COLORADO CLIMATE SUMMARY
WATER-YEAR SERIES
(October 1989–September 1990)

Nolan J. Doesken
Thomas B. McKee

STATE
COLORADO UNIVERSITY
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Climatology Report No. 91–1

DEPARTMENT OF ATMOSPHERIC SCIENCE
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO

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Fort Collins, CO 80523

January 1991

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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, Jerry Sherlin 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 her countless hours preparing and processing each month's climate data and assembling this finished product. The work of John Kleist in maintaining and upgrading computer processing has been very helpful.

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I. INTRODUCTION

The 1990 Water Year marked the 16th year of existence of the Colorado Climate Center (CCC) and the 13th 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, some of the snowiest years in the past 60 years and one of the wettest consecutive periods in the state as a whole, and in recent years a return to drought conditions. 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 averages, these summaries 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.

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: "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 trying 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 follows 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 60 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 several 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.

Beginning in January 1988 an additionally energy-related climate feature was added to the monthly climate report. A special program at University of Colorado at Boulder and Colorado State University called the Joint Center for Energy Management (JCEM) is funded to undertake various efforts to help conserve energy in Colorado. One project at the University of Colorado established 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.

1) Fire It Up. (October 89, pp. 20)
2) One Beam at a Time. (November 89, pp. 31)
3) Wind Power. (December 89, pp. 42)
4) Hydro-Electric Power. (January 90, pp. 53)
5) Ice Storage. (February 90, pp. 64)
6) Home Energy Rating System. (March 90, pp. 75)
7) A Bright Savings Plan. (April 90, pp. 86)
8) Solar Water Heaters. (May 90, pp. 97)
9) JCEM Bulletin Board. (June 90, pp. 108)
10) Solar Water Heaters II. (July 90, pp. 119)
11) Wind Shears. (August 90, pp. 130)
12) The Ultimate Furnace. (September 90, pp. 141)

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.

III. 1990 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 1990 summary found on pages 132-134.

COLORADO CLIMATE

OCTOBER 1989

Colorado Climate Center
Department of Atmospheric Science
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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 13 Number 1

October in Review:

Most days in October were either warmer or colder than average. For the most part, the cold days balanced the warm and the month as a whole ended up very close to average. Sunshine was plentiful, as it usually is in October. Precipitation was generally less than average with most of the State's October precipitation falling from a mid-month storm. But some parts of southern Colorado received heavy early-October rains associated with the remains of Pacific hurricane Raymond. These areas ended up with near-average moisture.

Colorado's December Climate:

The Rocky Mountains always play a big part in Colorado's weather and climate. Mountain-induced contrasts become greatest in mid-winter as strong, prevailing westerly winds aloft lift Pacific moisture up the west side of the mountains and squeeze out periodic snows. The winds then descend the east slopes of the mountains -- warming and drying out as they go. Wave-shaped clouds, lip-chapping dry air and an occasional burst of strong winds may be all that remains of mountain storms by the time they reach the east slope. But evey now and then the winds turn. Storms tracking south of Colorado or surges of Arctic air from the north sometimes produce winds with an easterly component. Then the east side gets the "upslope" while the Western Slope enjoys the sunshine. Regardless, of the situation, you can be assured that whatever the weather you're experiencing in December -- other parts of Colorado are experiencing something else.

Average temperatures across Colorado in December reflect these contrasts and also show the effect of cold, dense air's tendency to collect in valleys. Daytime temperatures in the mountains average in the 20s while the surrounding valleys may reach the 30s. East of the mountains highs average in the 40s and sometimes reach the 50s and 60s. Lows often approach 0°F in the mountains with colder temperatures in the high valleys. From the Front Range foothills eastward across the plains, lows average in the teens. The east side of the mountains definitely enjoy warmer average temperatures in mid-winter compared to the mountains and Western Slope. But areas east of the mountains pay for the relative warmth by tolerating more windstorms and greater day-to-day variations in temperature. Downslope windstorms can occur quite frequently in midwinter and sometimes produce winds in excess of 100 mph in preferred locations at the base of the foothills. One or more Canadian cold fronts can also be expected in December bringing sharply colder temperatures east of the mountains (sometimes subzero) and light wind-blown snows.

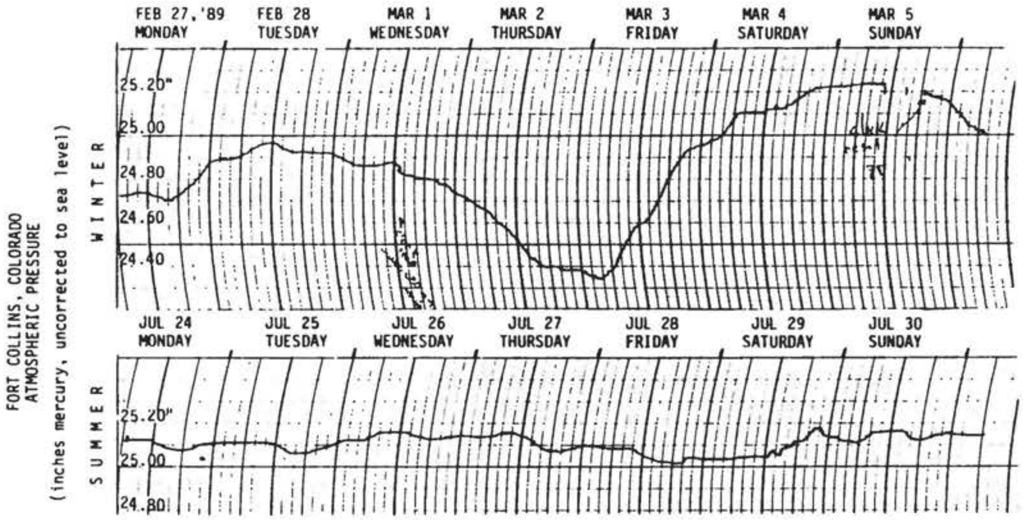
In a typical December, expect precipitation to be heavy in the mountains as several storm systems normally march over the Rockies. The northern mountains can expect an average of 10 to 15 days with snow during the month. Only 6-12 snow days are expected in the southern mountains, but southern areas are more likely to have heavier individual snowstorms. East of the mountains only average 3 to 6 snow days. Total precipitation ranges from 2" to 5" in the mountains (30-80" snow). The Western Slope and eastern foothills average 0.50" to 0.80" (8-20" snow), and on the plains precipitation is typically between 0.25" and 0.50" (5-10" smow).

Climate and Health -- Are They Related?

For centuries people have noted and scholars have written about some of the apparent effects of climate on human health and emotional well-being. Some relationships are obvious. Certain diseases originate only in tropical climates. Others are most common in more temperate zones. It was noted after some of the early expeditions to polar regions that these areas were nearly disease free. But as humans have come to travel the entire world so freely and reside in comfort-controlled environments world over, several diseases have become more widespread and their apparent relationship to climate has lessened. Be that as it may, every year beginning some time in the fall, our office sees a notable

(continued on Page -2-)

increase in the number of health-related phone calls in which people perceive some aspect of their health and well-being to be adversely affected by climate and day-to-day weather changes. The increased level of concern correlates extremely well with decreased outdoor temperature, decreased indoor humidity and a significant increase in day-to-day and hour-by-hour fluctuations in atmospheric pressure. In a few months -- typically in about May -- the health-related phone calls will diminish again except for a few calls about high elevation climate and altitude sickness.



I am not a health expert. I am not qualified to comment on health related concerns. But I do find our climate-health phone calls very interesting, and I -- just like many of you -- have noted "apparent" associations between weather changes and how I feel. For example, I am convinced that I am most likely to get a headache when the atmospheric pressure is rising rapidly and indoor relative humidity is very low. Other people tell me they get headaches when the pressure is very low or dropping fast. Still others tell me that high pressure bothers them. If we are so bothered by pressure changes, I wonder if we also suffer from driving in the mountains. A change in the atmospheric pressure of 1 inch of mercury in 24 hours (rising or falling) is very unusual here in Colorado and in most of the rest of the country for that matter. But the pressure change we experience on a drive from Denver to the Eisenhower Tunnel is equivalent to about 5 inches of mercury in about an hour -- a rate of change nearly 100 times more dramatic than observed when a storm passes over. (I'm sure that some people do get headaches from that drive, but none of them call me to tell me about it.)

Sudden changes in temperature also seem to trigger problems for some people. And then, of course, there is the wind. It is hard to keep your sense of humor when winds howl for a prolonged period of hours or days. It may not be appropriate, however, to separate the effects of wind from those of pressure. Winds are a direct result of pressure gradients. When the winds are blowing strong, we often are also experiencing significant pressure changes (and probably also temperature changes).

From what I have gathered, the modern medical profession does not deny that weather-health relations may exist, but they are unlikely to take those effects too seriously or recommend their patients move to different climates to improve their health. This is a much different philosophy that just a few decades ago when doctors often prescribed long trips or permanent moves to regions of "preferred climate" in their treatments for several diseases. It turns out that a fair number of Coloradans ended up in this part of the country because of medical advice given many years ago.

When you dig into the history of Colorado, you find that much of the early work on monitoring and conducting research on Colorado's climate was performed or initiated by the medical profession. The very first professional medical organization in Colorado formed a committee on climatology in 1874 headed by Dr. Charles Dennison from Denver. In the 1880s the Colorado Meteorological Association was established. Many of its members were medical doctors. Remarks written on monthly weather observation forms in the 19th Century often contained health-related comments.

It was widely believed at that time that Colorado afforded a very healthy climate. A paper by Walter A Jayne, M.D. of Georgetown, Colorado, presented September 19, 1888 to the American Climatological Association in Washington D.C. and published in "The Medical News," Vol. 53, no. 19, stated, "Colorado affords these conditions (the purest and most aseptic atmosphere -- in which people may spend the maximum of time under the open sky safely and agreeably) to an extent hardly to be found elsewhere, since not only is the climate suitable for a very large class of consumptives, but from the great combination of elevated plains and mountains an invalid may find an all the year climate of infinite variety from which to select." He went on to say that thousands of people in Colorado who were once invalids had become "useful, active citizens."

Dr. S. E. Solly, writing in the October 1888 issue of COLORADO WEATHER (the bulletin of the Colorado Meteorological Association) expounded the merit and liability of Colorado's climate upon several medical conditions:

> "Consumption, it is now proved, owes its peculiar and fatal character to the presence of a tiny parasite called the bacillus, which gives rise to tubercle. All theory demonstrates that the air of an elevated country like Colorado has advantages far beyond all other climates in arresting the ravages of this enemy to human flesh and the overwhelming testimony of doctors and laymen on both Continents confirms this fact. Therefore, in an early stage of consumption there is hardly ever a doubt of the wisdom of coming hither, but when the disease has a firm hold or there are complications, it requires the skill and judgement of a physician posted in climatology as well as medicine, to decide the choice of climate."
>
> "In convalescence from pneumonia, pleurisy or bronchitis, the recovery is usually more rapid and complete at an altitude than at sea level."
>
> "In heart disease or disturbance, the answer is generally wisely in the negative, but in some cases if prudence is observed benefit is derived, but such cases require the best medical judgment to be first passed upon them."
>
> "In nervous affections, if there is positive disease of structure, the climate is adverse. Such a disease as apoplexy or the warning signs of age are also contra-indications, but many disorders are benefitted, especially asthma. Nervous exhaustion from over work, etc, is usually recovered from much more rapidly here than at sea level, though the nervous feelings that accompany it are at first aggravated."
>
> "With affections of the liver if dependent on a weak or sluggish circulation, the answer is favorable, but a liver inclined to inflammatory conditions is made worse here."
>
> "Kidney diseases as a rule, though not always, do better in a more equable climate."
>
> "Convalescence from fevers, blood poisoning and similar conditions are invariably benefitted."
>
> "Chronic nasal catarrh and throat affections of a sluggish, thin-blooded type improve, but irritable conditions are generally aggravated."
>
> "As regards the effect of the climate upon the lungs, and more or less upon the other parts of the body, it is like putting it in a gymnasium; in which to exercise without advice is foolish and dangerous, and so in Colorado, no person who is really sick, should come without the approval of a competent physician, and remain without an early consultation with one on the spot after his arrival."
>
> "Not only is the matter of exercise important, but also avoidance of cold catching, the difference of climatic conditions making a stranger liable to err through ignorance. Therefore let the invalid and visitor remember to make haste slowly and so chose for their motto: 'Festina lente.'"

With the dissemination of such information along with the highly advertized benefits derived from mineral hot springs in Colorado complimented by active promotions by the railroad industry, thousands of travelers came to Colorado in search of good health and stimulation. Some found it -- others didn't.

So now we pose the question, "Is Colorado a healthier place to live today than other parts of the country?" It seems like an easy enough question to answer. However, depending on how you analyze the data, you can come up with a variety of answers. Based on conversations with several people at the Colorado Department of Health, I learned that we have fewer incidents of some animal and insect-borne diseases that prefer warmer, damper regions. We may be a good place to recover from certain respiratory ailments because of our relatively dry atmosphere. We may at one time have been a good refuge to escape "hayfever," but with urbanization has come more diverse irrigated vegetation and associated pollens. We are no less susceptible to the common communicable diseases than residents of other states. We utilize more orthopedic treatment than some other parts of the county. Coloradans statistically do tend to be healthier than citizens of some other parts of the country, but on average we also smoke less, excercise more and are younger and better educated. These factors are probably more important than climate or other geographical attributes in determining health.

Have I answered any questions? I doubt it. The weather and climate system, of and by itself, is already extremely complex and we haven't even considered environmental pollution problems. Add to it the complexity of human health, behavior, emotions and perceptions and we end up with an intertwined physical system that will keep data gatherers and statisticians occupied for many centuries to come. I wish you good health.

OCTOBER 1989 DAILY WEATHER

Date	Event
1-5	A Pacific front cooled temperature a bit statewide on the 1st. Then a storm system began forming 2-3rd over the western plateau states while a strong, cool high pressure area dropped southward from the Canadian prairies producing weak upslope flow east of the mountains. Such patterns often bring considerable precipitation to Colorado, but moisture was lacking until late on the 3rd when remnants of Pacific hurricane Raymond began to move northward across Arizona and New Mexico to join the system. Light showers dampened portions of western Colorado as temperatures remained mild early on the 4th, but heavy rains fell across some parts of southern Colorado. By the end of the day on the 4th, Durango had received 1.36", Silverton totalled 2.13" and Wolf Creek Pass 1E measured 3.78". Most of this precipitation fell as rain except at very high elevations. Rains diminished as they spread eastward, but close to 0.50" was also noted east of the mountains from near Trinidad to Springfield. Areas north of the Arkansas River remained dry.
6-7	Pleasantly cool autumn weather. Dry statewide except for some light showers over the northeast plains early on the 7th. Sedgwick reported 0.15" of rainfall.
8-13	Dry and unseasonable warm as an upper-level high pressure ridge prevailed over the southwest U.S. A low pressure area raced eastward well to the north of Colorado on the 11th but created strong winds over parts of northern and eastern Colorado. Temperatures soared into the 80s 10-13th at many lower elevation location and some new record highs were set especially 11th and 13th east of the mountains. Sterling hit 90° on the 13th. The 96° reading at Las Animas on the 11th was the highest in the state.
14-19	A large low pressure trough aloft moved slowly across the Rockies while a cold air mass pushed southward out of Canada. Temperatures remained very warm on the 14th as clouds increased. Rains and high elevation snows began early on the 15th across most of western Colorado. Precipitation also began late on the 15th along the Front Range from Fort Collins to Denver and quickly changed to snow as it spread gradually southward and eastwards. Precipitation was heaviest in a band from near Norwood and Cedaredge northeastward to Grand Lake and along the Front Range. Some larger totals for the storm were 0.57" at Denver (4.4" snow), 0.60" at Estes Park (6" snow), 0.84" at Norwood, 0.82" at Eagle, 0.88" at Rifle, and 1.23" at Paonia. The weather station near Redstone recorded 1.70" (3" snow). Precipitation ended on the 16th in western Colorado and tapered off east of the mountains on the 17th. From the mountains eastward, temperatures on the 16th and 17th remained only in the 30s. As skies cleared, chilly nighttime temperatures were observed. Akron and Pueblo both dipped to 19° on the 19th.
19-25	Mild autumn weather. Mostly dry as high pressure dominated the area. However, an upper-level disturbance brought a brief dose of moisture to the Western slope late on the 21st and early on the 22nd. Cedaredge got 0.34" of rain.
26-31	A deep low pressure system moved quickly across Colorado on the 26th bringing a dose of snow to the mountains and colder, blustery weather to the entire State. A respite on the 27th and then another storm on the 28-29th looked very threatening but only produced a dusting of northern mountain snow and a few inches of snow along the southern Front Range from Westcliffe to Trinidad. Clearing but still cold on the 30th. The morning of the 30th produced the coldest temperatures of the month for most of the state. Westcliffe's -4°F reading was Colorado's coldest. Then on the 31st (Halloween) a strong cold front pushed south from Montana producing a burst of snow and winds along the northern Front Range and northeast plains just in time for Halloween festivities. As much as 6" of snow fell from Fort Collins to Castle Rock by midnight.

