests that we should try our best to soak up the moisture from these few biggest storms.

Saving Energy By Keeping Score

Glancing at the calendar we see that fall is rapidly approaching. As the days shorten and the nights become colder, many of us will be turning on our furnaces and bringing the space heaters down from the attic. Although it is nice to see the snow once again, it is not so nice when the utility bill arrives at the end of the month. Many people try to "weather-proof" their homes by installing storm windows, sealing leaks where cold air enters and adding insulation to areas that need it. While this undoubtedly increases the energy efficiency of a house, it is often unknown just how much energy is actually saved. Also, since no two winters are the same, it is difficult to estimate how the weather affects these conservation measures. Utility companies which offer retrofit assistance programs usually do not keep track of records which could relate to their customers how much energy - and money - their conservation efforts are saving.

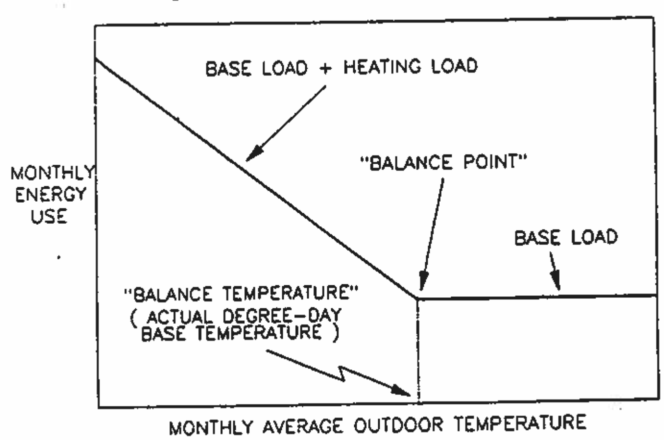
Unfortunately, these problems can discourage homeowners who spend money weather-proofing then end up with higher utility bills because the temperatures are lower than the previous season. It be nice if there was a way for a homeowner to account for the weather in his/her energy use, hence "keeping score" becomes a viable and accurate way of communicating the effectiveness of an energy conservation measure.

The PRInceton Scorekeeping Method (or PRISM) is a statistical procedure which uses records of utility bills and weather data to produce accurate estimates of weather-adjusted energy consumption. The data required for this method is easily obtained - PRISM uses monthly utility bills and average daily temperatures from a nearby weather station to determine a weather adjusted index of consumption. This relates the level of energy used to the severity of the weather at the time. Once the house has been weatherized, energy savings are found by taking the difference between figures in the pre and post-retrofit periods. This way, conservation effects are not distorted by an unusually cold or warm winter.

How does it Work?

PRISM is based upon three physical parameters which relate to the billing data for the heating fuel (natural gas, fuel oil, electricity) of an individual house. What is unique about PRISM is that the first parameter, being the house's breakeven temperature, is treated as a variable rather than a constant such as 65°F. This parameter can be thought of as the base temperature for measuring degree-days. Next is the house's base-level consumption or the amount of fuel used to run appliances in the home. This parameter is basically independent of the outside temperature. Finally, for each additional degree drop below the reference temperature, a constant amount of heating fuel is required. These parameters can provide indications of the sources of conservation: insulating, turning down thermostats, more efficient appliance usage, etc., and thus define an "energy signature" of a house.

Relationship Between the Three PRISM Parameters



If a home's reference temperature is not accurately determined, or if it changes over the time period studied, the error or change will inversely affect the other parameters as well. Therefore, an assumed (incorrect) reference temperature, such as the value of 65°F so commonly used, is likely to lead to less physically meaningful values of the base level and the heat-loss rate. It is better to calculate this parameter, usually between 60° to 75°F, depending on the ability of the house to keep heat inside. A well insulated house will have a lower balance temperature, and vice versa. This makes sense: the outdoor temperature must drop farther before the well-insulated house begins to "feel" the effect. Just as no two homes are exactly alike, the same goes for the energy demands and heat loss rates between households.

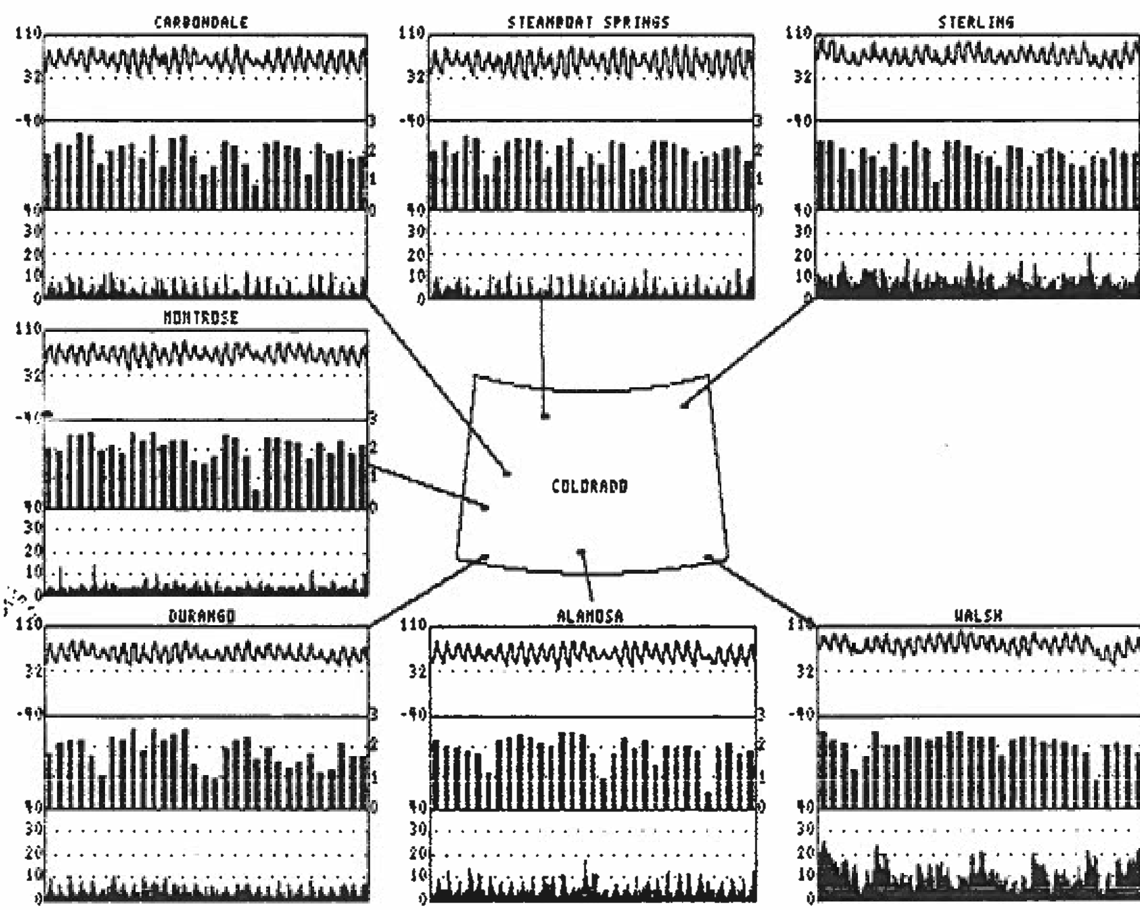
This report prepared by Mike O'Shea and Peter Curtiss of the Joint Center for Energy Management, a collaboration between Colorado State University and the University of Colorado at Boulder.