October 1989 Extremes

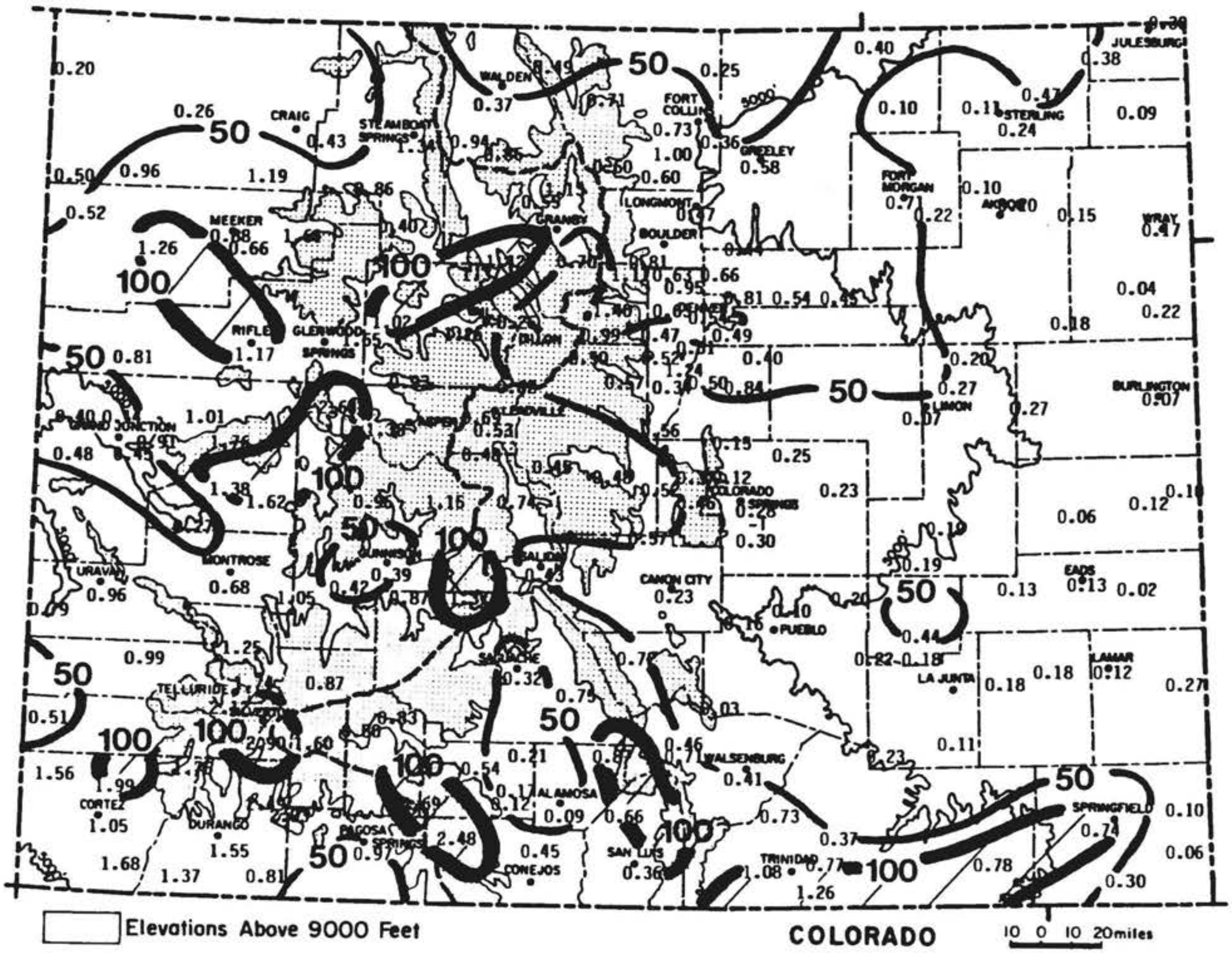
Highest Temperature	96°F	October 11	Las Animas
Lowest Temperature	-4°F	October 30	Westcliffe
Greatest Total Precipitation	4.69"		Wolf Creek Pass 1E
Least Total Precipitation	Trace		Fountain
Greatest Total Snowfall*	22"		Mt Evans Res Center
Maximum Snowdepth*	13"	October 18	Mt Evans Res Center

* For existing weather stations with complete daily records.
Higher values are likely for unmonitored locations.

OCTOBER 1989 PRECIPITATION

Most of October's precipitation was produced by a mid-month storm system that affected most of Colorado. The remnants of Pacific hurricane Raymond did contribute some early October rainfall to southern Colorado, and a brief Halloween snowstorm affected parts of the Front Range. Total precipitation for the month ended up well below average over most of the state. Most of eastern Colorado had less than half of the October average. Conditions were more variable in the western half of the State ranging from less than 25% of average in extreme northwestern areas and part of the San Luis Valley to more than 120% of average in isolated areas of the southern and central mountains. Of 206 official reports for October, 90 stations received less than 50% of their average precipitation, 67 stations had 50%-79% of average, 26 locations reported 80%-99%, 13 stations had 100%-119% and 10 stations received at least 120% of average.

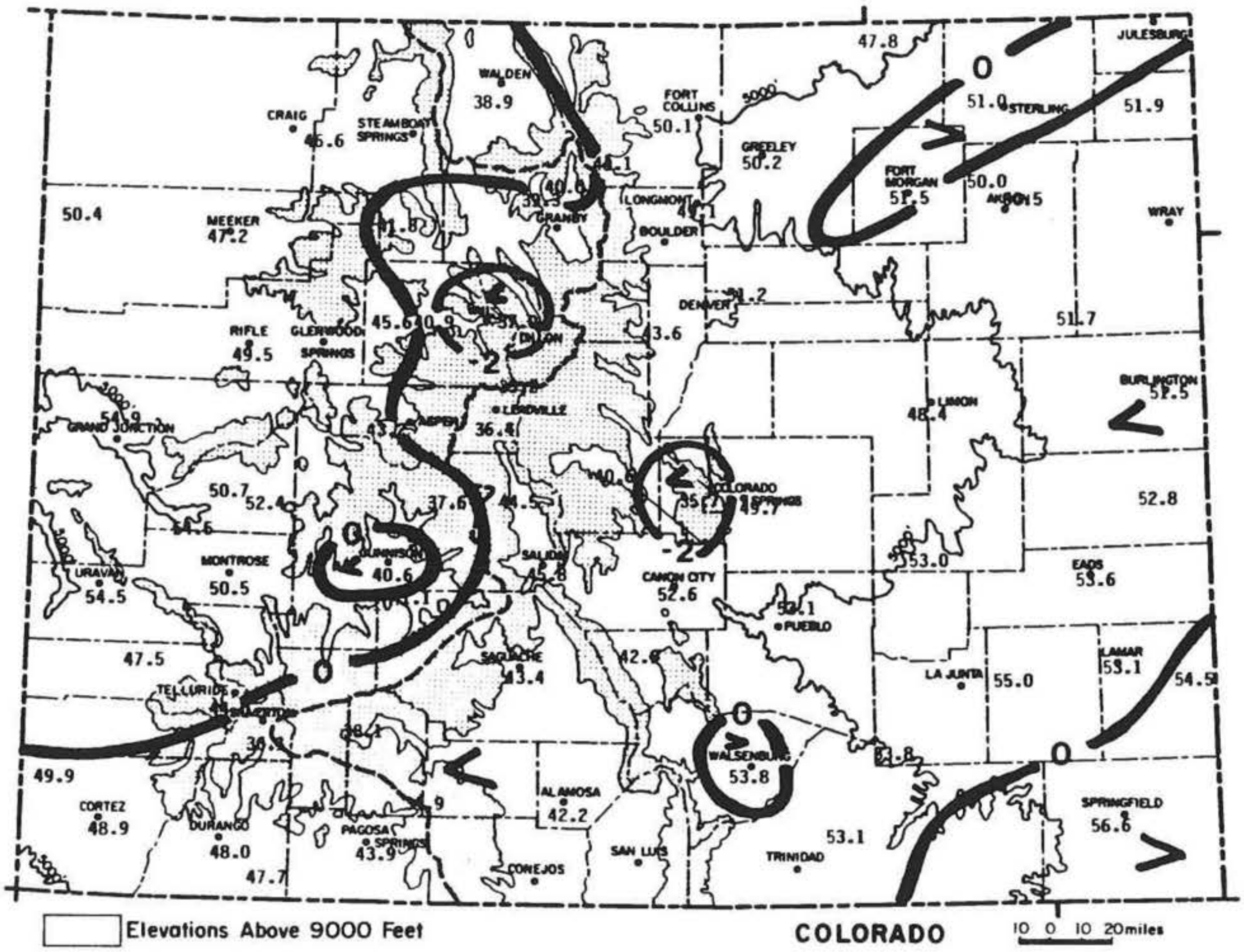
Greatest		Least	
Wolf Creek Pass 1E	4.69"	Fountain	Trace
Silverton	2.90"	Brandon	0.02"
Redstone 4W	2.64"	Rye	0.03"
Lemon Dam	2.49"	Idalia 5NNE	0.04"
Platoro Dam	2.48"	Kit Carson 6S	0.06"



Precipitation amounts (inches) for October 1989 and contours of precipitation as a percent of the 1961-1980 average.

OCTOBER 1989 TEMPERATURES AND DEGREE DAYS

October ended on a cool note after going through 3 cycles of alternating above and below average temperatures. For the month as a whole, temperatures were well within the normal range but ended up slightly cooler than average over most of eastern and southern Colorado and a bit warmer than average over northwestern and extreme southeast portions of the State. Most reporting stations were within 2 degrees F of their long-term October averages.



October 1989 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

OCTOBER 1989 SOIL TEMPERATURES

October soil temperatures marched dramatically but irregularly downward in response to alternating periods of mild and cold weather.

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.

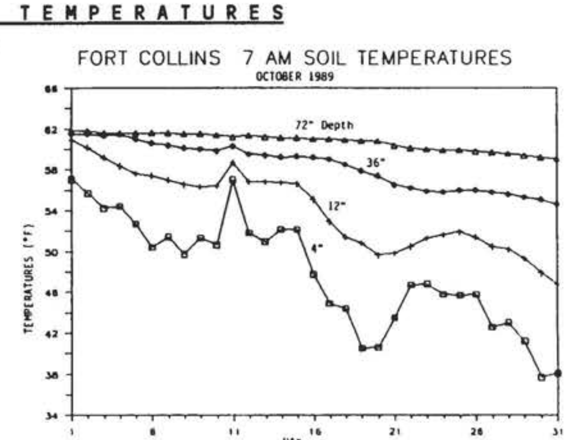


Table 1. Heating Degree Day Data through October 1989 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698									1068
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671									1218
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M									M
BUENA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
VISTA	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628									1049
BURLING-	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
TON	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415									M
CANON	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
CITY	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379									510
COLORADO	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
SPRINGS	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473									649
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494									652
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	M									285
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330									M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424									577
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861									1946
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520									647
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593									871
EVER-	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
GREEN	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657									1149
FORT	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
COLLINS	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458									630
FORT	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
MORGAN	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416									574
GRAND	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
JUNCTION	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316									356

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

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

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
LAKE	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768									1669
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454									623
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749									1306
LAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
ANIMAS	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323									422
LEAD-	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
VILLE	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880									2122
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508									719
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484									694
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543									782
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439									559
PAGOSA	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
SPRINGS	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646									1072
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373									467
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473									578
STEAMBOAT	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
SPRINGS	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M									450
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428									M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644									1161
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369									481
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802									1674
WALSEN-	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
BURG	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345									464

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

OCTOBER 1989 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	63.4	32.3	47.8	-1.4	86	14	528	4	246	0.40	-0.12	76.9	4
STERLING	69.8	32.1	51.0	1.1	92	18	428	1	321	0.11	-0.73	13.1	3
FORT MORGAN	68.0	35.1	51.5	0.5	91	17	416	6	302	0.71	0.14	124.6	3
AKRON FAA AP	63.9	36.2	50.0	-0.9	84	16	462	6	254	0.10	-0.55	15.4	1
AKRON 4E	66.8	34.2	50.5	0.1	90	14	447	6	291	0.20	-0.34	37.0	2
HOLYOKE	67.1	36.7	51.9	-0.4	87	18	400	4	294	0.09	-0.64	12.3	2
JOES	68.6	34.9	51.7	-0.3	91	18	411	5	311	0.18	-0.62	22.5	1
BURLINGTON	66.5	36.5	51.5	-2.5	88	20	415	3	284	0.07	-0.69	9.2	2
LIMON WSMO	63.9	32.9	48.4	-0.2	84	14	508	0	248	0.07	-0.53	11.7	2
CHEYENNE WELLS	70.0	35.5	52.8	-0.5	89	19	375	4	317	0.12	-0.71	14.5	1
EADS	70.6	36.7	53.6	-0.7	89	20	349	3	335	0.13	-0.64	16.9	2
ORDWAY 21N	72.2	33.7	53.0	0.2	94	14	375	9	353	0.19	-0.30	38.8	3
LAMAR	74.4	31.8	53.1	-1.9	94	15	371	8	378	0.12	-0.61	16.4	1
LAS ANIMAS	73.3	36.6	55.0	-0.8	96	20	323	19	366	0.18	-0.45	28.6	2
HOLLY	73.4	35.6	54.5	0.5	93	18	324	6	369	0.27	-0.53	33.7	3
SPRINGFIELD 7WSW	73.5	39.8	56.6	1.4	89	19	274	22	381	0.74	0.04	105.7	5
TIMPAS 13SW	70.0	37.6	53.8	-0.2	90	18	358	17	337	0.23	-0.48	32.4	2

Foothills/Adjacent Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	64.2	35.9	50.1	0.1	83	18	458	2	248	0.73	-0.28	72.3	5
GREELEY UNC	65.5	34.9	50.2	-0.5	85	16	454	1	266	0.58	-0.41	58.6	4
ESTES PARK	56.5	31.7	44.1	-1.2	73	12	639	0	146	0.60	-0.18	76.9	1
LONGMONT 2ESE	67.1	31.2	49.1	-1.3	89	15	484	3	286	0.47	-0.41	53.4	2
DENVER WSFO AP	65.8	36.7	51.2	-0.5	84	18	424	5	272	0.81	-0.07	92.0	4
EVERGREEN	61.3	25.8	43.6	-1.2	79	11	657	0	206	0.47	-0.71	39.8	3
CHEESMAN	65.0	23.2	44.1	-3.2	81	8	640	0	263	0.56	-0.63	47.1	3
LAKE GEORGE 8SW	56.2	25.0	40.6	-1.7	72	10	749	0	145	0.48	-0.25	65.8	4
ANTERO RESERVOIR	56.5	17.7	37.1	-1.1	71	2	859	0	145	0.45	-0.26	63.4	3
RUXTON PARK	50.6	20.8	35.7	-3.5	70	0	901	0	85	0.46	-0.90	33.8	3
COLORADO SPRINGS	63.7	35.7	49.7	-0.9	82	16	473	3	244	0.28	-0.47	37.3	4
CANON CITY 2SE	67.8	37.4	52.6	-1.6	86	19	379	3	302	0.23	-0.64	26.4	2
PUEBLO WSO AP	71.3	35.0	53.1	-0.9	89	15	373	11	343	0.10	-0.48	17.2	1
WESTCLIFFE	60.5	25.3	42.9	-1.2	78	-4	655	0	184	0.72	-0.47	60.5	3
WALSENBURG	69.1	38.5	53.8	0.7	84	18	345	8	315	0.41	-0.67	38.0	4
TRINIDAD FAA AP	70.1	36.1	53.1	-0.5	86	14	369	6	331	0.37	-0.52	41.6	4

Mountains/Interior Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	56.0	21.7	38.9	0.2	70	2	802	0	141	0.37	-0.45	45.1	4
LEADVILLE 2SW	51.6	21.3	36.4	-0.6	68	3	880	0	87	0.53	-0.57	48.2	4
SALIDA	63.8	27.7	45.8	-1.4	80	10	590	0	239	0.43	-0.59	42.2	3
BUENA VISTA	62.5	26.4	44.5	-1.6	77	10	628	0	215	0.74	-0.04	94.9	3
SAGUACHE	60.8	26.1	43.4	-1.4	75	8	661	0	181	0.32	-0.42	43.2	4
HERMIT 7ESE	58.1	18.0	38.1	-0.4	72	0	824	0	147	0.80	-0.77	51.0	2
ALAMOSA WSO AP	62.3	22.0	42.2	-1.5	77	-2	698	0	205	0.09	-0.63	12.5	1
YAMPA	56.4	27.2	41.8	-0.4	71	8	711	0	143	0.40	-0.78	33.9	6
GRAND LAKE 1NW	58.1	21.8	40.0	1.4	73	6	768	0	165	1.13	-0.09	92.6	9
GRAND LAKE 6SSW	55.7	22.9	39.3	-0.5	70	9	788	0	131	0.55	-0.34	61.8	6
DILLON 1E	54.4	19.5	37.0	-2.1	72	5	861	0	126	0.26	-0.49	34.7	4
AVON	59.6	22.2	40.9	-3.1	75	7	736	0	187	0.93	-0.07	93.0	4
CLIMAX	46.3	20.0	33.2	-0.8	63	0	978	0	48	0.62	-0.65	48.8	6
ASPEN 1SW	58.4	28.0	43.2	-0.3	76	12	671	0	168	1.38	-0.33	80.7	7
TAYLOR PARK	52.7	22.5	37.6	4.6	67	8	845	0	85	1.15	-0.09	92.7	6
TELLURIDE	62.3	25.7	44.0	0.9	78	8	644	0	204	2.12	-0.10	95.5	8
PAGOSA SPRINGS	64.4	23.5	43.9	-1.4	80	6	646	0	235	0.97	-1.02	48.7	6
SILVERTON	55.7	16.5	36.1	-0.9	71	0	887	0	126	2.90	0.63	127.8	6
WOLF CREEK PASS 1	47.5	22.3	34.9	-1.6	67	6	930	0	43	4.69	0.56	113.6	6