WTHRNET WEATHER DATA AUGUST 1988

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
monthly average temperature (°F)						
	62.3	62.1	64.5	67.7	60.5	75.8
monthly temperature extremes and time of occurance (°F day/hour)						
maximum:	84.0 15/15	84.2 14/17	89.8 14/16	89.2 14/14	86.7 24/15	100.2 14/16
minimum:	36.3 13/ 6	43.5 29/ 6	39.2 10/ 5	44.2 9/ 6	33.6 23/ 6	43.0 29/ 4
monthly average relative humidity / dewpoint (percent / °F)						
5 AM	94 / 47	90 / 48	94 / 46	84 / 49	96 / 41	80 / 56
11 AM	57 / 54	62 / 57	47 / 51	50 / 56	40 / 46	45 / 59
2 PM	43 / 50	53 / 55	35 / 46	39 / 52	27 / 40	36 / 56
5 PM	45 / 48	59 / 53	30 / 42	37 / 50	29 / 39	35 / 54
11 PM	76 / 49	82 / 51	68 / 47	59 / 48	75 / 44	60 / 56
monthly average wind direction (degrees clockwise from north)						
day	177	191	248	261	243	158
night	167	84	183	156	126	214
monthly average wind speed (miles per hour)						
	3.82	2.82	2.98	2.78	2.84	9.76
wind speed distribution (hours per month for given hourly average mph range)						
0 to 3	338	456	484	447	496	53
3 to 12	399	288	259	295	244	441
12 to 24	7	0	1	2	4	248
> 24	0	0	0	0	0	2
monthly average daily total insolation (Btu/ft²·day)						
	1917	1819	1966	2045	2003	2063
"clearness" distribution (hours per month in specified clearness index range)						
60-80%	217	150	217	205	241	265
40-60%	82	75	85	73	82	80
20-40%	65	81	48	47	51	43
0-20%	38	66	26	37	20	26

The State-Wide Picture

The figure below shows the monthly weather for the eight WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40 degrees to 110 degrees Fahrenheit, the middle one gives the daily total solar radiation on a horizontal plane, up to 4000 Btu per square foot per day, and the bottom graph illustrates the hourly average wind speed from 0 to 40 miles per hour. Continuing problems with the Stratton station have prevented us from retrieving data from this site.



COLORADO CLIMATE

SEPTEMBER 1988

Colorado Climate Center
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523

This report has been prepared each month since January 1977 with the support of the Colorado Agricultural Experiment Station and the College of Engineering.

Volume 11 Number 12

September in Review:

A period of damp, chilly weather about halfway through the month was the only major interruption in what was otherwise a sunny, dry and comfortably pleasant month. Temperatures for the month as a whole ended up a bit cooler than average over most of the state. Precipitation ranged from much above average in southeast Colorado and across some western parts of the state, to well below average across a good portion of central and south central Colorado.

Colorado's November Climate:

If you like winter, November will tickle your fancy. Compared to the months that follow, November is pretty mild and easy going. But with markedly increased cloudiness, steadily colder temperatures, more frequent snows, more mountain winds and long, cold nights, the reality of winter is upon us. Some years we can sneak through October with few signs of winter weather. But after the first couple weeks of November that becomes a much more difficult trick. It's time for skiers to get happy and cold haters to make your reservations to head south.

Temperatures drop more rapidly in November than in any other month. The 6th to the 20th of November is the period when the onset of winter is most commonly felt. During that period, daily average temperatures, based on historic measurements throughout the state, drop at a rate of almost a degree (Fahrenheit) per day. By late November, lower elevation areas are generally seeing high temperatures in the 40s with lows dropping to near 20 on the average. In the mountains, highs only in the 20s and 30s are expected after Thanksgiving with lows in the teens or single digits. Occasionally a severe arctic outbreak can occur dropping temperatures well below zero. Back in 1984, Taylor Park Reservoir dropped to -30° in November, but don't bet on a lot of really cold weather until closer to Christmas.

Snowstorms can occur at anytime and in any part of Colorado in November. At low elevations, some rain can fall in November, but eventually most of the moisture turns to snow. Snows are heaviest and most frequent in the northern and central mountains. As the wintertime jetstream strengthens over North America, the primary source of moisture comes from the Pacific Ocean. As a result, from now until about March, western parts of the state tend to be cloudier and wetter than areas east of the mountains, and precipitation totals tend to increase dramatically with elevation. Totals for the month average between 0.60" and 2.00" over most of western Colorado but increase to 2-4" in the higher mountains. Precipitation decreases quickly on the east side of the mountains and is less than 0.50" over portions of the northeastern and southeastern plains. Still the possibility for heavy snow does exist east of the mountains. On the average a major snowstorm (>5" snowfalls) strikes the Eastern Plains and Front Range sometime in November about every other year.

1988 Water Year Wrap-Up:

Yes, another water year has come to an end. The dreaded word "drought" made its way into the news in 1988 in a big way. Areas west, north and east of Colorado were affected by severe deficits of precipitation. With drought in the national news nearly every day throughout the spring and summer, many Coloradans perceived that we, too, were suffering through a drought. But when the numbers were added up, most of Colorado had a pretty fair year. There were a few local drought problems here in Colorado, particularly in the northwest. For much of the state it was drier than it has been for a number of years. But it is easy to forget that we have been enjoying consistently above average precipitation over much of the state 8 out of 10 years since 1978. While it may have seemed dry, it was a very average year when compared to the past several decades.

(continued on page 4 and 5)

SEPTEMBER 1988 DAILY WEATHER

Date	Event
1-2	Summerlike. Scattered thunderstorms developed on the 1st and continued overnight in parts of southeast Colorado. Some heavy rains reported: Springfield 7WSW 1.44", Kim 10SSE 2.01" and Campo 7S 2.54". Smoke-filled skies from the Yellowstone fires shrouded parts of our state.
3-4	Windy on the 3rd as a strong push of cooler, drier and cleaner air came down from the north. It was nearly cloudless both days over the entire state as the winds aloft drove the smoke southwestward toward Nevada and California.
5-8	Hot and dry with very low humidities 5-7th. Forest fire smoke moved back into Colorado, especially the northeast half. Temperatures climbed into the 90s at lower elevations on the 7th. As hot, downslope winds developed east of the Divide, several Colorado forest fires broke out. A cold front dipped southward across the eastern plains on the 8th dropping high temperatures by 10-15°. But the mountains and west remained warm and dry.
9-15	Quite hot across Colorado 9-10th as a strong winter-like storm system began to develop over the western U.S. Clouds and moisture spread into western Colorado from the southwest. Rain was widespread already on the 10th across western Colorado while east of the mountains temperatures in the 90s were common. Durango hit 88° on the 9th and Palisade reached 97°. The 102° reading at Wray 1E on the 10th was the state's hottest temperature for the month. Strong foothill winds continued to fan several forest fires. Then temperatures began dropping 11-12th as rain and thunderstorms spread eastward to cover the entire state. Fort Collins got 1.29" of rain from afternoon thunderstorms on the 11th. Rains turned to snow over the higher mountains and became quite heavy, especially in the central mountains. High temperatures on the 12th stayed in the 40s and 50s even at lower elevations. Bonham Reservoir (Grand Mesa) dipped to 9° early on the 12th to claim the "cold spot" award for the month. By the 13th, a cut-off low pressure area aloft finally began to weaken and move eastward. By the time clouds began breaking up in western Colorado some large rainfalls had occurred. Cedaredge totalled 2.46". Ridgway's 4.69" total was the greatest in the state. As much as 1 foot of snow was reported in the high country. Fog, drizzle and a few thunderstorms continued east of the mountains 13-15th. Rains were especially heavy in the southeast. Cheyenne Wells totalled 2.83" for the period.
16-18	The storm finally left Colorado and warm weather returned. Some clouds from the remains of famous Hurricane Gilbert crossed southeast Colorado on the 17th. Then a very strong upper-level disturbance and cold front raced across the state on the 18th. Very strong winds developed along the Front Range and eastern plains during the evening marking an unusually early start to the high wind season. Winds gusts from 70-92 mph snapped trees and powerlines from Fort Collins and Northglenn out onto the plains.
19-20	Beautiful, clear autumn weather with mild days and chilly nights. Gunnison climbed from a chilly low of 19° on the 19th to a high of 75°. From Montrose to Craig, a number of West Slope areas had their first freeze of the season.
21-26	A weaker cousin to the big storm of Sept. 10-15th moved across Colorado 21-23rd. Moderate showers fell over the San Juan Mountains on the 21st and then moved eastward. Heavier precipitation was all confined to southern counties. Trinidad enjoyed 1.40" of rain on the 23rd. Skies cleared and pleasant fall weather returned 24-26th.
27-30	A cold front triggered evening thunderstorms over northeast Colorado late on the 27th. New Raymer reported 0.50". Then windy, much colder and unsettled 28th as some snowshowers fell over the mountains. As the month ended, an upper level low pressure center spun over western Kansas keeping the entire state cool. Over extreme eastern Colorado 0.25" to 0.50" rains were common 29-30th, while clear skies were the rule from the mountains westward. A few low elevation areas including an area near Pueblo and Canon City had their first freeze of the autumn on the 29th.

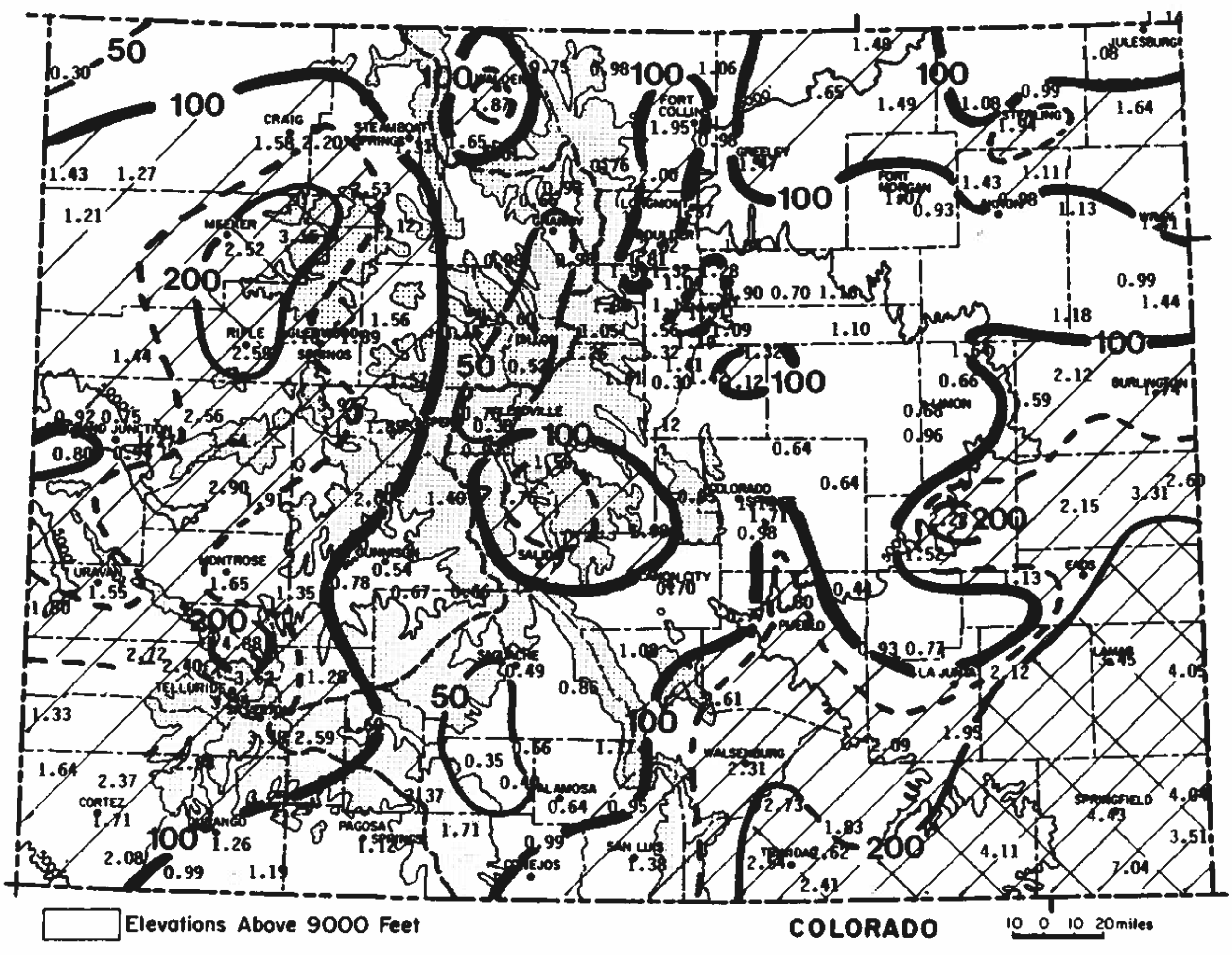
September 1988 Extremes

Highest Temperature	102°F	September 10	Wray 1E
Lowest Temperature	9°F	September 12	Bonham Reservoir
Greatest Total Precipitation	7.04"		Campo 7S
Least Total Precipitation	0.30"		South Platte, Brown's Park Refuge
Greatest Total Snowfall	16"		Mount Evans Research Research Center