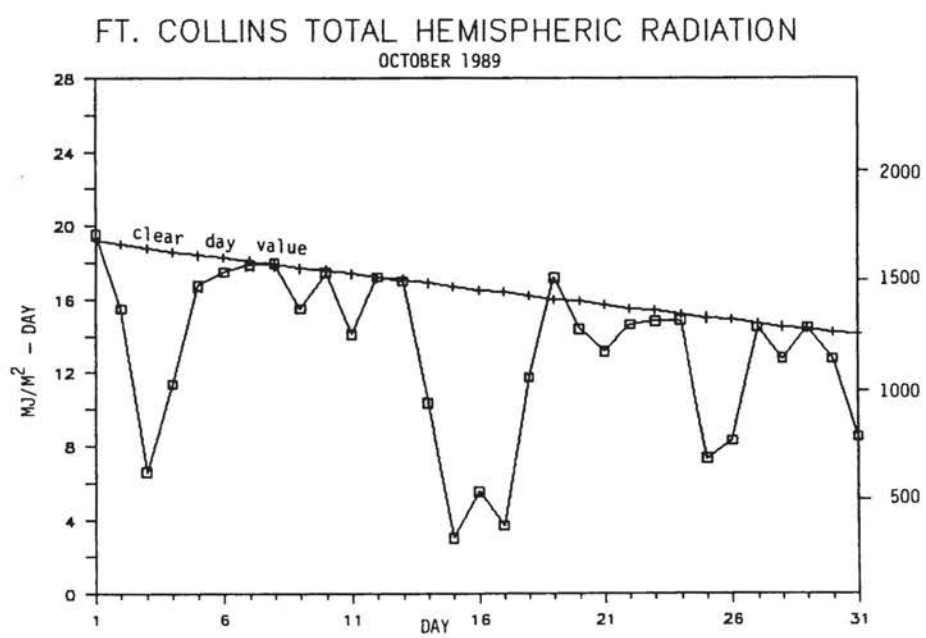
Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
HAYDEN	63.3	30.0	46.6	1.6	77	18	561	0	229	0.43	-0.91	32.1	6
MEEKER NO. 2	64.2	30.3	47.2	1.0	79	14	543	0	236	0.88	-0.50	63.8	6
RANGELY 1E	67.5	33.4	50.4	1.9	85	16	446	0	282	0.52	-0.43	54.7	4
EAGLE FAA AP	63.3	28.0	45.6	0.8	79	11	593	0	223	1.02	0.14	115.9	6
RIFLE	68.2	30.7	49.5	0.8	83	12	473	0	291	1.17	0.02	101.7	6
GRAND JUNCTION WS	68.5	41.3	54.9	-0.0	81	18	316	11	308	0.14	-0.77	15.4	3
CEDAREDGE	66.2	35.2	50.7	-0.0	87	19	436	0	270	1.38	0.15	112.2	4
PAONIA 1SW	67.8	37.0	52.4	1.0	84	25	383	0	286	1.62	0.20	114.1	6
DELTA	71.7	37.2	54.5	2.8	89	12	330	14	346	0.27	-0.61	30.7	2
GUNNISON	60.3	20.9	40.6	-0.7	78	3	749	0	183	0.39	-0.47	45.3	6
COCHETOPA CREEK	60.8	21.4	41.1	0.5	78	3	736	0	188	0.87	-0.04	95.6	5
MONTROSE NO. 2	65.7	35.2	50.5	-0.0	82	18	439	0	256	0.68	-0.45	60.2	6
URAVAN	72.6	36.5	54.5	-0.1	86	19	320	3	360	0.96	-0.44	68.6	6
NORWOOD	63.3	31.7	47.5	1.2	83	11	537	1	225	0.99	-0.49	66.9	4
YELLOW JACKET 2W	63.8	36.0	49.9	-0.2	79	18	461	0	225	1.56	-0.39	80.0	5
CORTEZ	66.2	31.6	48.9	-1.1	81	13	494	0	261	1.05	-0.55	65.6	4
DURANGO	66.0	30.0	48.0	-1.0	81	11	520	0	258	1.55	-0.47	76.7	6
IGNACIO 1N	67.0	28.4	47.7	-0.0	78	9	530	0	273	0.81	-0.74	52.3	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.

OCTOBER 1989 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	15	10	6	--	--
Denver	16	7	8	68%	73%
Fort Collins	13	10	8	--	--
Grand Junction	18	9	4	80%	74%
Pueblo	17	7	7	80%	79%



FIRE IT UP

Although Indian Summer is lingering on, most parts of the state have experienced a touch of winter. The furnace has needed to be fired up to allow for walking about the house without a coat. That initial running usually brings with it a slightly musty odor as the air moves through ducts that have 5-6 months of dust accumulated in them. It is the time when people think about getting the furnace 'tuned up' and buying a new supply of filters. Last years utility bills may be uninvited ghosts as you think of paying for the energy you use to keep the home livable. What are some ways to help decrease those bills?

Among the most obvious are caulking around windows to decrease the infiltration rate and having enough insulation in the walls and roof to keep the heat inside. This winter, look at your roof after the first major storm. If there are areas that appear to be melting more quickly and/or there are places where you can see the roof in spots, chances are that you do not have enough insulation in the roof. Those spots are caused by your furnace melting the snow and it is basically money going through the roof. Another way to decrease utility bills is called night-setback. It is not a new concept and most people have heard of it in some form or another. It decreases the heat needed during the coldest times of the day (generally 12 a.m. to 6 a.m.) and save on fuel consumption. But how much can it save you?

One estimate for the Boulder area is that by setting the thermostat to 55 degrees Farenheit at night and bringing it up to 68 degrees during the day, you can save as much as 15% of your bill. This is a large swing (13 degrees) and some may feel that you actually defeat the purpose by going so low at night since you have to then warm everything back up which could take extra fuel. For homes with large thermal mass (made of adobe or thick concrete), this may be true. But for the average American home, made of wood framing and a covering of brick or wood, this does not hold. The thermal mass of these materials is low; it does not take much time to heat them up to where they are conducting heat through them at a steady state. This is shown by the furnaces' ability to heat the home up within 30 minutes after setting to the higher thermostat temperature after night setback.

To get an estimate of how much energy you can save by night-setback, the heating degree hour is used. A heating degree hour is a number that gives an idea of how much heat is needed during that hour. Figure 1 shows the degree hours for three towns in Colorado for the month of February,1989. What is most helpful about this graph is the difference seen by the night setback. Walsh shows an 14% decrease when setting the thermostat back 15 degrees as opposed to leaving it at 65 degrees all day. (These numbers are obtained using 50 degrees from 10p.m. to 8 a.m. and 65 degrees the rest of the day.) The decrease in degree hours means that the furnace needs to put out less heat and money is saved. Figure 2 gives the exact numbers shown in the graph.

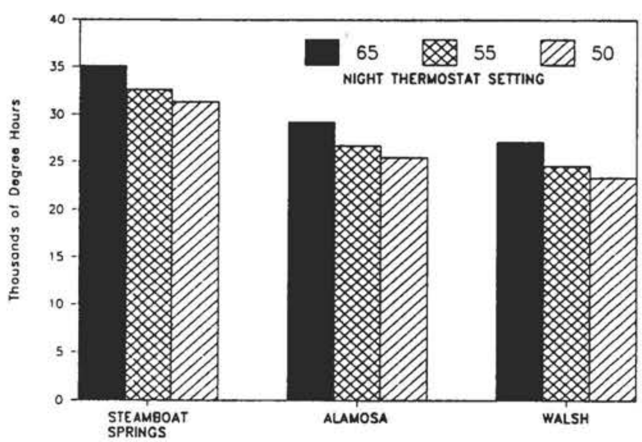


FIGURE 1

DEGREE HOURS AT THREE LOCATION FOR THREE SETBACK POINTS FEBRUARY, 1989			
LOCATION	15 DEGREE SETBACK	10 DEGREE SETBACK	NO SETBACK
STEAMBOAT SPRINGS	31,347	32,607	35,127
ALAMOSA	25,467	26,727	29,247
WALSH	23,418	24,678	27,198

FIGURE 2

No matter what your decision is in how to weatherize your home, now is the time to begin the process before the first major snow falls. Night-setback combined with decreasing infiltration through caulking or plastic around windows can begin savings right away and over the course of the winter, save substantial amounts of money.

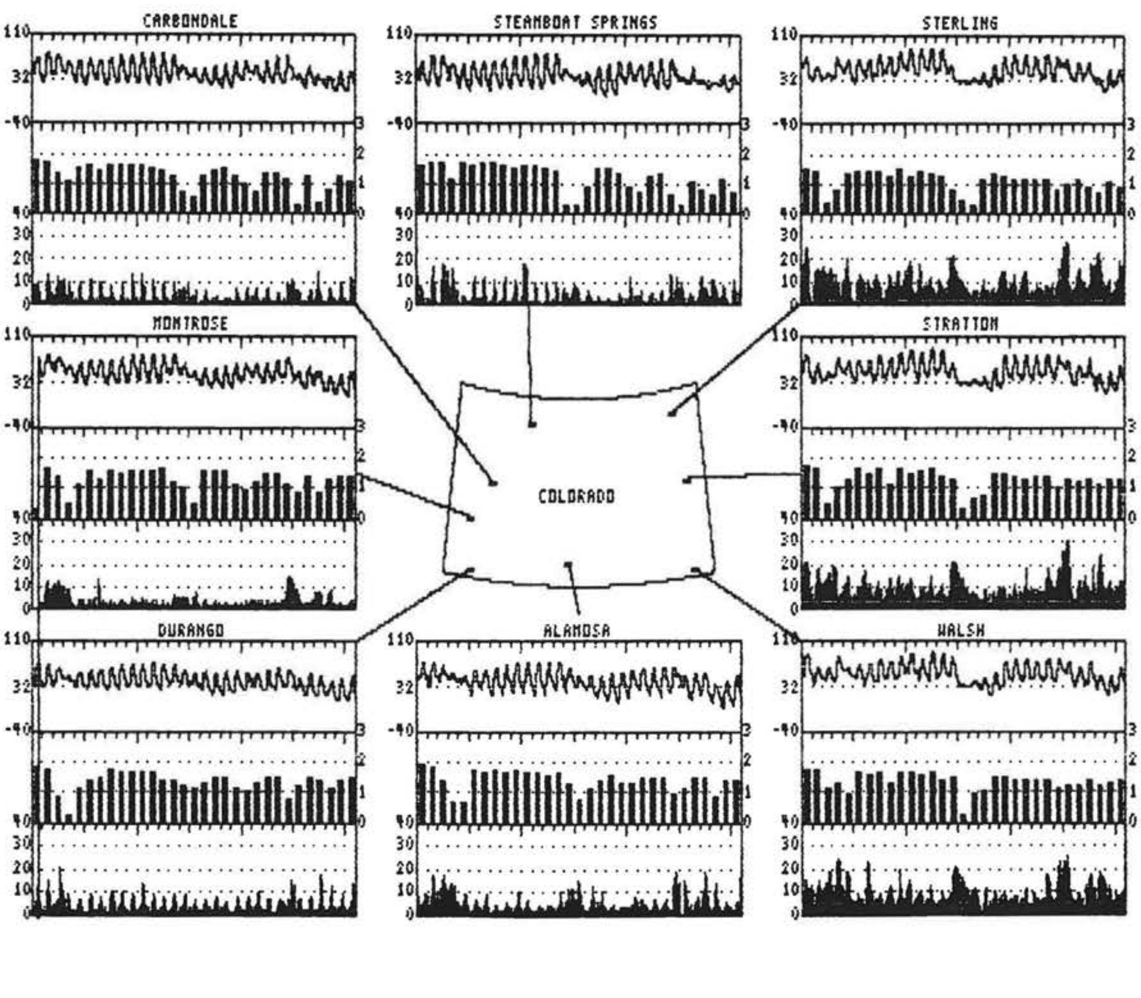
This article was written by Mary Sutter of the Joint Center for Energy Management, University of Colorado, P.O. Box 428, Boulder, CO 80309-0428 .

WTHRNET WEATHER DATA OCTOBER 1989

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)								
	41.8	43.5	43.3	47.6	39.4	49.2	50.3	54.4
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	75.7 1/15	72.9 12/14	76.8 13/15	79.3 13/15	76.1 13/15	87.8 14/14	89.2 13/15	89.6 13/15
minimum:	-1.8 30/ 6	10.2 30/ 7	13.1 30/ 7	12.4 31/ 6	7.2 19/ 6	16.5 30/ 1	16.9 30/ 5	20.8 19/ 6
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	75 / 17	74 / 23	86 / 25	67 / 23	86 / 22	50 / 20	63 / 26	57 / 26
11 AM	37 / 25	41 / 31	41 / 26	39 / 28	45 / 26	29 / 23	33 / 27	29 / 27
2 PM	25 / 21	35 / 29	30 / 24	30 / 28	32 / 22	23 / 21	24 / 24	22 / 25
5 PM	29 / 21	32 / 25	30 / 22	29 / 26	32 / 20	26 / 19	28 / 22	25 / 23
11 PM	53 / 19	61 / 24	65 / 25	55 / 25	65 / 20	41 / 17	53 / 25	43 / 23
monthly average wind direction (degrees clockwise from north)								
day	167	207	251	253	232	209	106	157
night	159	86	176	151	125	209	214	231
monthly average wind speed (miles per hour)								
	4.28	3.53	3.27	3.16	3.42	8.99	9.25	8.50
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	336	445	478	455	465	72	40	36
3 to 12	361	278	255	280	241	477	513	558
12 to 24	47	20	11	9	30	188	176	147
> 24	0	0	0	0	0	7	15	3
monthly average daily total insolation (Btu/ft²·day)								
	1398	1349	1264	1245	1222	1129	1277	1359
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	187	121	192	113	133	188	208	230
40-60%	37	74	44	46	52	54	52	66
20-40%	43	45	50	60	35	46	34	21
0-20%	7	25	22	36	41	41	27	22

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

NOVEMBER 1989

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 13 Number 2

November in Review:

November was abnormally dry over most of Colorado. The only precipitation of significance for the month fell on the weekend following Thanksgiving but was limited to the northern and central mountains of the State. Sunshine was much more plentiful than usual and temperatures were above average statewide.

Colorado's January Climate:

January has a well-deserved reputation for being the coldest month of the year. It is not always true. Sometimes December sneaks in a little colder. Occasionally cold waves wait until February (as in 1989) to blitz Colorado. But on the average, January is the month with the greatest chances for prolonged and severe cold. Subzero temperatures usually occur in all areas of the state at least once. At Mesa Verde National Park and Colorado National Monument there is only an average of one subzero night in January, but frequencies increase to 3-8 subzero nights east of the mountains and up to 13-23 occurrences in the mountains. In 1984, Colorado's traditional cold spot, Taylor Park Reservoir, dropped to zero or below every day in January. But the news is not all cold. Periods of bright sunshine are normal in January. When combined with occasional downslope winds east of the mountains, several wonderfully warm days can usually be expected. In Denver, for example, in all but the coldest of Januarys, daily maximum temperatures exceed 50°F at least 6 times. Back in 1986 temperatures exceeded 60 degrees on 11 days in January.

January precipitation patterns are comparable to those of other winter months. Precipitation is normally moderate to heavy in the mountains (2-4", 30-60" snow and locally more), light to moderate on the Western Slope and in the eastern foothills (0.30" to 1.00", 6-25" snow), and very light across the eastern plains and the San Luis Valley (0.20" to 0.50", 5-12" snow). Nearly all precipitation statewide falls as snow, and fluffy powder is the rule. The ground generally remains snowcovered from the eastern foothills west to Utah throughout January, but east of the mountains the ground is often bare for at least half of the month. January is not known for its eastern plains blizzards. They usually arrive later in winter and spring. But they are possible and must be treated with the greatest of respect by both residents and travellers. A storm in January 1988 created drifts from 10' to 20', closed most highways on the plains and was responsible for 2 deaths.