SEPTEMBER 1988 PRECIPITATION

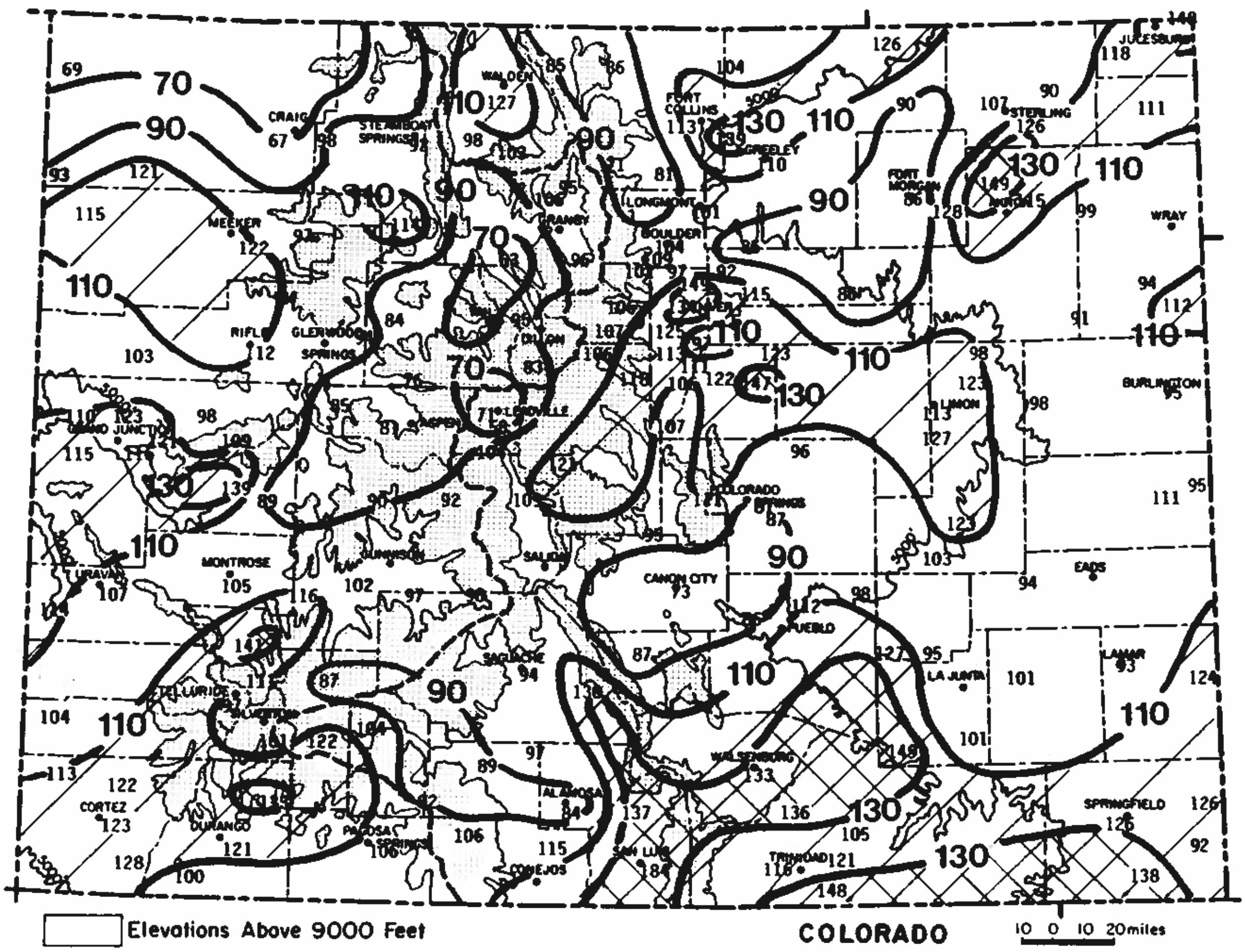
All of Colorado was dampened by a period of cold rain and high elevation snow September 10-14th. This accounted for the majority of the entire month's precipitation. As a result, wetter than average conditions were observed over most of western Colorado and over the southeastern plains. Twelve stations in southeast Colorado enjoyed more than double their average rainfall. Campo's 7.04" total was 4 times the average. Meanwhile, portions of central Colorado remained dry. From Pagosa Springs northward through Leadville and Grand Lake, precipitation was generally between 30% and 70% of average. A few areas east of the mountains such as Limon and Byers were also quite dry.

Greatest		Least	
Campo 7S	7.04"	South Platte	0.30"
Ridgway	4.88"	Browns Park Refuge	0.30"
Springfield 7WSW	4.43"	Del Norte	0.35"
Kim 10 SSE	4.11"	Leadville 2SW	0.38"
Holly	4.05"	Monte Vista 1E	0.40"



Precipitation amounts (inches) for September 1988 and contours of precipitation as a percent of the 1961-1980 average. Dotted line is 150% of average.

Looking at the 1988 Water Year precipitation pattern in more detail, the driest area of the state was Moffat county with 65%-90% of their annual average moisture. A sizeable dry area was also noted that encompassed much of Grand, Eagle, Summit, Lake, Pitkin and Gunnison counties. Most locations there received between 80% and 90% of their average precipitation with some locally drier spots. Other dry areas included the foothills portions of Larimer and Boulder counties, an area from Brighton and Byers northeast to Fort Morgan, most of Fremont County and parts of El Paso County, and the northeastern slopes of the San Juan mountains including much of the San Luis Valley. Alamosa totalled just 6.53" of precipitation for the year. Wetter than average areas occurred both east and west of the mountains but included few of the higher mountain locations. Wettest areas were found on the southwest slopes of the San Juans, a narrow strip along the western slopes of the Sangre de Cristo mountains and scattered areas east of the mountains. Castle Rock totalled 23.06" for the year, 47% above average. Julesburg received 24.70" (48% above average).

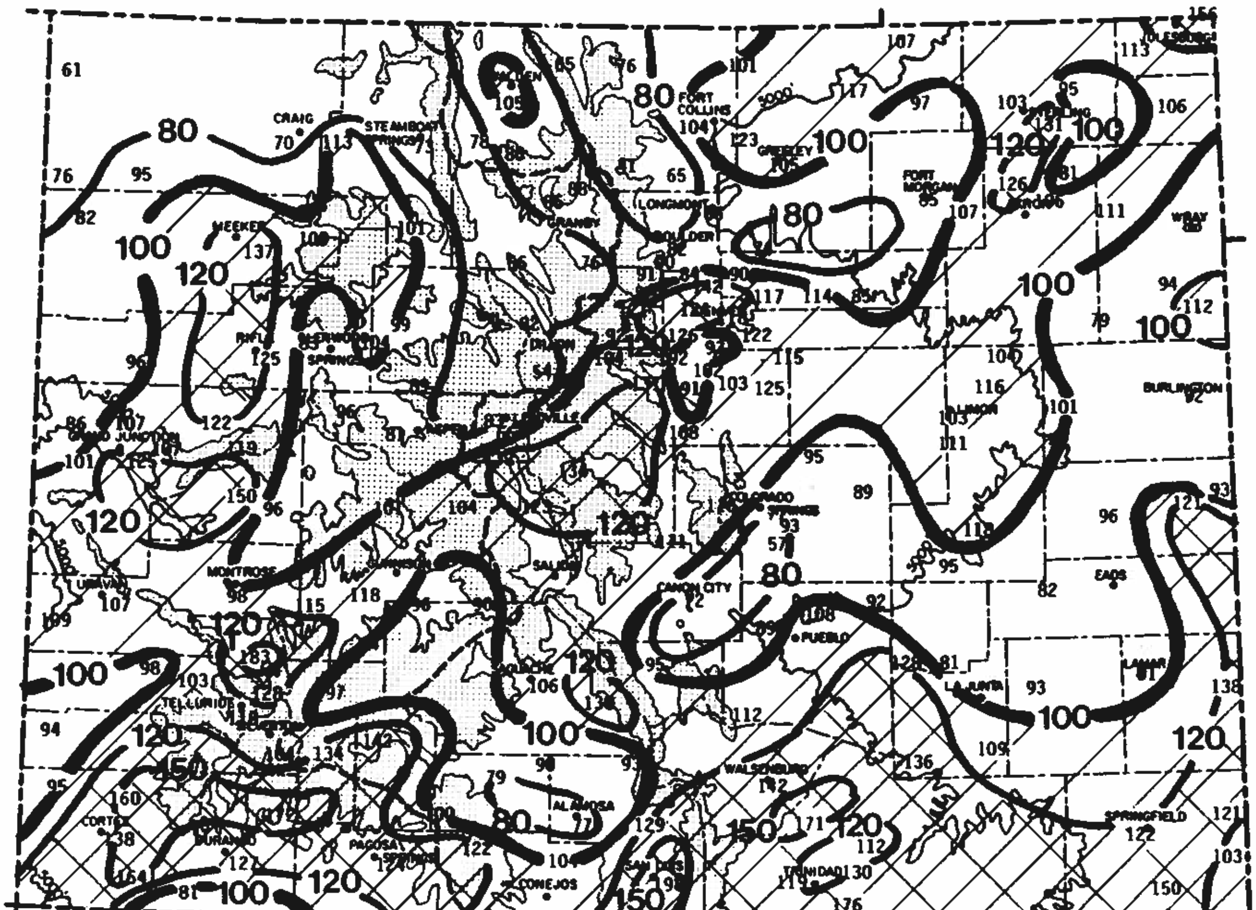


Precipitation for October 1987 through September 1988 as a percent of the 1961-1980 average.

For the 1988 Water Year, 163 official National Weather Service (NWS) cooperative weather stations had complete precipitation statistics. 65 stations (40%) received less than average precipitation for the year while 98 stations (60%) were above average. Of the total sample, 40% of the stations were within 10% of their average precipitation for the year. 40% received more than 110% of average while only 20% of the stations received less than 90% of average precipitation. When interpreting this information, it is important to remember that NWS stations are most often located near cities and towns. Thus, they are more representative of low elevation areas than the higher mountains. Streamflow data and mountain snowpack information suggested that the majority of the Colorado mountain areas were near or below average for the year.

Water-Year 1988: continued

Precipitation for the 1988 growing season (May through September) was also quite close to average over much of the state. Much drier than average conditions were observed over portions of northwestern and north central Colorado, while wet areas were most prevalent in southern Colorado. Lemon Reservoir, near Durango, had the most growing season rainfall with 18.41". The driest location during the summer was Brown's Park Refuge in extreme northwest Colorado. They received just 2.27". One thing that Colorado did have in common with the drought-stricken portions of the country this year was heat. Temperatures were well above average for the growing season. June, especially, was much warmer than usual. This resulted in a higher than average demand for water during the summer. Reservoirs were drawn down and are now lower than they have been during these recent wet years. Even so, statewide reservoir storage as of October 1 remains a little above the long-term average.



Elevations Above 9000 Feet

COLORADO

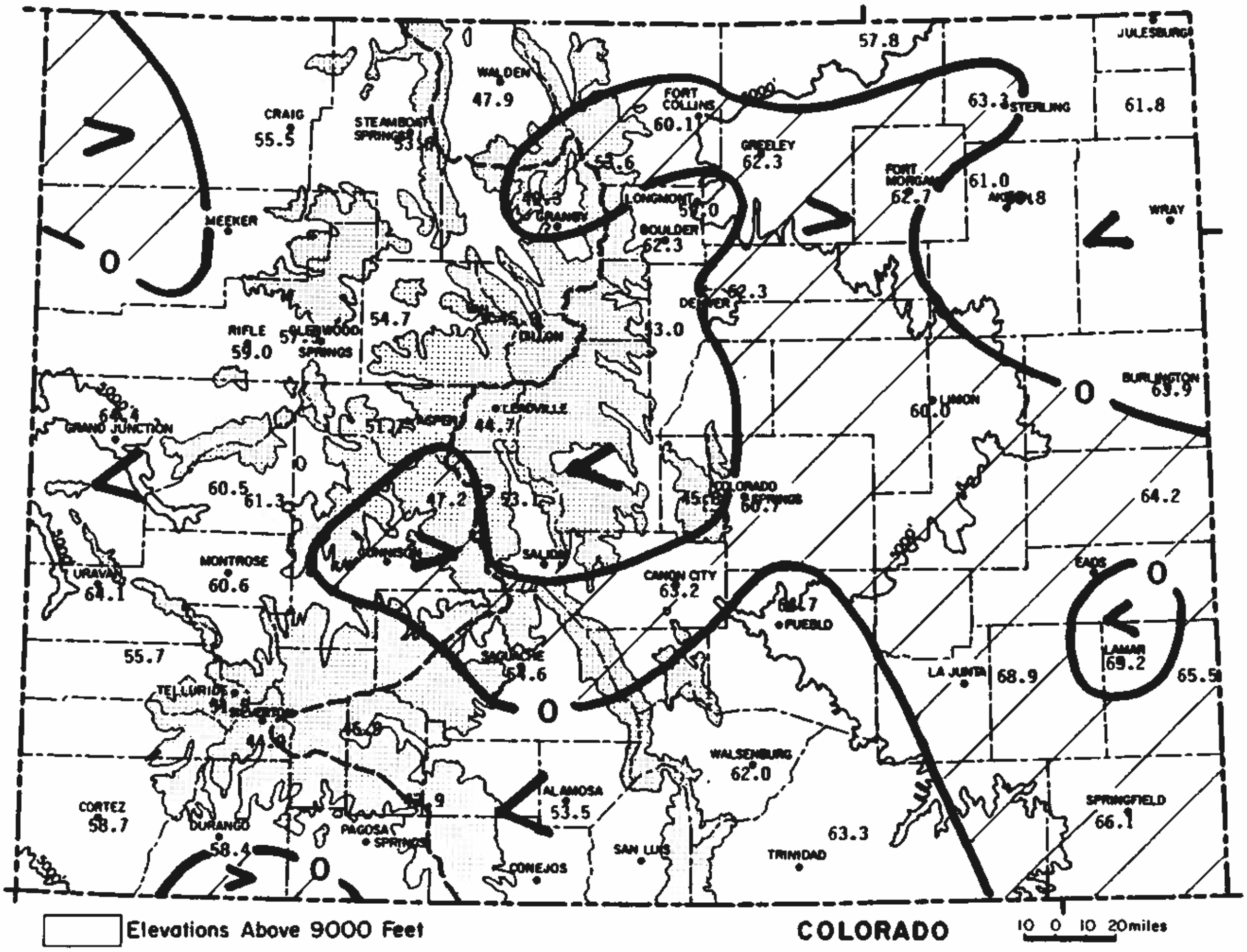
10 0 10 20 miles

Precipitation for May-September 1988 (growing season) as a percent of the 1961-80 average.

There were a number of interesting weather events during the 1988 water year. Here is a brief review. Colorado enjoyed a pleasant autumn and the first snowfall was unusually late in some areas. But from Thanksgiving into mid-February, winter held a firm grip on the state. Denver was buried by a heavy snowstorm just after Christmas, and a wicked blizzard blitzed the plains January 18-20th. Strong winds made the winter cold less bearable than usual. Spring was fairly typical, with plenty of wind and many ups and downs of temperature, but precipitation was unusually light over much of the state. The northern Front Range was an exception. Fort Collins received 40" of wind-driven snow in March making it their snowiest March in 100 years of record. Early April brought the last blizzard of the season to parts of the Eastern Plains. Dry weather then prevailed until a widespread soaking rain blessed the state in mid May. Hot weather then dominated the summer. There were few extremes -- just consistent heat. Some locations in northern Colorado experienced the warmest June-August period on record. The summer severe weather season was quite lively. Lightning claimed several lives, hail did plenty of damage, and one of the most photographed tornado system of all time took aim on Denver (June 15).

SEPTEMBER 1988 TEMPERATURES AND DEGREE DAYS

Statewide temperatures in September were slightly cooler than average. On the Eastern Plains, temperatures were about as close as you can come to average. From the mountains westward, most locations were a degree or two cooler than the 1961-1980 average. With a few local exceptions, such as Canon City and Longmont, most of Colorado escaped unusually early frosts.