Reflections on Deep Winter:

I have now been the author of these monthly climate summaries for 12 complete years and a student of Colorado's stimulating climate for the same period. Winter continues to hold a special fascination for me which I can't totally understand. Watching the powerful winter jet stream as it dips and meanders, and waiting until at last it drops into just the right position to trigger a large snowstorm or spill a huge frigid mass of arctic air across the Great Plains brings out some of the same feelings and emotions I experienced as a young boy waiting for Christmas. When I was only 6 years old, if a snowstorm was forecast I would stay up all night watching for the first flakes to appear. Some of you probably think I'm crazy. Others of you undoubtedly feel the same way.

Whether or not you enjoy winter the fact of the matter is--winter has a big impact on Colorado--both positively and negatively. Because of our climate Colorado is a premier winter recreation state. Mountain snows bring moisture that supplies farms and cities that thrive in areas that would otherwise be dry and desolate. But we also pay a price

(continued on Page -9-)

N O V E M B E R   1 9 8 9   D A I L Y   W E A T H E R

Date	Event
1-3	A little snow lingered in southern Colorado on the 1st. Walsenburg reported 0.20" of moisture (2.5" snow). It was sunny and quite cold on the 2nd. By the 3rd, temperatures were returning to normal.
4-8	Winds aloft were strong over Colorado from the northwest 4-5th producing locally windy conditions and many mountain wave clouds. An upper air disturbance crossed the state 6-7th bringing snow to the northern and central mountains and a few sprinkles to the northeast plains. Winter Park picked up 9" of snow during the period. Strong winds accompanied the storm with gusts of 30-60 mph from the Front Range eastward across the plains 7-8th.
9-12	The jet stream moved well north of Colorado. Sunshine was plentiful and temperatures soared into the 60s and 70s at lower elevations with some 60s reaching high into the mountains. Many cities set record highs on the 11th and 12th such as Denver's 76°F reading each day. The 63° temperature at Vail on the 12th was very unusual for so late in the fall. The 84° reading at Holly was the warmest in the state for the month.
13-16	The jet stream dropped southward again and a storm system began forming over Colorado 13-14th. Temperatures remained unseasonably warm on the 13th as gusty winds developed, but colder air began working its way into northern and eastern Colorado. A strong disturbance moved across the Rockies 14-15th, and in its wake a brief blast of arctic air slipped southward into eastern Colorado. The storm looked powerful, but only limited areas of the northern mountains picked up snowfall. Yampa measured 7" of new snow. The coldest temperatures of the month occurred on the morning of the 16th at many locations east of the mountains. Burlington reported 9° and Limon hit 6°F.
17-21	Temperatures rebounded rapidly as a large upper level high pressure ridge was restored over the southwest U.S. Extraordinarily warm temperatures were reported over much of the state 19-21st. Many new record high temperatures were set on the 19th. Canon City hit 81° on the 19th but topped that with 82° on the 21st. Denver hit 79° on the 19th. Evergreen reached 77°. Some interesting contrasts were noted on the Western Slope. Telluride, for example, hit a record shattering 71° on the 20th while down at Montrose the high was only 59°F.
22-27	Continued warm in western Colorado 22nd but briefly cooler east. Then warmer again on the 23rd-24th as the first large winter storm complex of the season took aim on California. A round of precipitation crossed the Rockies 24-25th dropping 4-12" of much appreciated snows over parts of our northern and central mountains and spreading a few snowshowers across the eastern foothills and northeast plains on the 25th. Snow began again on the 26th and strong winds blasted much of the state as a deep low pressure area swept across southern Wyoming. More significant snows fell but mostly only in the northern and central mountains. Marvine Ranch east of Meeker got more than 20" of new snow. Vail reported close to 10" in town. Sharply colder on the 27th and continued breezy with some snow showers over the mountains and Front Range. Two inches of snow fell in Wheatridge and Brighton during Denver's evening rush hour.
28-30	Mostly clear and cold. An upper level low pressure area over New Mexico pushed a few clouds into southern Colorado but no precipitation. Temperatures in snow covered areas of the mountains dropped below zero each night. Crested Butte's -25° on the 28th was the coldest in the state.

November 1989 Extremes

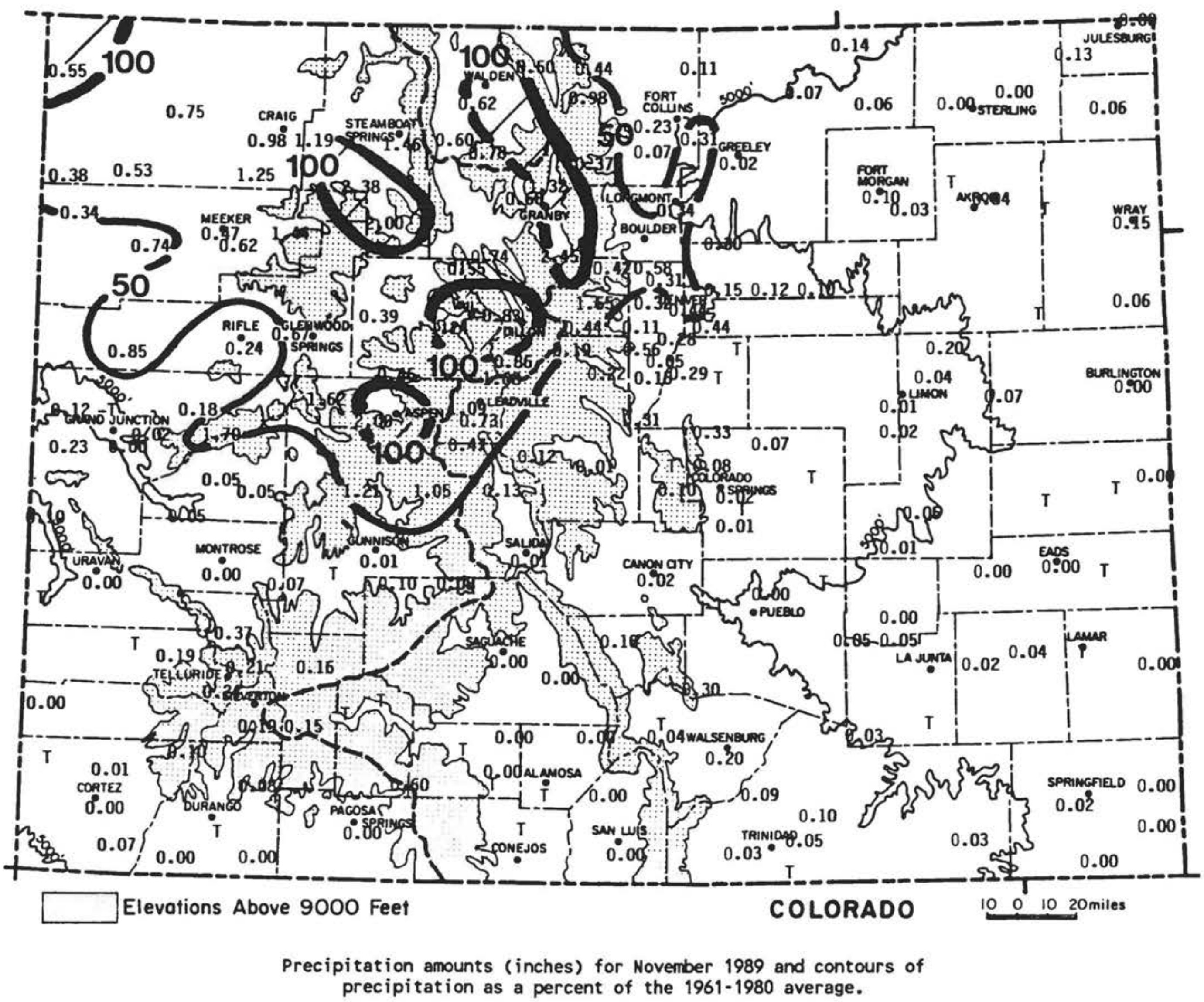
Highest Temperature	84°F	November 12	Holly
Lowest Temperature	-25°F	November 28	Crested Butte
Greatest Total Precipitation	2.45"		Winter Park
Least Total Precipitation	0.00"		Blanca and many other locations
Greatest Total Snowfall*	33"		Pyramid
Greatest Snowdepth*	19"		Winter Park

* For existing weather stations with complete daily records. Higher values are likely for unmonitored locations.

NOVEMBER 1989 PRECIPITATION

Quite a unique distribution of precipitation was observed in Colorado in November. Little or no precipitation fell over much of eastern and southern Colorado. 107 official weather stations reported less than 0.10" of precipitation in November--half of all Colorado weather stations. At the same time, the northwestern quarter of the state enjoyed significant precipitation (most of it falling November 24-27th. A few limited areas actually ended up wetter than average such as Dillon, Aspen, Winter Park and Walden. Yampa's precipitation total of 2.00" was 192% of average.

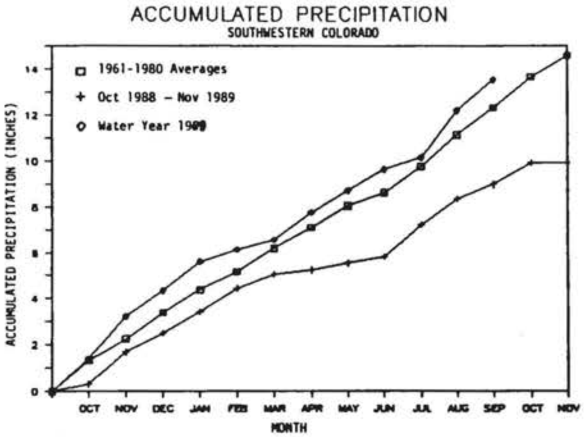
Greatest		Least	
Winter Park	2.45"	Burlington	0.00"
Pyramid	2.38"	Campo 7S	0.00"
Yampa	2.00"	Center 4SSW	0.00"
Aspen 1SW	2.00"	Cortez	0.00"
Bonham Reservoir	1.70"	Eads	0.00"
		(and numerous other locations)	

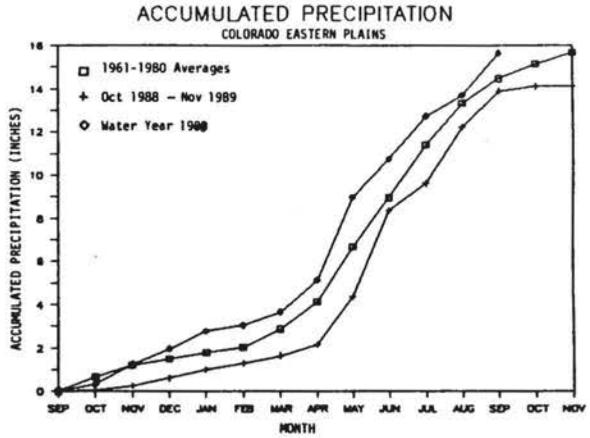


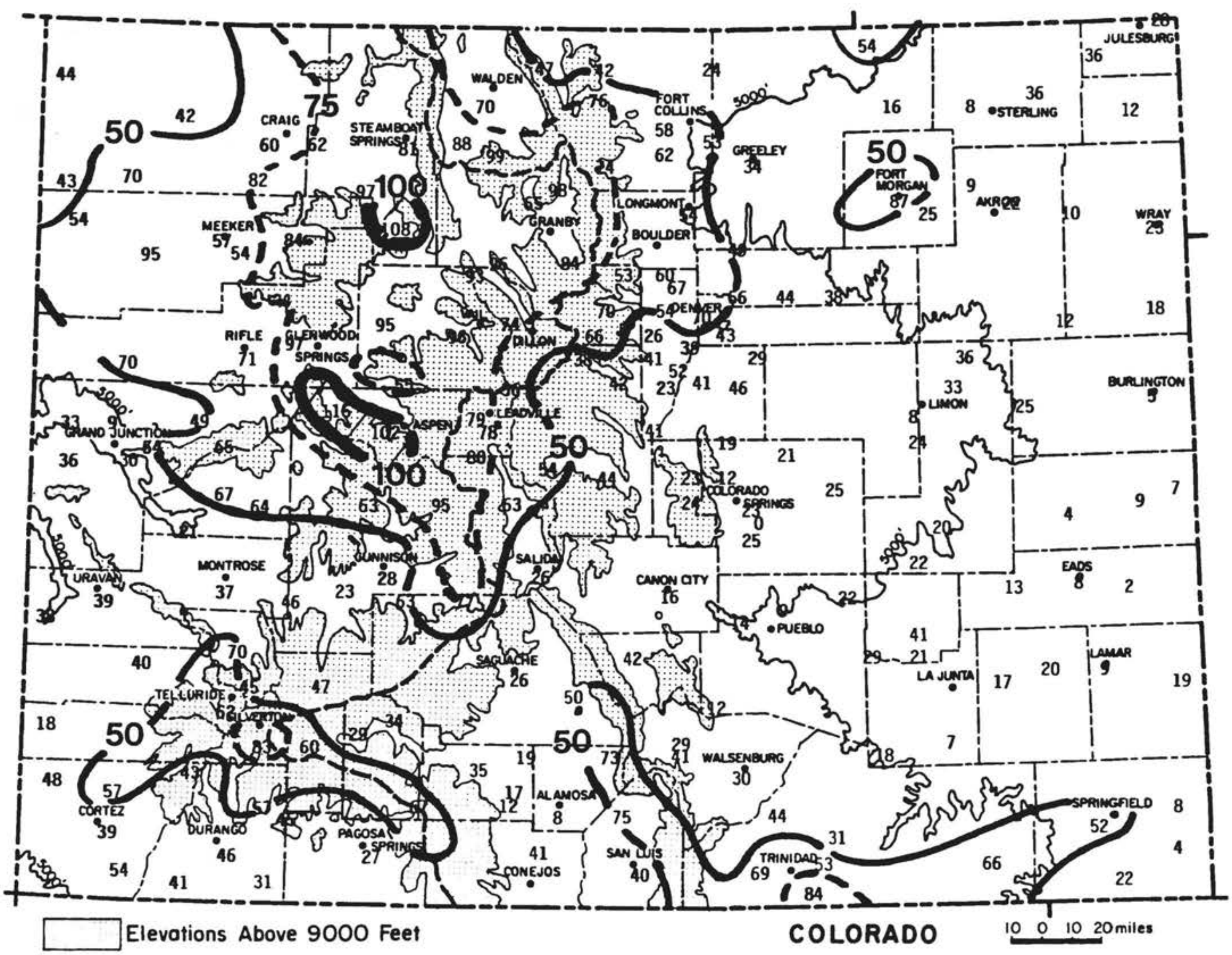
Precipitation amounts (inches) for November 1989 and contours of precipitation as a percent of the 1961-1980 average.

1 9 9 0 WATER YEAR PRECIPITATION

The 1990 water year is getting off to a very slow start. Accumulated precipitation since October 1, 1989 is well under 50% of average over most of eastern and southern Colorado. Only the northern mountains and portions of the central mountains are even close to average. While this raises some concern for next year's water supplies, dry falls have occurred in the past with some regularity. The chances for recovery remain good, with the possible exception of the southwestern mountains where fall precipitation contributes a higher percentage of total water year precipitation than in other parts of the state.



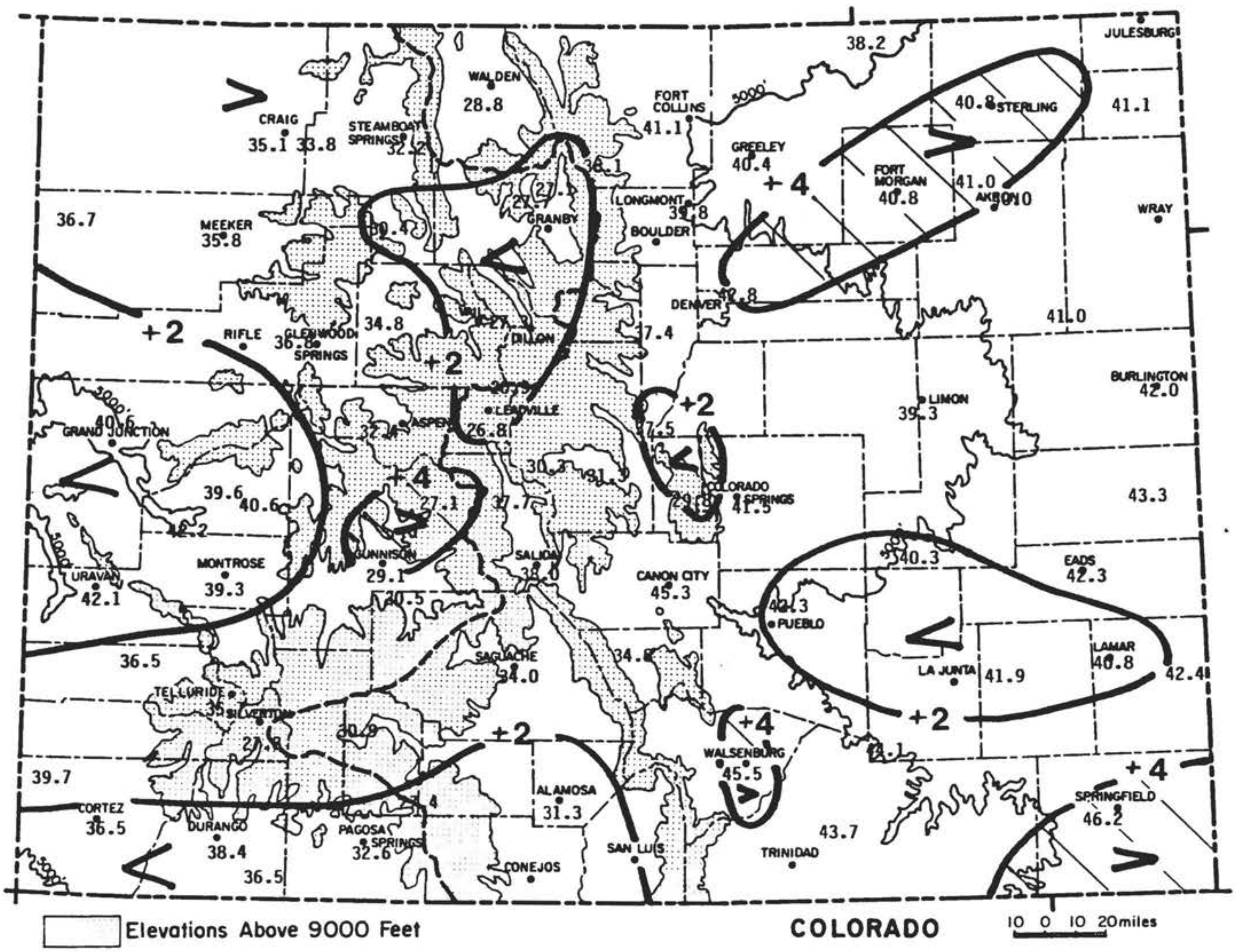




Precipitation for October 1989 through November 1989
as a percent of the 1961-1980 average.