September 1988 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

SEPTEMBER 1988 SOIL TEMPERATURES

A rapid drop in soil temperatures occurred September 12 in conjunction with cold rains and dense clouds. This accelerated the normal fall reversal in which temperatures near the ground change from being warmer than the deeper soils (which they are all summer) to being cooler than the ground below.

These soil temperature measurements were taken at Colorado State University beneath sparse unirrigated sod with a flat, open exposure. These data are not representative of all Colorado locations.

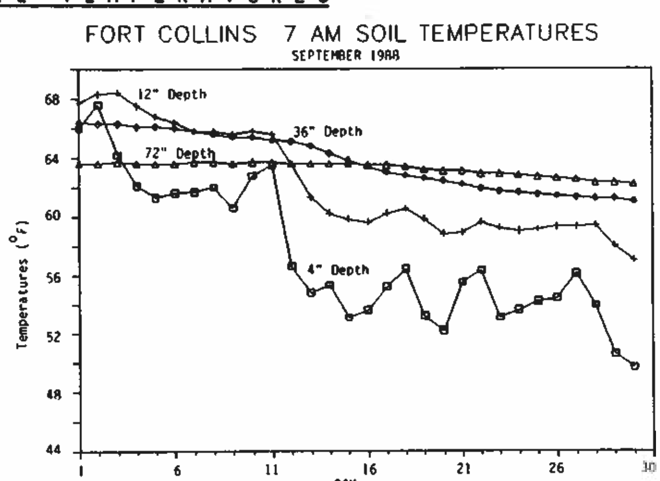


Table 1. Heating Degree Day Data through September 1988.

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
ALAMOSA	AVE	40	100	303	657	1074	1457	1519	1182	1035	732	453	165	8717
	87-88	66	96	364	601	1130	1556	1867	1381	1031	658	454	102	9306
	88-89	28	50	337										415
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	87-88	112	152	355	563	1024	1382	1450	1146	1136	734	517	123	8694
	88-89	34	79	394										507
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	87-88	7	33	122	370	713	1053	1107	842	739	400	203	14	5603
	88-89	1	4	125										130
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	87-88	49	117	313	549	955	1277	1357	1010	1030	639	472	102	7870
	88-89	37	41	350										428
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	87-88	5	20	72	375	724	1037	1221	935	779	449	178	14	5809
	88-89	4	5	101										110
CANON CITY	AVE	0	9	81	301	639	831	911	734	707	411	179	33	4836
	87-88	11	36	87	374	668	1007	1144	858	767	407	191	16	5566
	88-89	M	9	112										121
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	87-88	17	74	150	445	767	1108	1256	958	886	499	273	25	6458
	88-89	7	10	154										171
CORTEZ	AVE	0	11	115	434	813	1132	1181	921	828	555	292	68	6350
	87-88	6	35	154	396	860	1179	1351	1008	899	609	362	56	6915
	88-89	0	1	188										189
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	87-88	55	96	227	534	950	1376	1561	1264	1076	593	399	52	8183
	88-89	1	14	285										300
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	87-88	0	11	108	354	737	1102	1300	M	M	M	M	M	3612
	88-89	M	M	M										0
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	87-88	11	21	110	410	745	1125	1227	889	811	437	215	14	6015
	88-89	7	0	129										136
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	87-88	296	346	556	763	1145	1491	1629	1376	1379	933	717	322	10953
	88-89	M	283	565										848
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	87-88	14	44	188	435	851	1206	1391	972	859	514	346	42	6862
	88-89	1	5	191										197
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	87-88	54	75	254	509	950	1331	1544	1173	1002	607	404	52	7955
	88-89	3	11	301										315
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	87-88	69	118	333	602	922	1255	1310	1029	992	645	462	111	7848
	88-89	60	50	355										465
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	87-88	12	37	146	453	784	1140	1252	936	821	479	217	8	6285
	88-89	3	2	163										168
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	87-88	12	29	110	430	773	1154	1484	1055	826	495	206	17	6591
	88-89	6	3	124										133
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	87-88	0	6	34	248	754	1147	1469	1031	741	350	172	8	5960
	88-89	0	0	106										106

M = MISSING DATA

Heating Degree Data — Colorado Climate Center (303) 491-8545

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND LAKE	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
	87-88	207	257	480	677	1098	1516	1642	1413	1372	907	602	238	10409
	88-89	191	208	461										860
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	87-88	10	26	119	424	762	1157	1363	955	807	437	204	6	6270
	88-89	5	1	116										122
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
	88-89	M	M	394										394
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	87-88	0	3	35	273	653	1032	1278	837	638	327	103	1	5180
	88-89	0	0	32										32
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	87-88	346	393	578	763	1180	1534	1577	1326	1355	957	741	360	11110
	88-89	318	306	601										1225
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	87-88	21	66	158	502	840	1209	1354	1022	943	569	321	35	7040
	88-89	9	7	167										183
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	87-88	12	33	159	464	805	1169	1383	1035	847	509	222	20	6658
	88-89	10	8	203										221
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	87-88	M	M	M	M	M	M	M	M	M	M	M	M	0
	88-89	M	M	M										0
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	87-88	5	30	129	349	849	1160	1332	1003	817	468	230	26	6398
	88-89	0	1	169										170
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	87-88	104	105	347	523	947	1292	1548	1187	996	663	485	143	8340
	88-89	30	61	325										416
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	87-88	4	17	43	355	754	1111	1399	903	777	399	167	8	5937
	88-89	1	0	84										85
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	87-88	9	24	125	391	819	1209	1430	1039	865	454	268	14	6647
	88-89	0	0	198										198
STEAMBOAT SPRINGS	AVE	113	169	390	704	1101	1476	1541	1277	1184	810	533	297	9595
	87-88	77	127	330	590	1033	1448	1619	1336	1167	674	433	95	8929
	88-89	27	45	336										408
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	87-88	12	31	108	413	742	M	1475	1029	831	476	197	12	5326
	88-89	1	1	116										118
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	87-88	161	222	426	603	992	1269	1354	1109	1092	720	547	208	8703
	88-89	131	147	397										675
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	87-88	4	25	80	330	730	1054	1209	850	803	438	234	13	5770
	88-89	8	5	100										113
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	87-88	215	281	495	740	1242	1499	1572	1343	1340	835	638	184	10384
	88-89	144	189	507										840
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	87-88	3	30	101	332	707	977	1109	826	773	401	238	25	5522
	88-89	2	3	119										124

M = MISSING

SEPTEMBER 1988 CLIMATIC DATA

Eastern Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	74.0	41.6	57.8	-1.7	94	32	223	16	363	1.51	0.34	129.1	7
STERLING	80.9	45.8	63.3	2.2	99	37	116	71	443	1.08	-0.02	98.2	11
FORT MORGAN	78.6	46.8	62.7	0.5	97	35	124	62	437	1.07	-0.11	90.7	7
AKRON FAA AP	76.1	46.0	61.0	-0.7	94	35	158	46	403	1.43	0.35	132.4	11
AKRON 4E	77.2	44.5	60.8	-1.2	96	33	162	43	407	0.98	-0.07	93.3	8
HOLYOKE	76.0	47.5	61.8	-1.0	96	41	137	48	396	1.64	0.35	127.1	9
BURLINGTON	77.7	50.1	63.9	-0.2	96	40	101	75	447	1.74	0.24	116.0	6
LIMON WSMO	75.6	44.4	60.0	0.3	94	31	167	24	388	0.68	-0.22	75.6	4
CHEYENNE WELLS	78.8	49.6	64.2	0.2	97	38	89	72	457	3.31	1.52	184.9	6
LAMAR	83.1	47.2	65.2	-1.6	100	35	75	88	487	3.45	2.32	305.3	7
LAS ANIMAS	86.4	51.4	68.9	1.6	101	39	32	156	545	2.12	1.08	203.8	7
HOLLY	82.5	48.6	65.5	0.2	101	35	66	91	488	4.05	2.50	261.3	8
SPRINGFIELD 7WSW	81.6	50.5	66.1	0.8	94	36	58	99	505	4.43	3.26	378.6	8

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	75.3	44.9	60.1	0.1	91	34	163	23	396	1.95	0.71	157.3	7
GREELEY UNC	77.6	46.9	62.3	0.1	94	35	116	41	428	1.47	0.34	130.1	7
ESTES PARK	69.0	38.2	53.6	0.3	83	25	335	1	295	0.76	-0.59	56.3	4
LONGMONT 2ESE	78.8	39.2	59.0	-1.6	96	28	203	33	424	1.37	-0.06	95.8	4
BOULDER	77.3	47.2	62.3	-0.3	93	33	125	51	430	2.02	0.16	108.6	5
DENVER WSFO AP	77.7	46.8	62.3	0.4	94	35	129	55	432	0.90	-0.48	65.2	5
EVERGREEN	71.0	35.0	53.0	-0.9	86	24	355	0	323	1.56	0.11	107.6	3
RUXTON PARK	62.7	28.9	45.8	-2.0	76	23	566	0	208	0.95	-0.93	50.5	7
COLORADO SPRINGS	74.7	46.8	60.7	0.4	90	32	154	33	393	1.19	-0.17	87.5	6
CANON CITY 2SE	78.3	48.0	63.2	0.5	90	31	112	65	452	0.70	-0.39	64.2	6
PUEBLO WSO AP	82.1	47.4	64.7	-0.9	98	32	84	84	480	1.80	0.91	202.2	6
WALSENBURG	77.2	46.8	62.0	-0.5	88	32	119	38	432	2.31	1.09	189.3	6
TRINIDAD FAA AP	79.1	47.5	63.3	-0.3	92	33	100	56	455	1.83	0.76	171.0	6

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	66.5	29.3	47.9	-0.2	83	12	507	0	257	1.87	0.75	167.0	8
LEADVILLE 2SW	61.5	28.0	44.7	-1.8	74	13	601	0	182	0.38	-1.02	27.1	3
BUENA VISTA	70.5	35.7	53.1	-2.0	83	25	350	0	319	1.76	0.71	167.6	4
SAGUACHE	71.0	38.3	54.6	0.5	82	30	306	0	320	0.49	-0.46	51.6	4
HERMIT 7ESE	63.4	28.4	45.9	-1.5	75	16	566	0	207	1.60	0.17	111.9	3
ALAMOSA WSO AP	72.7	34.3	53.5	-1.2	83	18	337	0	347	0.64	-0.19	77.1	5
STEAMBOAT SPRINGS	73.5	33.6	53.6	2.0	85	18	336	1	362	1.31	-0.29	81.9	6
GRAND LAKE 6SSW	66.0	32.6	49.3	0.3	83	18	461	0	247	0.65	-0.59	52.4	7
DILLON 1E	63.9	27.9	45.9	-2.0	75	15	565	0	219	0.60	-0.74	44.8	6
ASPEN 1SW	67.2	36.2	51.7	-0.8	80	22	394	0	264	1.85	0.05	102.8	7
TAYLOR PARK	63.1	31.3	47.2	3.3	74	20	526	0	203	1.40	-0.14	90.9	5
TELLURIDE	68.9	34.1	51.5	-0.0	78	21	397	0	290	3.35	1.21	156.5	8
PAGOSA SPRINGS	73.9	34.1	54.0	-0.6	85	23	325	0	368	1.12	-0.98	53.3	8
SILVERTON	64.9	24.9	44.9	-0.6	75	14	595	0	233	3.39	0.85	133.5	12
WOLF CREEK PASS 1	57.7	30.1	43.9	-1.3	70	20	625	0	132	3.37	-0.62	84.5	7

Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	72.5	38.5	55.5	-0.6	88	20	285	7	343	1.58	0.28	121.5	6
HAYDEN	72.6	37.8	55.2	-0.4	85	23	289	2	350	2.20	0.99	181.8	6
RANGELY 1E	78.3	43.5	60.9	0.6	91	26	169	54	433	1.21	0.12	111.0	6
EAGLE FAA AP	73.4	36.0	54.7	-0.6	88	20	301	0	356	1.56	0.38	132.2	6
GLENWOOD SPRINGS	75.5	39.5	57.5	-1.2	90	27	237	19	381	2.16	0.57	135.8	6
RIFLE	78.3	39.7	59.0	-0.2	92	28	198	23	410	2.59	1.51	239.8	5
GRAND JUNCTION WS	78.6	50.3	64.4	-2.3	93	37	106	97	460	0.75	0.03	104.2	5
CEDAREDGE	77.4	43.7	60.5	-0.7	92	27	168	40	415	2.90	1.71	243.7	6
PAONIA 1SW	77.3	45.3	61.3	-0.7	91	33	149	46	419	1.91	0.56	141.5	8
GUNNISON	72.5	30.7	51.6	0.3	86	17	394	0	345	0.54	-0.37	59.3	4
MONTROSE NO. 2	77.1	44.1	60.6	-0.5	91	31	169	45	419	1.65	0.48	141.0	4
URAVAN	82.5	45.7	64.1	-1.6	96	34	103	83	467	1.55	0.48	144.9	6
NORWOOD	71.4	40.1	55.7	-0.8	83	23	273	0	330	2.72	1.12	170.0	5
YELLOW JACKET 2W	74.8	44.9	59.8	-0.5	89	33	171	22	387	1.64	0.26	118.8	5
CORTEZ	76.1	41.3	58.7	-1.5	88	29	188	7	398	1.71	0.51	142.5	6
DURANGO	76.2	40.7	58.4	-0.1	90	30	191	5	400	1.26	-0.47	72.8	6
IGNACIO 1N	79.3	37.7	58.5	0.7	90	24	195	7	445	1.19	-0.34	77.8	7

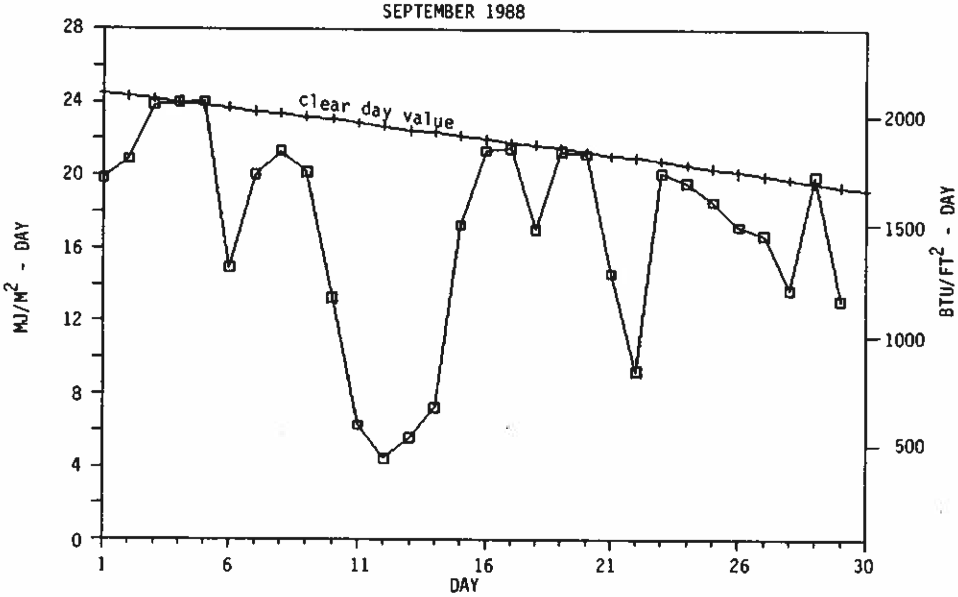
* Data are received by the Colorado Climate Center for more locations than appear in these tables. Please contact the Colorado Climate Center if additional information is needed.