NOVEMBER 1989 TEMPERATURES AND DEGREE DAYS

November temperatures were on the mild side throughout nearly all of Colorado ending up 2 to 4 degrees above average at most locations. A few locations in the Upper Colorado watershed, the lower Arkansas valley and areas south of the San Juan Mountains were near average for the month.



November 1989 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

NOVEMBER 1989 SOIL TEMPERATURES

Soil temperatures continued their normal gradual declime. By the end of the month frost was beginning to penetrate a few inches into the ground.

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.

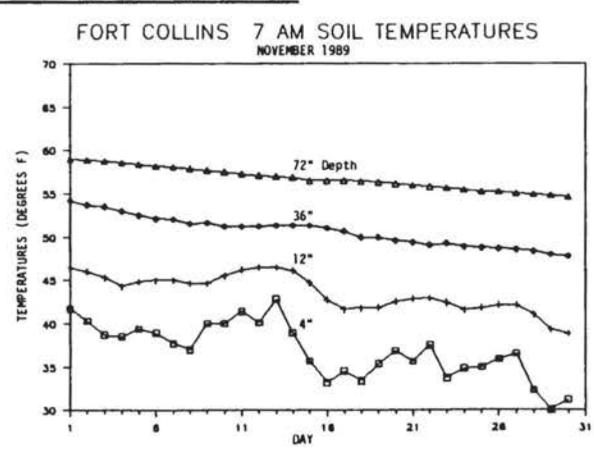


Table 1. Heating Degree Day Data through November 1989 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001								2069
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974								2192
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M								M
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812								1861
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684								M
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584								1094
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699								1348
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850								1502
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892								1763
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M								M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658								1235
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124								3070
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789								1436
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896								1767
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818								1967
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711								1341
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721								1295
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729								1085

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

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
	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132								2801
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729								1352
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069								2375
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684								1106
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138								3260
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762								1481
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749								1443
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869								1651
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768								1327
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964								2036
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676								1143
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M								M
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974								M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719								M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869								2030
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633								1114
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075								2749
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581								1045

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

NOVEMBER 1989 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	53.5	22.9	38.2	2.3	74	7	797	0	96	0.14	-0.14	50.0	3
STERLING	57.4	24.2	40.8	4.7	78	9	719	0	148	0.00	-0.44	0.0	0
FORT MORGAN	57.2	24.4	40.8	4.1	79	8	721	0	145	0.10	-0.26	27.8	2
AKRON FAA AP	55.5	26.5	41.0	4.3	76	8	713	0	119	0.00	-0.46	0.0	0
AKRON 4E	56.1	23.8	40.0	3.2	77	4	744	0	133	0.04	-0.49	7.5	1
HOLYOKE	57.2	25.0	41.1	3.1	78	9	711	0	143	0.06	-0.46	11.5	1
JOES	57.3	24.7	41.0	2.0	80	6	714	0	147	0.00	-0.60	0.0	0
BURLINGTON	57.0	27.0	42.0	2.3	77	9	684	0	140	0.00	-0.55	0.0	0
LIMON WSMO	55.8	22.8	39.3	3.3	76	6	762	0	129	0.01	-0.37	2.6	1
CHEYENNE WELLS	60.1	26.6	43.3	4.3	79	8	642	0	172	0.00	-0.49	0.0	0
EADS	60.0	24.7	42.3	2.7	78	7	673	0	183	0.00	-0.71	0.0	0
ORDWAY 21N	60.4	20.2	40.3	1.7	79	5	731	0	181	0.01	-0.37	2.6	1
LAMAR	63.3	18.3	40.8	0.5	80	3	717	0	218	0.00	-0.60	0.0	0
LAS ANIMAS	62.5	21.4	41.9	0.9	77	8	684	0	202	0.02	-0.48	4.0	1
HOLLY	62.1	22.7	42.4	3.1	84	8	671	0	203	0.00	-0.57	0.0	0
SPRINGFIELD 7WSW	63.2	29.2	46.2	4.5	82	9	557	0	211	0.02	-0.73	2.7	1
TIMPAS 13SW	60.6	27.6	44.1	2.7	79	9	619	0	188	0.03	-0.69	4.2	1

Foothills/Adjacent Plains

		Temperature					Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	55.3	26.9	41.1	3.8	76	10	711	0	116	0.23	-0.40	36.5	2
GREELEY UNC	55.1	25.8	40.4	3.5	78	10	729	0	116	0.02	-0.74	2.6	1
ESTES PARK	47.8	28.5	38.1	3.5	63	10	799	0	42	0.37	-0.15	71.2	1
LONGMONT 2ESE	57.5	22.2	39.8	2.6	79	-1	749	0	141	0.34	-0.27	55.7	2
DENVER WSFO AP	57.7	27.9	42.8	4.0	79	12	658	0	145	0.15	-0.68	18.1	2
EVERGREEN	55.0	19.9	37.4	3.2	77	1	818	0	109	0.11	-0.89	11.0	3
CHEESMAN	57.3	17.7	37.5	1.6	75	-3	816	0	134	0.31	-0.59	34.4	3
LAKE GEORGE 8SW	46.5	16.1	31.3	3.0	64	-3	1001	0	35	0.01	-0.37	2.6	1
ANTERO RESERVOIR	46.2	14.4	30.3	6.3	66	-13	1035	0	41	0.12	-0.22	35.3	2
RUXTON PARK	43.8	15.9	29.8	1.9	63	-6	1048	0	30	0.10	-0.84	10.6	1
COLORADO SPRINGS	56.8	26.1	41.5	3.8	74	12	699	0	136	0.02	-0.51	3.8	1
CANON CITY 2SE	61.9	28.7	45.3	3.0	82	9	584	0	197	0.02	-0.64	3.0	1
PUEBLO WSO AP	62.2	22.4	42.3	1.8	82	7	676	0	202	0.00	-0.47	0.0	0
WESTCLIFFE	53.6	16.1	34.8	2.4	71	-4	899	0	89	0.10	-0.66	13.2	1
WALSENBURG	61.3	29.6	45.5	4.4	79	8	581	0	184	0.20	-0.69	22.5	1
TRINIDAD FAA AP	62.0	25.4	43.7	2.7	79	10	633	0	204	0.10	-0.49	16.9	2

Mountains/Interior Valleys

		Temperature					Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	41.7	16.0	28.8	2.6	64	-14	1075	0	23	0.62	0.03	105.1	7
LEADVILLE 2SW	40.0	13.7	26.8	1.9	61	-14	1138	0	16	0.73	-0.17	81.1	7
SALIDA	54.2	21.8	38.0	1.5	71	-1	801	0	95	0.01	-0.61	1.6	1
BUENA VISTA	53.2	22.2	37.7	3.9	69	6	812	0	100	0.13	-0.46	22.0	2
SAGUACHE	51.3	16.6	34.0	2.7	65	5	921	0	63	0.00	-0.49	0.0	0
HERMIT 7ESE	51.9	10.0	30.9	6.4	69	-4	1014	0	61	0.00	-1.18	0.0	0
ALAMOSA WSO AP	52.9	9.8	31.3	1.6	66	-7	1001	0	82	0.00	-0.36	0.0	0
STEAMBOAT SPRINGS	46.0	18.5	32.2	3.4	67	-6	974	0	48	1.46	-0.35	80.7	5
YAMPA	41.9	18.9	30.4	1.0	62	-4	1032	0	23	2.00	0.96	192.3	9
GRAND LAKE 1NW	41.8	12.3	27.1	1.5	61	-10	1132	0	19	1.32	0.05	103.9	8
GRAND LAKE 6SSW	40.8	14.7	27.7	-0.1	55	-8	1110	0	10	0.60	-0.27	69.0	9
DILLON 1E	40.8	13.7	27.3	0.6	63	-9	1124	0	21	0.83	0.12	116.9	9
CLIMAX	32.6	9.2	20.9	-0.9	59	-13	1317	0	6	1.08	-0.65	62.4	9
ASPEN 1SW	45.3	19.6	32.4	2.4	66	-4	974	0	43	2.00	0.40	125.0	7
TAYLOR PARK	41.8	12.4	27.1	7.9	57	-16	1133	0	16	1.05	-0.02	98.1	4
TELLURIDE	54.2	17.3	35.7	4.6	71	-5	869	0	101	0.24	-1.31	15.5	4
PAGOSA SPRINGS	54.7	10.6	32.6	-0.4	70	0	964	0	91	0.00	-1.60	0.0	0
SILVERTON	48.7	5.9	27.3	3.5	68	-14	1124	0	55	0.19	-1.26	13.1	1
WOLF CREEK PASS 1	40.8	14.3	27.4	1.3	52	-8	562	0	1	0.60	-3.10	16.2	1

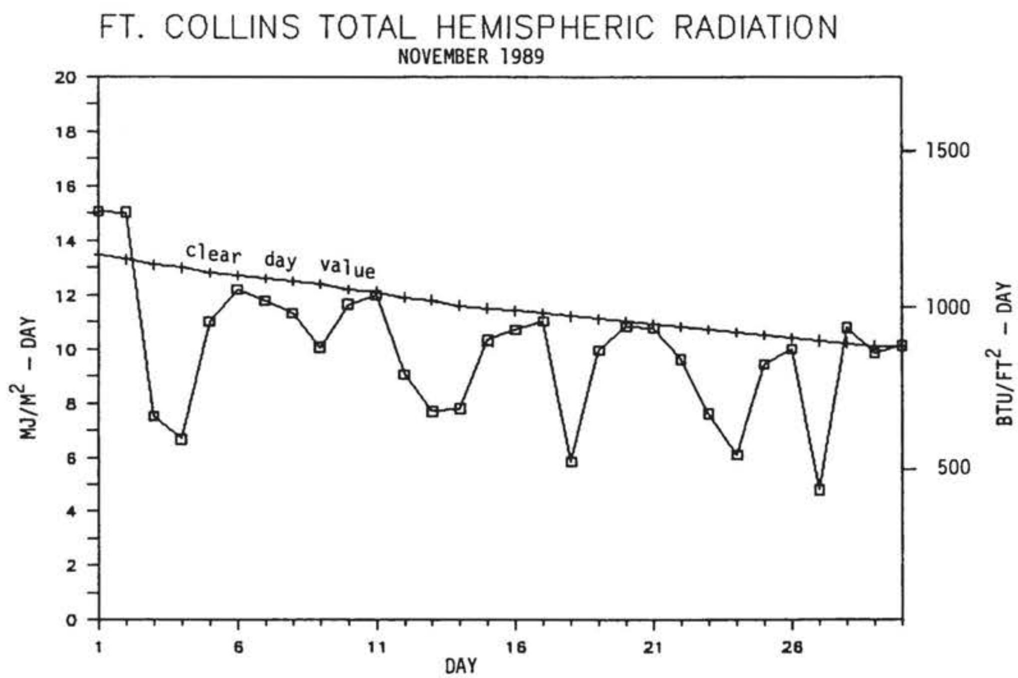
Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	48.5	21.6	35.1	3.6	67	2	892	0	60	0.98	-0.22	81.7	7
HAYDEN	46.9	20.7	33.8	1.9	68	-2	927	0	50	1.19	-0.05	96.0	8
MEEKER NO. 2	50.6	21.0	35.8	2.7	68	1	869	0	80	0.47	-0.49	49.0	4
RANGELY 1E	52.0	21.4	36.7	3.0	65	10	843	0	76	0.34	-0.29	54.0	2
EAGLE FAA AP	50.4	19.2	34.8	3.2	66	1	896	0	66	0.39	-0.20	66.1	5
GLENWOOD SPRINGS	52.0	21.6	36.8	1.4	67	7	813	0	70	0.67	-0.33	67.0	5
GRAND JUNCTION WS	54.5	26.6	40.6	0.4	67	12	729	0	96	0.00	-0.61	0.0	0
CEDAREDGE	55.3	24.0	39.6	1.7	71	8	755	0	105	0.05	-0.85	5.6	1
PAONIA 1SW	55.1	26.1	40.6	1.9	71	9	722	0	107	0.05	-1.12	4.3	2
DELTA	59.8	24.5	42.2	3.7	74	12	Missing	0	106	0.05	-0.55	8.3	1
GUNNISON	49.1	9.1	29.1	1.0	62	-4	1069	0	48	0.01	-0.55	1.8	1
COCHETOPA CREEK	49.3	11.7	30.5	2.9	62	-7	1028	0	47	0.10	-0.51	16.4	1
MONTROSE NO. 2	53.3	25.2	39.3	1.8	70	10	768	0	88	0.00	-0.68	0.0	0
URAVAN	59.9	24.3	42.1	1.1	73	12	676	0	168	0.00	-1.06	0.0	0
NORWOOD	51.8	21.2	36.5	2.7	66	5	846	0	65	0.00	-0.98	0.0	0
YELLOW JACKET 2W	53.2	26.2	39.7	2.4	65	11	749	0	78	0.00	-1.24	0.0	0
CORTEZ	55.7	17.2	36.5	-1.8	67	8	850	0	109	0.00	-1.03	0.0	0
DURANGO	56.8	19.9	38.4	1.0	70	6	789	0	125	0.00	-1.33	0.0	0
IGNACIO 1N	57.2	15.9	36.5	0.9	69	3	844	0	129	0.00	-1.03	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.

NOVEMBER 1989 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	18	10	2	--	--
Denver	12	12	6	84%	65%
Fort Collins	13	14	3	--	--
Grand Junction	14	11	5	82%	63%
Pueblo	17	10	3	89%	74%



Reflections on Deep Winter: continued

for these benefits. We require abundant energy supplies to stay warm. Winter weather sometimes disrupts our transportation systems. Our manmade structures (homes, businesses, highways, utilities, etc.) need to be specially designed, built and maintained. Our vehicles require special attention--as do our wardrobes.

Winter in Colorado seems to come early and stay late. This is mostly a direct result of our high elevation. Colorado occupies 3/4 of the total land area in the contiguous 48 United States that lies at least 10,000' above sea level. Yet, except for a few weeks in midwinter, our weather is quite tolerable and is sometimes downright pleasant. It is the midwinter period, when subzero temperatures are most common, icy roads are most prevalent and heating bills are highest, that we refer to as "DEEP WINTER."

Deep winter has no specific definition. It obviously lasts longer in some parts of Colorado than in others. It's duration and timing vary from year to year as well. By Dillon's standards Denver may experience no deep winter. Likewise, residents of the Grand Mesa have little respect for winter in Grand Junction. In practice, deep winter is simply that time of year when temperatures are coldest (i.e. the period of the year when your car battery is most likely to fail).