SEPTEMBER 1988 SUNSHINE AND SOLAR RADIATION

Station	Number of Days: clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	15	6	9	--	--
Denver	13	9	8	73%	75%
Fort Collins	13	10	7	--	--
Grand Junction	20	5	5	80%	76%
Pueblo	16	6	8	83%	80%

FT. COLLINS TOTAL HEMISPHERIC RADIATION

SEPTEMBER 1988



Thermal Energy Storage in Buildings

Have you ever walked in bare feet on an asphault roadway on a warm, sunny afternoon? If the sun has been shining on the road long enough, you probably regretted not wearing your shoes that day. The dark pavement absorbs the incident solar radiation and stores it in the form of heat. Even after sunset the roadway remains warm for a few hours.

Buildings also exhibit this effect. It is more noticable in "light" houses (wood frame construction), where there is less mass to temper the effects of the added energy, than in "heavy" (masonry) houses. That is, a heavy building will store more energy than a similarly sized light structure, and will tend to show less radical temperature changes within the occupied zones. This thermal storage is a benefit in the spring and fall when it gets chilly after sunset, but can be undesirable during a hot summer night when you are trying to sleep.

The mass of a building also plays a role during the heating season. A heavy building which cools off (for example, over a weekend) is more difficult to bring up to normal habitable temperatures. A light building, like most residences, does not store much heat within the structure itself, and therefore relies on insulation to prevent heat loss through the walls and roof.

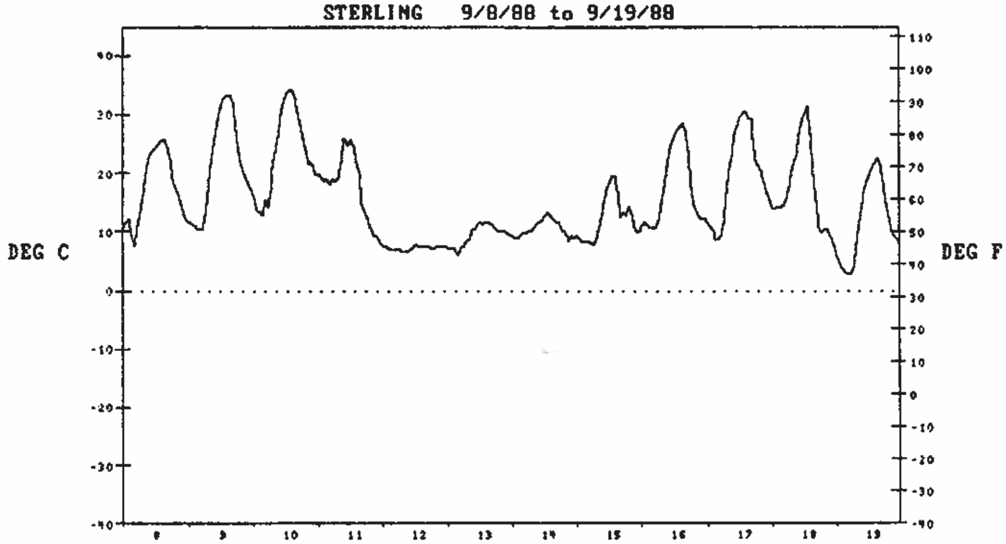
Of course, any deviation from normal operating conditions translates into energy use: heaters or air-conditioners must be used to bring the internal climate back into the "comfort zone." When designing low energy-use homes, therefore, it is important to correctly size the thermal mass of the building for optimal heating and cooling applications.

In passive solar-heated homes, sizing the thermal mass is an integral part of the design process. Since the main energy source is not available for half of the day, solar houses are designed to take advantage of the heat capacity of the construction materials through correct orientation and thicknesses of heat storage walls.

An Example

In September most of the state experienced a cold spell from the 11th to the 15th. This little preview of winter clearly illustrates the benefit of thermal storage, since most of us had probably not done our yearly furnace maintenance by then. The graphic below shows the temperature in Sterling over a twelve day period starting on the 8th. Just before the cold snap the daytime temperatures reached 94°F, then plummeted to around 45° for the next four and a half days. Whereas the interior of a thick-walled stone house might not "see" this temperature drop for a few days, a stud and sheetrock framed home would most likely be uncomfortably cool by the end of the first day.

AMBIENT TEMPERATURE
STERLING 9/8/88 to 9/19/88



This report prepared by Peter Curtiss of the Joint Center for Energy Management, a collaboration between Colorado State University and the University of Colorado at Boulder.

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Walsh
monthly average temperature (°F)						
	53.2	54.0	52.8	57.2	49.3	64.0
monthly temperature extremes and time of occurance (°F day/hour)						
maximum:	81.9 8/16	82.9 8/15	84.7 7/16	84.4 8/14	84.4 9/15	95.0 7/13
minimum:	18.5 29/ 6	26.6 29/ 7	20.8 29/ 6	27.0 29/ 6	15.3 29/ 6	39.4 29/ 1
monthly average relative humidity / dewpoint (percent / °F)						
5 AM	85 / 32	81 / 35	90 / 34	76 / 36	90 / 30	79 / 47
11 AM	39 / 37	44 / 41	41 / 37	44 / 42	39 / 33	49 / 47
2 PM	25 / 30	34 / 37	29 / 32	34 / 38	31 / 30	42 / 45
5 PM	28 / 29	34 / 35	29 / 30	32 / 36	31 / 28	42 / 45
11 PM	55 / 31	69 / 37	65 / 34	57 / 35	70 / 31	71 / 47
monthly average wind direction (degrees clockwise from north)						
day	178	216	256	232	234	168
night	174	86	177	156	129	214
monthly average wind speed (miles per hour)						
	4.86	3.52	3.47	3.00	3.52	9.14
wind speed distribution (hours per month for hourly average mph range)						
0 to 3	286	406	468	432	453	73
3 to 12	391	305	231	288	235	450
12 to 24	43	9	21	0	32	190
> 24	0	0	0	0	0	7
monthly average daily total insolation (Btu/ft²·day)						
	1779	1758	1627	1722	1542	1517
"clearness" distribution (hours per month in specified clearness index range)						
60-80%	248	172	205	211	210	207
40-60%	60	66	68	49	52	53
20-40%	32	41	46	37	44	38
0-20%	15	36	19	25	47	55

The State-Wide Picture

The figure below shows the monthly weather for the eight WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40 degrees to 110 degrees Fahrenheit, the middle one gives the daily total solar radiation on a horizontal plane, up to 4000 Btu per square foot per day, and the bottom graph illustrates the hourly average wind speed from 0 to 40 miles per hour. Continuing problems with the Stratton station have prevented us from retrieving data from these sites. Solar data was not available in Sterling on the 6th.