DEEP WINTER -- Some Comparative Temperature Information for Colorado

Average dates when:

Location	Daily avg. min T < 20°F	>25% chance that min T < 10°F	Daily avg. max T < 40°F	>25% chance that max T ≤ 32°F
Alamosa	Oct 30-Apr 5	Nov 15-Mar 8	Dec 4 -Feb 10	Dec 7 -Feb 8
Aspen	Nov 14-Mar 29	Nov 14-Mar 20	Dec 3 -Mar 5	Dec 5 -Mar 4
Berthoud Pass	Oct 20-May 3	Nov 1 -Apr 19	Oct 23-Apr 22	Oct 26-Apr 24
Boulder	Dec 31-Jan 21	Jan 1 -Jan 18	Does not occur	Jan 3 -Jan 4
Buena Vista	Nov 13-Mar 16	Nov 19-Mar 4	Dec 24-Jan 8	Dec 27-Jan 6
Burlington	Dec 5 -Feb 10	Dec 8 -Feb 1	Dec 31-Jan 2	Dec 30-Jan 22
Canon City	Jan 3 -Jan 8	Jan 3 -Jan 4	Does not occur	Does not occur
Colorado Springs	Nov 25-Mar 5	Dec 8 -Feb 2	Dec 28-Jan 10	Dec 28-Jan 10
Denver	Nov 27-Feb 11	Dec 8 -Feb 5	Jan 1 -Jan 4	Jan 1 -Jan 9
Dillon 1 E	Oct 15-Apr 24	Oct 25-Apr 14	Nov 15-Mar 23	Nov 18-Mar 7
Durango	Nov 17-Mar 7	Dec 5 -Feb 19	Dec 22-Jan 19	Dec 31-Jan 5
Eagle	Nov 2 -Mar 20	Nov 15-Mar 8	Nov 25-Feb 12	Nov 26-Feb 8
Estes Park	Nov 23-Mar 14	Nov 27-Mar 14	Dec 6 -Feb 8	Dec 21-Mar 3
Fort Collins	Nov 26-Mar 4	Dec 8 -Feb 15	Dec 26-Jan 20	Dec 9 -Feb 8
Glenwood Springs	Nov 23-Mar 1	Dec 4 -Feb 19	Dec 8 -Feb 4	Dec 12-Jan 30
Grand Junction	Dec 10-Feb 6	Dec 24-Feb 1	Dec 12-Feb 4	Dec 14-Feb 1
Greeley	Nov 18-Mar 6	Nov 28-Feb 13	Dec 27-Jan 29	Dec 7 -Feb 2
Gunnison	Oct 19-Apr 5	Nov 2 -Mar 27	Nov 25-Mar 15	Nov 27-Mar 5
Lamar	Nov 26-Feb 11	Dec 9 -Feb 8	Does not occur	Does not occur
Leadville	Oct 29-Apr 19	Nov 1 -Apr 8	Nov 12-Apr 7	Nov 8 -Apr 3
Limon	Nov 21-Mar 9	Dec 9 -Mar 6	Dec 26-Jan 19	Dec 12-Jan 31
Montrose	Nov 27-Feb 16	Dec 8 -Feb 4	Dec 12-Feb 3	Dec 14-Jan 23
Pueblo	Nov 26-Feb 13	Dec 7 -Feb 9	Does not occur	Dec 29-Jan 10
Silverton	Oct 21-Apr 16	Nov 1 -Apr 9	Nov 25-Mar 13	Nov 27-Mar 4
Steamboat Springs	Oct 31-Apr 4	Nov 9 -Mar 28	Nov 22-Mar 6	Nov 22-Mar 1
Sterling	Nov 20-Mar 6	Nov 28-Feb 16	Dec 8 -Feb 1	Dec 5 -Feb 1
Taylor Park	Oct 25-May 1	Nov 2 -Apr 16	Nov 13-Mar 28	Nov 14-Mar 14
Telluride	Nov 1 -Apr 6	Nov 13-Mar 31	Dec 5 -Feb 24	Dec 8 -Feb 5

Generalizing is never easy in Colorado, but if I had to define DEEP WINTER in Colorado I would probably say at lower elevations it begins around Thanksgiving and ends in the second week of February. For the mountains, winter sets in in early November and doesn't lose its grip until March or April. Is there any great value in knowing when deep winter is? It is the period when urban snow removal problems are greatest and outdoor construction is most likely to be disrupted. It may be the best time to take your vacation to Disney World. It is a good time for farmers and gardeners to prepare for the next growing season. But perhaps best of all, as we sit here in midwinter, it encourages us that in only a few weeks the worst is over and springtime is once again ours to enjoy.

ONE BEAM AT A TIME

This column often emphasizes the use of solar and other alternative energy resources. Here at the Joint Center for Energy Management we study the feasibility of these renewable resources and recommend ways in which to use them. Often, however, the data we require for our methods of analysis differ from the standard format with which weather information is traditionally measured.

For example, the usual measurement of solar radiation is one taken on a horizontal plane that views the total irradiance of the sky. The sensor used to take these kinds of measurements is known as a pyranometer. By using yearly solar intensity measurements we can model the performance of various types of solar systems. But rarely will one find a solar collector oriented facing straight up. In order to use this 'horizontal' radiation to model many different types of systems we must first decide what the sky conditions are, such as the percentage and type of cloud cover and the angular distribution of the available solar energy.

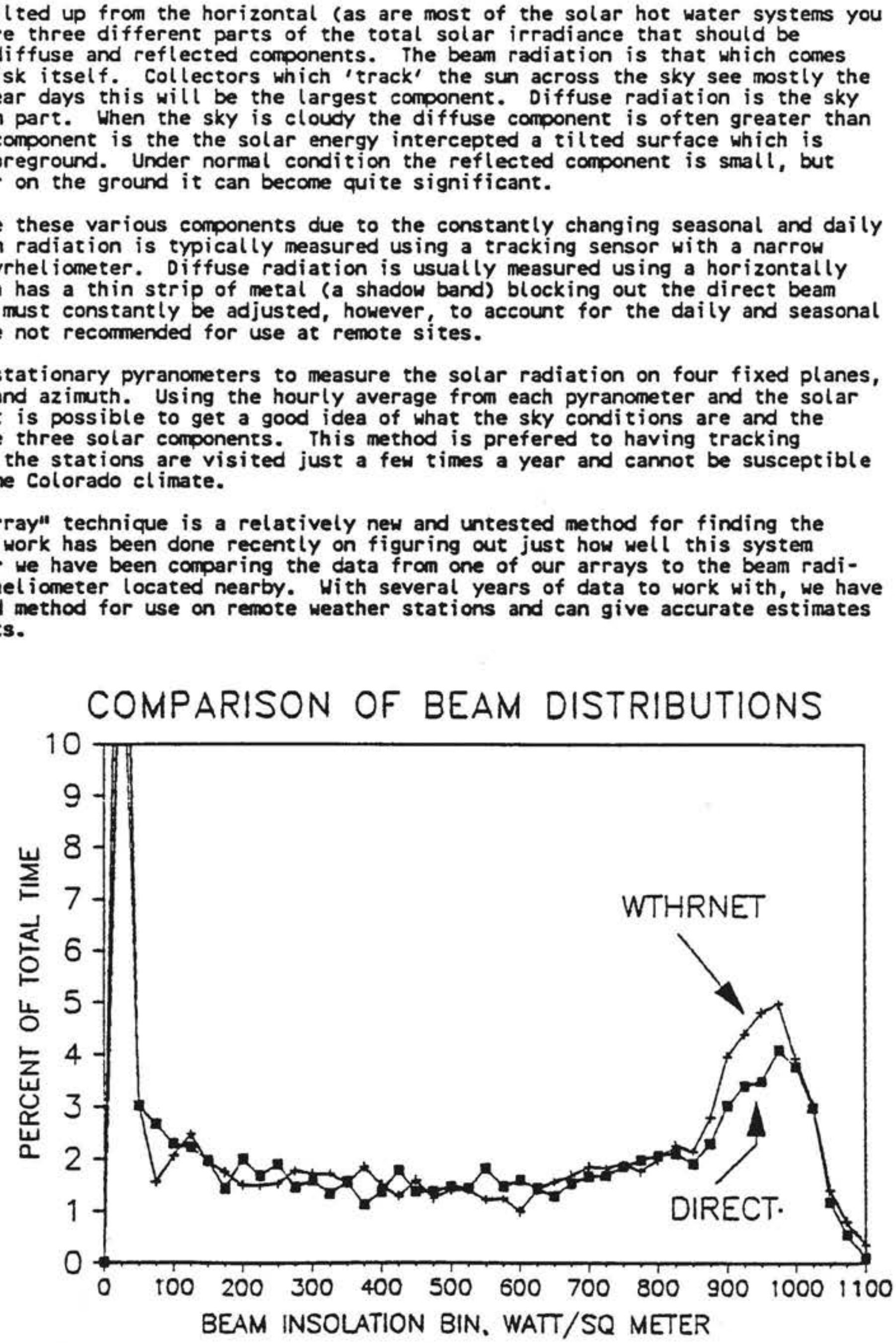
For a collector that is tilted up from the horizontal (as are most of the solar hot water systems you see in Colorado), there are three different parts of the total solar irradiance that should be accounted for: the beam, diffuse and reflected components. The beam radiation is that which comes directly from the solar disk itself. Collectors which 'track' the sun across the sky see mostly the beam radiation, and on clear days this will be the largest component. Diffuse radiation is the sky radiation without the beam part. When the sky is cloudy the diffuse component is often greater than the beam. The reflected component is the the solar energy intercepted a tilted surface which is first reflected off the foreground. Under normal condition the reflected component is small, but when there's snow or water on the ground it can become quite significant.

It is difficult to measure these various components due to the constantly changing seasonal and daily position of the sun. Beam radiation is typically measured using a tracking sensor with a narrow field of view, called a pyrheliometer. Diffuse radiation is usually measured using a horizontally oriented pyranometer which has a thin strip of metal (a shadow band) blocking out the direct beam radiation. These devices must constantly be adjusted, however, to account for the daily and seasonal motions of the sun and are not recommended for use at remote sites.

The WTHRNET stations use stationary pyranometers to measure the solar radiation on four fixed planes, each at a different tilt and azimuth. Using the hourly average from each pyranometer and the solar geometry for that hour, it is possible to get a good idea of what the sky conditions are and the relative magnitudes of the three solar components. This method is prefered to having tracking sensors or devices, since the stations are visited just a few times a year and cannot be susceptible to the whims of the extreme Colorado climate.

This "multi-pyranometer array" technique is a relatively new and untested method for finding the various components; much work has been done recently on figuring out just how well this system performs. Here in Boulder we have been comparing the data from one of our arrays to the beam radiation measured with a pyrheliometer located nearby. With several years of data to work with, we have shown that this is a valid method for use on remote weather stations and can give accurate estimates of the radiation components.

The graph to the right shows the distribution of beam insolation over the a period of more than 3000 hours of daylight (about eight months). The X-axis shows the intensity of the beam radiation in increments of 25 watts per square meter. The Y-axis shows the percent of total time that the beam magnitude fell within a specific range. The two distributions compare fairly well; the error in the measurements is rather small for beam values in the middle ranges, and averages out to about eight percent in the higher ranges.



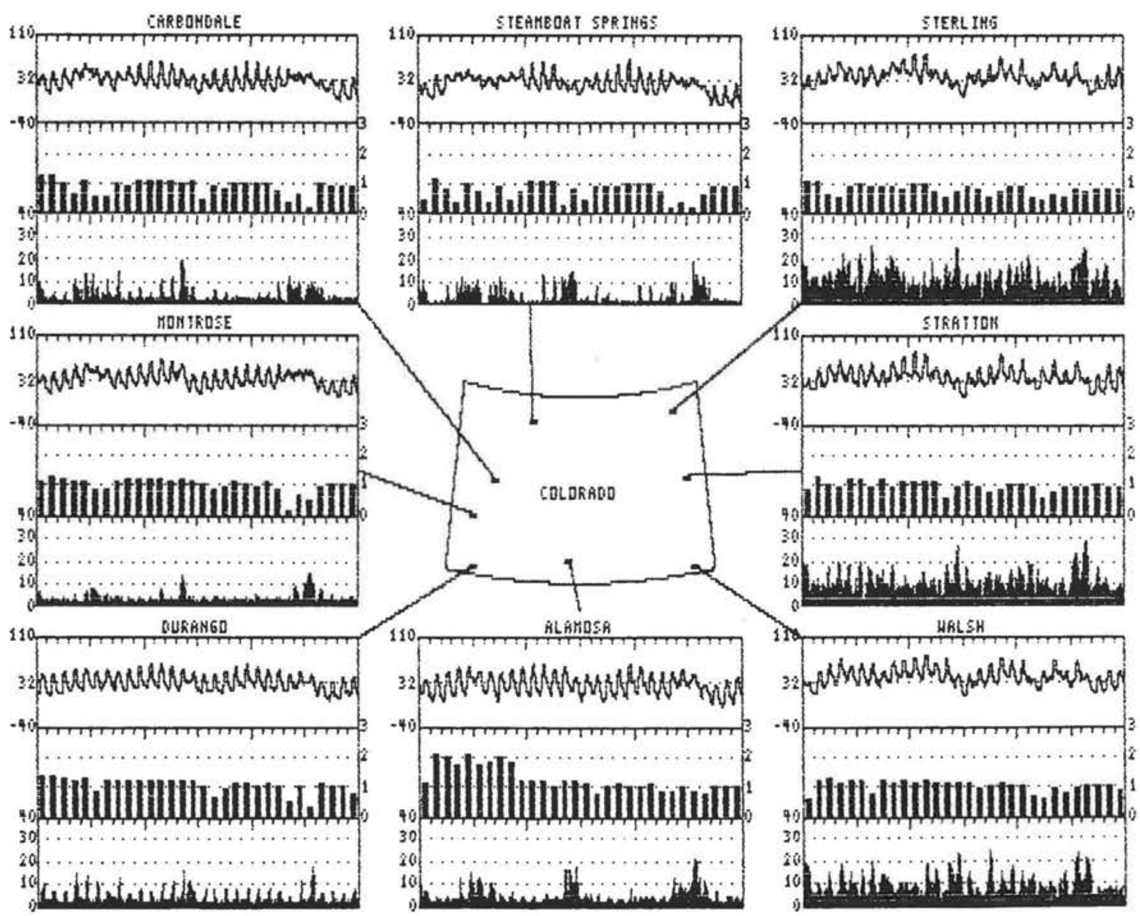
This report was prepared by Peter Curtiss of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder 80309-0428

WTHRNET WEATHER DATA NOVEMBER 1989

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)								
	30.1	33.4	32.0	35.7	27.4	39.0	39.1	42.7
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	65.1 12/16	66.2 20/14	65.3 11/16	70.7 12/15	66.4 20/16	77.9 11/15	81.5 11/14	80.1 12/14
minimum:	-5.8 29/ 2	5.0 28/ 8	-0.9 29/ 7	6.3 29/ 7	-9.8 30/ 6	7.9 16/ 1	6.4 16/ 3	11.3 16/ 6
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	59 / 1	58 / 8	80 / 16	60 / 12	89 / 16	49 / 12	56 / 14	44 / 11
11 AM	29 / 11	30 / 15	47 / 19	36 / 19	66 / 22	29 / 15	29 / 18	24 / 16
2 PM	21 / 11	23 / 14	29 / 16	27 / 17	44 / 19	22 / 14	22 / 16	20 / 16
5 PM	22 / 8	24 / 11	35 / 14	28 / 14	47 / 16	25 / 10	25 / 11	22 / 12
11 PM	43 / 4	47 / 9	68 / 17	48 / 12	82 / 17	38 / 8	44 / 10	35 / 9
monthly average wind direction (degrees clockwise from north)								
day	207	198	248	245	182	246	143	163
night	192	62	187	163	145	251	245	266
monthly average wind speed (miles per hour)								
	3.87	3.50	3.17	2.98	2.89	10.16	9.58	7.90
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	373	435	495	473	501	33	11	38
3 to 12	319	273	208	239	205	453	543	561
12 to 24	28	12	17	8	14	227	156	120
> 24	0	0	0	0	0	7	10	1
monthly average daily total insolation (Btu/ft²·day)								
	1285	1069	890	998	760	805	965	1026
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	173	164	163	194	137	147	200	200
40-60%	37	53	47	49	41	66	38	50
20-40%	11	47	52	29	57	42	31	19
0-20%	1	8	33	20	52	19	4	9

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

DECEMBER 1989

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 13 Number 3

December in Review:

Most of the Colorado high country was again on the short end of the stick in terms of December precipitation, except for localized areas of the northern mountains. For the second month in a row portions of extreme southwestern Colorado had no precipitation at all. Above average precipitation was observed in areas of eastern Colorado, especially along the Front Range from Loveland to Trinidad. A mid-December cold wave left all of eastern Colorado with well below average temperatures for the month while western Colorado enjoyed slightly above average temperatures.

Colorado's February Climate:

Since January has been kind to us this winter, temperature wise, it makes you wonder what might lie ahead in February. Last year, following a comparably gentle January, the infamous "Alaska Blaster" clobbered Colorado with snow and severe cold during the first week of February. In fact, you can go back in the Colorado climate history books and find several occasions when extreme cold gripped our fine state in early February. Maybell's record-breaking -61°F low occurred on February 1, 1985. Fort Morgan's record low of -41° occurred back in February of 1951. Such extreme cold is possible, but the good news is it doesn't always happen and even when it does It doesn't usually last long. As our "Deep Winter" article last month indicated, winter starts losing its grip on Colorado at lower elevations beginning some time in mid-February. Thereafter, the powerful sunshine begins to cause noticeable warming. Mean February temperatures during the past few decades are generally only 1-4 degrees warmer than January up in the mountains and eastern foothills. But in some of our lower valleys such as the Grand Junction and Lamar areas, February is nearly 10 degrees warmer than January on average.

February is not known for its heavy precipitation. Out on the eastern plains it is often the driest month of the year with an average of only 0.25" over much of the area (3-8" snow). Precipitation does increase closer to the mountains and mountain precipitation is normally quite abundant, averaging 2.00-4.00" (30-60" snow). February typically does not contribute as much to the mountain snowpack as the other winter and early spring months. With the shortages of mountain precipitation so far this winter, February precipitation could be especially important this year.

Colorado Temperatures -- Regional Patterns and Spatial Correlations:

If you have been reading COLORADO CLIMATE at all seriously in the past, you have probably taken some interest in the map each month showing temperatures across the state compared to average. This month (December 1989) you will note that temperatures east of the mountains were more than 4°F colder than average while some locations in western Colorado were several degrees warmer than average. A year ago in December the mountains were colder than average while extreme eastern and western Colorado were both warmer than average. Every month the patterns change. Only rarely does the whole state behave the same (relative to average). For any given month areas of both above and below average temperatures can usually be found. An average month when most of the state is within 2°F of average is surprisingly rare. October 1989 was about as average as we can get.

It is useful to know how consistent or variable temperature patterns may be. If the whole state were consistent (I say consistent rather than the same because we know elevation, latitude, topography and ground cover differ--all of which affect temperatures) we would only need 3 or 4 weather stations across the entire state to monitor the climate. If temperatures were extremely variable (like precipitation) a weather station every 5 miles might still not be enough. We are currently interested in temperature relationships in order to determine what areas of the state and what times of year may provide the most insight into how Colorado's temperatures might change if global temperatures really do rise. We are also involved in a study for a Federal resource management agency of how many weather stations are needed to adequately allow them to manage their resources.

(continued on Page -9-)

DECEMBER 1989 DAILY WEATHER

Date	Event
1-5	A dry and mild period. A weak upper level low pressure center over New Mexico produced a few flurries in the southern mountains on the 1st and dropped some locally significant moisture near Trinidad. Then sunny statewide on the 3rd with near record warmth in some areas. Canon City hit 72°. Clouds and winds increased 4-5th but temperatures still were very warm with many 60°+ readings east of the mountains with 40s up in the mountains. The Kim 15NNE station reached 73° on the 5th, the warmest in the state for December.
5-12	A Pacific cold front raced across the state late on the 5th bringing cooler temperatures and skiffs of mountain snows. A more significant period of snow developed on the 6th as an upper level low pressure trough deepened over Colorado. Mountain snows were quite light, but surprisingly heavy snows fell in southeast Colorado. By midday on the 7th Lamar had 2", Pueblo 4", Walsenburg 9" and nearly 1 foot near Rye. Fog and localized air pollution lingered early on the 8th but brisk westerly winds developed clearing the air and bringing a return of mild temperatures. As eastern Colorado enjoyed a warm but breezy day on the 9th, snows developed over the northern mountains late on the 9th. Then a strong Canadian cold front reached eastern Colorado on the 10th and helped trigger a modest Front Range snowstorm. Precipitation was light to nonexistent over the eastern plains, Western Slope and southern mountains. But Front Range and northern mountain areas experienced as much as 6-18" of fluffy powder. Canon City reported 8" and Echo Lake 17". As skies cleared on the 11th, some of the coldest temperatures of the month were observed in the mountains and Western Slope. Paonia has a low of 5° on the 11th and Climax dropped to -24°F.
13-23	Extremely cold air perched northeast of Colorado on the 13th and slipped into most of eastern Colorado on the 14th and 15th. At the same time, the jet stream became very strong from the north northwest and slammed moisture up against our northern mountains producing localized very heavy snows. From the 13th to the 19th, the town of Steamboat Springs measured 47" of new snow and Vail received 36". Nearby mountain areas received considerably more. Unfortunately, little moisture made it to the mountains from Aspen southward. Crested Butte totalled just 2.5" of new snow during the period and Wolf Creek Pass a mere 3.5". From the 14th until the 23rd much of eastern Colorado stayed in the ice box with nighttime temperatures often falling near or below zero. Some light snow was squeezed out of the frigid air as it was pushed up against the mountains by a large high pressure east and north of the area. Six inches or more of new snow accumulated gradually along parts of the Front Range. By the morning of the 19th temperatures were well below zero over nearly all of eastern Colorado with cold temperatures also reaching into some of the mountains. Denver set a new record low with -10°. Conditions moderated briefly on the 20th and temperatures climbed briefly into the 40s. Evergreen had a pleasant high of 51° that day. Then the coldest air of the season rushed back in from the northeast that evening accompanied by strong winds and dangerous wind chills. Temperatures east of the mountains stayed near zero during the day on the 21st. Skies cleared that evening and temperatures plummeted to the lowest level in several years. Sterling's -35° on the morning of the 22nd was their coldest official temperature ever observed there since records began in 1909. Briggsdale's -38° was the coldest in the state for the month. The cold wave then ended quickly. By the 23rd temperatures climbed back above freezing.
24-28	Dry and mild--great weather for holiday travel and festivities.
29-31	Seasonally chilly as a modest push of cold air moved down from Canada and a low pressure trough aloft moved across the Rockies. A little light snow in many mountain areas and along the Front Range, primarily on the 30th. Four inches of snow fell at Winter Park.

December 1989 Extremes

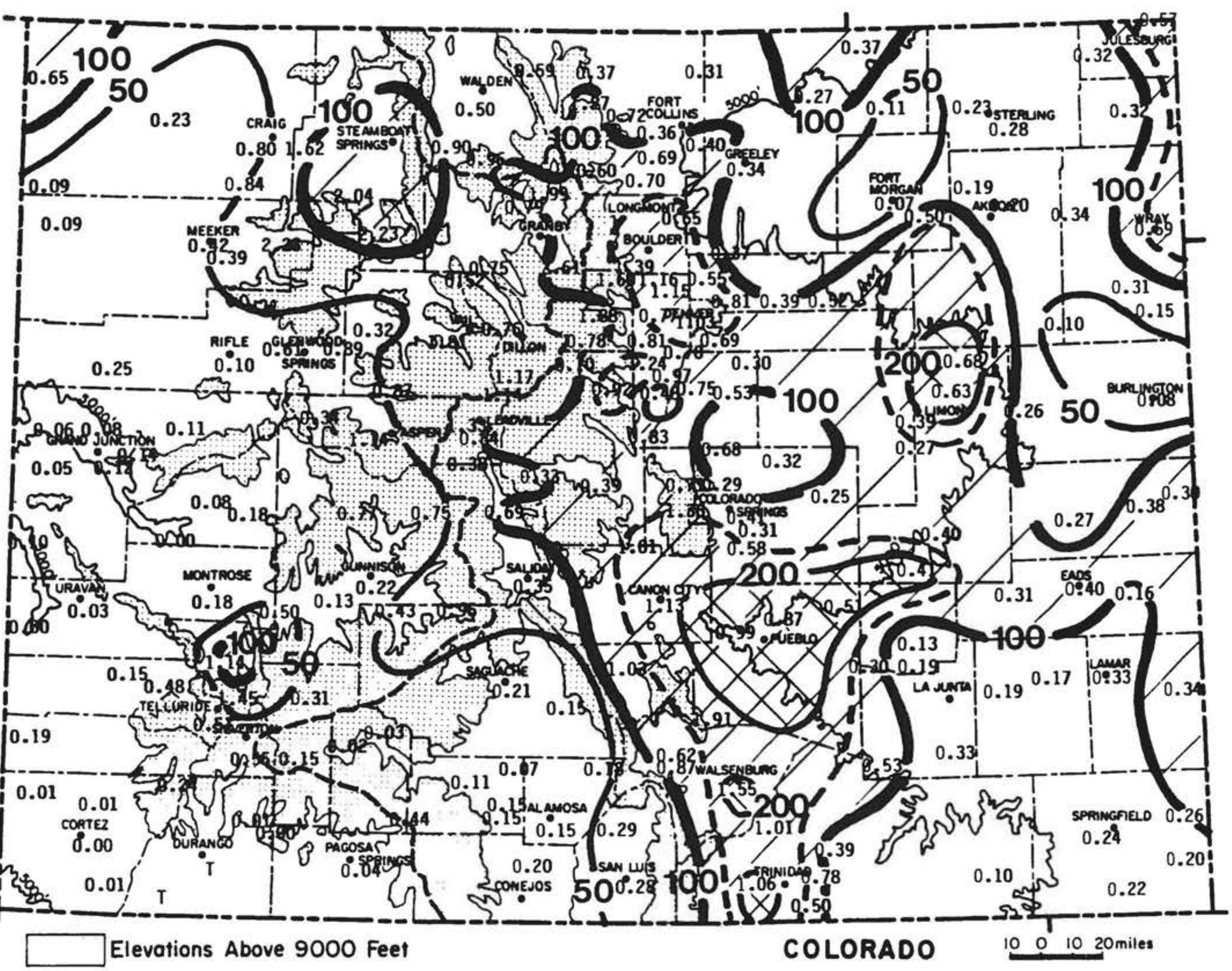
Highest Temperature	73°F	December 5	Kim 15NNE
Lowest Temperature	-38°F	December 22	Briggsdale,
Greatest Total Precipitation	3.60"		Steamboat Springs
Least Total Precipitation	0.00"		Cortez and other southwest locations
Greatest Total Snowfall*	67"		Steamboat Springs
Greatest Snowdepth*	41"	December 17	Climax

* For existing weather stations with complete daily records. Higher values are likely for unmonitored locations.

DECEMBER 1989 PRECIPITATION

December precipitation was scanty, as usual, over the eastern plains of Colorado. Close to the Front Range, however, precipitation was more abundant. At least double the average precipitation was observed near Limon, in parts of the Denver area, throughout the Pueblo vicinity and in some areas near Trinidad and Walsenburg. Most of this welcome moisture fell during the first half of December. Over the mountains and Western Slope, precipitation was extremely below average. About 40 weather stations reported less than 25% of their average December precipitation, and some locations in southwest Colorado had their second month in a row with no moisture. Fortunately, an episode of heavy snow in mid-December blanketed high elevations of the northern mountains and selected areas in the central mountains and left some areas like Yampa, Grand Lake and Winter Park with above average precipitation for the month.

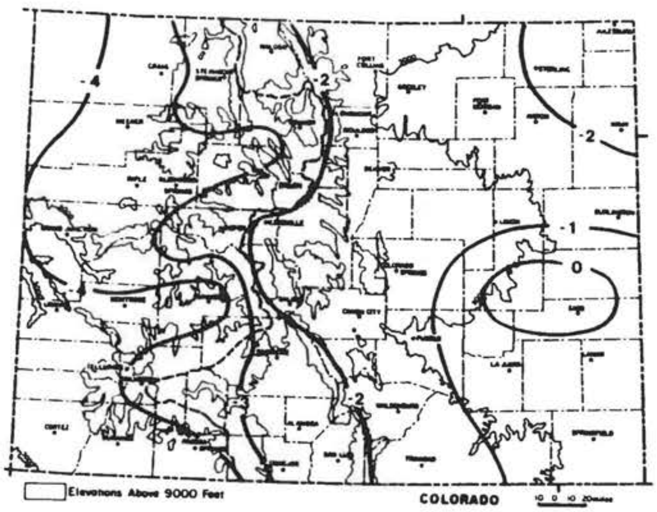
Greatest		Least	
Steamboat Springs	3.60"	Paradox 1W	0.00"
Winter Park	2.61"	Cortez	0.00"
Yampa	2.23"	Vallecito Dam	0.00"
Marvine Ranch	2.23"	Delta	0.00"
Pyramid	2.04"	Durango	T
		Fort Lewis	T



Precipitation amounts (inches) for December 1989 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

The 1990 water year continues to accumulate precipitation at an unusually slow rate. Except for a handful of stations in the Denver area and in the northern mountains, all the rest of Colorado is drier than average for the first 3 months of the 1990 water year. Nearly half of the State has received less than 50% of the average precipitation. There is still time to recover, but with each passing week, concern over next year's water supply is growing, especially in southwestern areas. For the 1989 calendar year, Telluride experienced their second driest year on record since 1911.

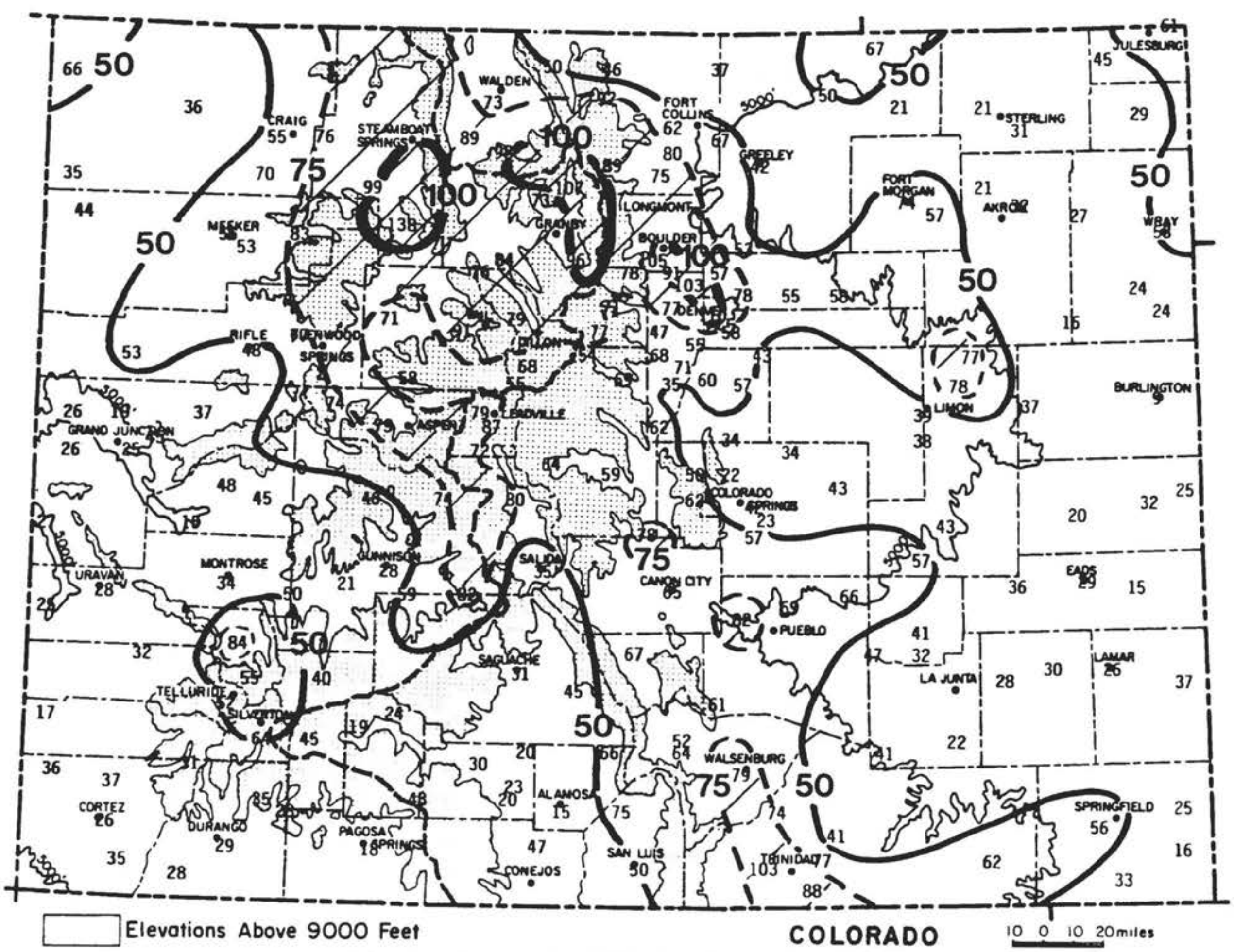


PALMER INDEX

The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

Interpretation of Index

	extremely wet
+4	----------------
+3	ample moisture
+2	----------------
+1	
0	near normal
-1	
-2	----------------
	moderate drought
-3	----------------
	severe drought
-4	----------------
	extreme drought

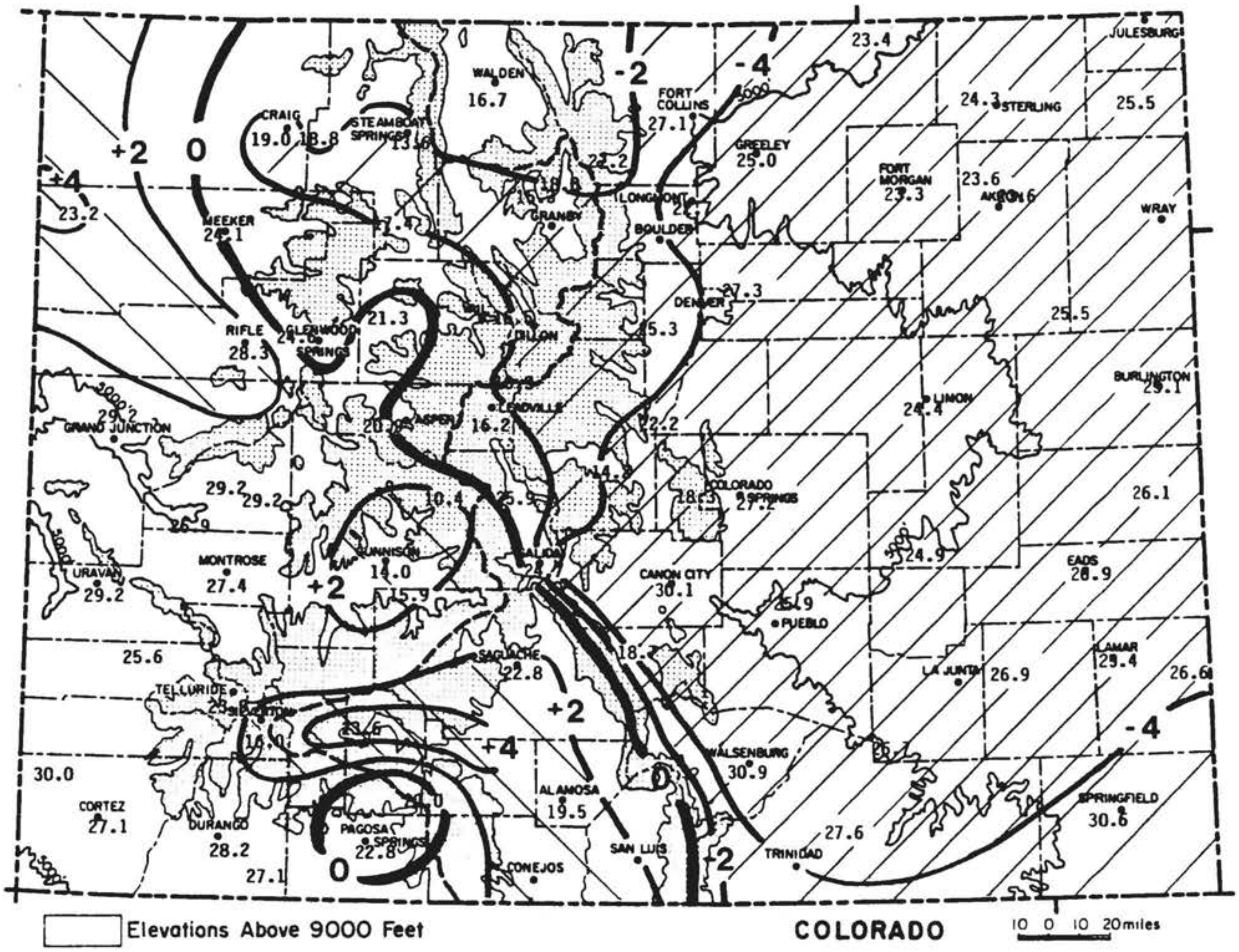


Precipitation for October 1989 through December 1989 as a percent of the 1961-1980 average.

DECEMBER 1989 TEMPERATURES

AND DEGREE DAYS

For the month of December, mean temperatures ended up near or a little above average in western Colorado but as much as 6 degrees colder than average east of the mountains. Temperatures were seasonal to warm at the beginning and end of the month across Colorado. However, an attack of very cold weather during the middle of the month, primarily east of the mountains, caused temperatures for the month as a whole to end up several degrees below average in those areas. For a change, the coldest temperatures in the state were not observed in the mountains. Sterling had a low of -35° on the 22nd, for example, while the traditional state icebox, Taylor Park, only dipped to -28° during the month. Lamar's coldest reading for the month, -23°, was ten degrees colder than Alamosa's coldest reading.



December 1989 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

DECEMBER 1989 SOIL TEMPERATURES

A few inches of fresh, fluffy snow in mid-December helped insulate the soil from the extremely frigid air temperatures that chilled eastern Colorado. Soil temperatures dropped, but frost did not penetrate deeply in snowcovered areas.

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.

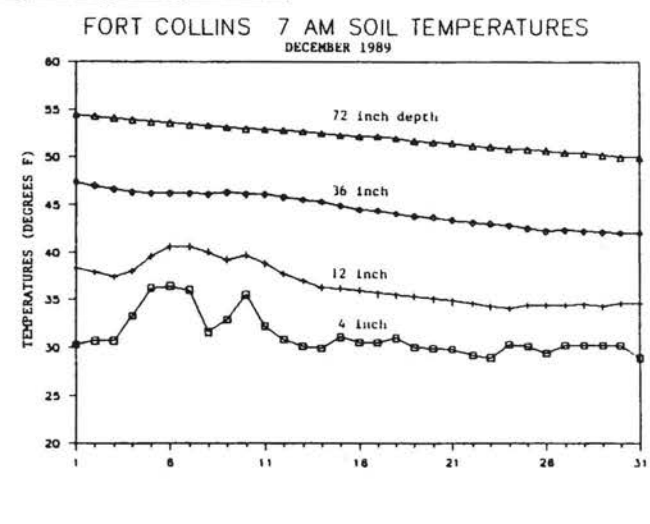


Table 1. Heating Degree Day Data through December 1989 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001	1400							3469
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974	1365							3557
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M	M							M
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812	1202							3063
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684	1229							M
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584	1076							2170
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699	1163							2511
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850	1166							2668
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892	1420							3183
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M	M							M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658	1160							2395
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124	1495							4565
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789	1133							2569
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896	1348							3115
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818	1221							3188
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711	1166							2507
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721	1285							2580
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729	1103							2188

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

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
	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132	1449							4250
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729	1230							2582
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069	1574							3949
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684	1176							2282
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138	1507							4767
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762	1252							2733
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749	1302							2745
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869	1261							2912
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768	1156							2483
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964	1298							3334
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676	1204							2347
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M	1130							M
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974	1533							M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719	1254							M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869	1264							3294
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633	1153							2267
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075	1490							4239
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581	1047							2092

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

DECEMBER 1989 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	37.0	9.7	23.4	-5.4	66	-31	1284	0	27	0.37	0.11	142.3	7
STERLING	39.7	8.9	24.3	-2.7	68	-35	1254	0	42	0.23	-0.08	74.2	4
FORT MORGAN	37.5	9.0	23.3	-4.0	67	-26	1285	0	36	0.07	-0.18	28.0	3
AKRON FAA AP	36.4	10.7	23.6	-5.0	63	-25	1274	0	25	0.19	-0.06	76.0	5
AKRON 4E	37.1	10.2	23.6	-4.0	64	-32	1274	0	32	0.20	-0.08	71.4	6
HOLYOKE	39.7	11.3	25.5	-4.2	67	-33	1217	0	53	0.32	-0.05	86.5	6
JOES	39.8	11.2	25.5	-4.5	68	-29	1215	0	54	0.10	-0.25	28.6	3
BURLINGTON	38.3	12.0	25.1	-6.8	66	-25	1229	0	36	0.08	-0.24	25.0	2
LIMON WSMO	38.2	10.6	24.4	-4.3	66	-22	1252	0	34	0.39	0.19	195.0	6
CHEYENNE WELLS	40.8	11.5	26.1	-4.6	67	-23	1197	0	47	0.38	0.16	172.7	4
EADS	41.9	11.9	26.9	-4.3	9999	-22	1136	0	57	0.40	0.06	117.6	3
ORDWAY 21N	39.7	10.0	24.9	-5.3	69	-21	1235	0	44	0.41	0.22	215.8	4
LAMAR	43.0	7.7	25.4	-6.2	70	-23	1219	0	61	0.33	-0.05	86.8	4
LAS ANIMAS	42.3	11.5	26.9	-4.8	72	-15	1176	0	59	0.19	-0.05	79.2	3
HOLLY	40.1	13.1	26.6	-4.2	68	-22	1183	0	44	0.34	0.09	136.0	6
SPRINGFIELD 7WSW	45.5	15.7	30.6	-3.6	69	-16	1059	0	71	0.24	-0.07	77.4	6
TIMPAS 13SW	40.9	12.5	26.7	-5.8	70	-14	1181	0	53	0.53	0.07	115.2	5

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	40.5	13.7	27.1	-2.8	66	-22	1166	0	36	0.36	-0.10	78.3	8
GREELEY UNC	37.5	12.5	25.0	-4.7	65	-24	1230	0	32	0.34	-0.13	72.3	6
ESTES PARK	38.5	15.9	27.2	-1.4	54	-20	1164	0	6	0.60	0.14	130.4	3
LONGMONT 2ESE	39.7	5.8	22.7	-6.8	68	-25	1302	0	37	0.65	0.22	151.2	6
DENVER WSFO AP	40.9	13.6	27.3	-4.7	68	-18	1160	0	48	0.81	0.27	150.0	8
EVERGREEN	42.3	8.2	25.3	-2.9	65	-19	1221	0	41	0.81	0.06	108.0	6
CHEESMAN	42.3	2.1	22.2	-7.2	66	-17	1320	0	40	0.83	0.20	131.7	6
LAKE GEORGE 8SW	31.3	-2.8	14.2	-4.2	52	-23	1568	0	1	0.39	0.02	105.4	6
RUXTON PARK	33.8	2.7	18.3	-4.1	60	-20	1443	0	8	1.36	0.60	178.9	9
COLORADO SPRINGS	39.0	15.5	27.2	-3.5	69	-12	1163	0	39	0.41	0.02	105.1	8
CANON CITY 2SE	43.9	16.2	30.1	-5.9	72	-11	1076	0	68	1.13	0.55	194.8	5
PUEBLO WSO AP	41.0	10.7	25.9	-6.1	70	-15	1204	0	48	0.87	0.52	248.6	7
WESTCLIFFE	37.2	0.1	18.7	-6.2	59	-23	1430	0	14	1.03	0.22	127.2	7
WALSENBURG	45.7	16.1	30.9	-3.6	70	-11	1047	0	55	1.55	0.80	206.7	12
TRINIDAD FAA AP	43.8	11.4	27.6	-5.6	69	-11	1153	0	59	0.39	-0.18	68.4	6

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	29.8	3.5	16.7	-1.5	44	-20	1490	0	0	0.50	-0.12	80.6	8
LEADVILLE 2SW	29.1	3.3	16.2	-1.8	47	-20	1507	0	0	0.84	-0.26	76.4	11
SALIDA	41.5	7.9	24.7	-4.1	61	-12	1242	0	17	0.35	-0.26	57.4	4
BUENA VISTA	41.0	10.9	25.9	-0.3	57	-9	1202	0	11	0.69	0.11	119.0	4
SAGUACHE	38.0	7.6	22.8	2.1	57	-5	1300	0	4	0.21	-0.22	48.8	1
HERMIT 7ESE	43.9	3.2	23.6	10.7	57	-12	1279	0	7	0.02	-1.41	1.4	1
ALAMOSA WSO AP	40.5	-1.4	19.5	2.0	57	-13	1400	0	5	0.15	-0.30	33.3	4
STEAMBOAT SPRINGS	27.1	0.2	13.6	-3.6	40	-11	1533	0	0	3.60	1.06	141.7	14
YAMPA	28.0	6.7	17.4	-3.4	41	-10	1469	0	0	2.23	1.11	199.1	10
GRAND LAKE 1NW	30.2	5.7	18.0	0.6	45	-8	1449	0	0	1.99	0.35	121.3	14
GRAND LAKE 6SSW	26.5	4.2	15.3	-2.3	41	-13	1531	0	0	0.79	-0.08	90.8	12
DILLON 1E	29.3	3.8	16.5	-2.2	47	-12	1495	0	0	0.76	-0.11	87.4	11
CLIMAX	23.5	-2.8	10.3	-5.1	43	-24	1688	0	0	1.14	-0.97	54.0	14
ASPEN 1SW	32.5	9.3	20.9	-1.1	48	-4	1365	0	0	1.14	-1.27	47.3	14
TAYLOR PARK	28.4	-7.6	10.4	3.9	44	-28	1685	0	0	0.75	-0.90	45.5	8
TELLURIDE	40.0	7.9	23.9	0.7	56	-5	1264	0	6	0.51	-1.20	29.8	7
PAGOSA SPRINGS	44.7	0.9	22.8	-0.7	57	-6	1298	0	17	0.04	-1.85	2.1	2
SILVERTON	37.2	-5.2	16.0	2.0	55	-17	1510	0	6	0.55	-1.39	28.4	5
WOLF CREEK PASS 1	34.2	5.9	20.0	-1.8	50	-10	1387	0	0	0.44	-4.79	8.4	4

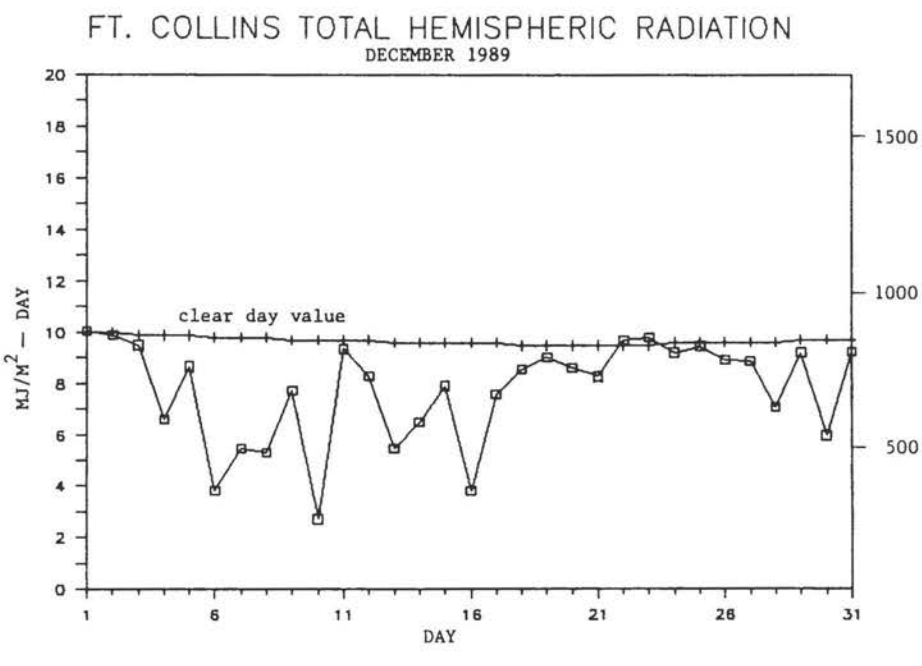
Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	30.3	7.6	19.0	-2.3	45	-6	1420	0	0	0.80	-0.85	48.5	10
HAYDEN	29.3	8.2	18.8	-1.2	42	-5	1426	0	0	1.62	-0.03	98.2	11
MEEKER NO. 2	37.1	11.2	24.1	-0.8	51	-5	1261	0	1	0.42	-0.39	51.9	4
RANGELY 1E	37.0	9.4	23.2	4.0	51	-2	1290	0	1	0.09	-0.46	16.4	1
EAGLE FAA AP	35.5	7.0	21.3	1.4	49	-7	1348	0	0	0.32	-0.62	34.0	5
GLENWOOD SPRINGS	37.7	11.5	24.6	-0.4	51	5	1243	0	1	0.61	-0.84	42.1	9
RIFLE	43.8	12.9	28.3	3.7	54	2	1130	0	6	0.10	-1.03	8.8	2
GRAND JUNCTION WS	41.9	16.4	29.2	1.4	52	8	1103	0	1	0.08	-0.52	13.3	2
CEDAREDGE	43.8	14.5	29.2	0.9	66	3	1105	0	10	0.08	-0.92	8.0	3
PAONIA 1SW	43.0	15.3	29.2	0.6	57	5	1102	0	7	0.18	-1.33	11.9	3
DELTA	43.2	10.6	26.9	-1.5	9999	6	872	0	3	0.00	-0.57	0.0	0
GUNNISON	31.8	-3.8	14.0	0.3	51	-12	1574	0	1	0.22	-0.55	28.6	3
COCHETOPA CREEK	34.4	-2.5	15.9	1.9	52	-14	1513	0	1	0.43	-0.40	51.8	5
MONTROSE NO. 2	40.6	14.3	27.4	0.0	53	7	1156	0	2	0.18	-0.52	25.7	4
URAVAN	45.8	12.5	29.2	-1.1	57	8	1103	0	10	0.03	-1.00	2.9	3
NORWOOD	40.4	10.8	25.6	1.6	55	-1	1216	0	3	0.15	-0.89	14.4	2
YELLOW JACKET 2W	43.2	16.7	30.0	2.7	56	5	1080	0	3	0.01	-1.14	0.9	1
CORTEZ	45.9	8.4	27.1	-0.9	62	-1	1166	0	17	0.00	-1.27	0.0	0
DURANGO	45.9	10.5	28.2	0.7	55	2	1133	0	14	0.00	-1.99	0.0	0
IGNACIO 1N	47.9	6.3	27.1	1.7	57	-5	1166	0	22	0.01	-1.23	0.8	1

* 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 1989 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	11	9	11	--	--
Denver	8	10	13	64%	67%
Fort Collins	9	12	10	--	--
Grand Junction	14	11	6	81%	60%
Pueblo	12	9	10	64%	72%



Colorado Temperatures -- Regional Patterns and Spatial Correlations: continued

It is helpful to know how much year to year variation to expect at any location across Colorado before evaluating similarities from region to region. The greatest year to year variations occur during the winter. While day to day temperatures are most variable in eastern Colorado, the greatest year to year differences in temperature averaged over the entire winter season occur in our mountain valleys. The Gunnison area leads the state with a standard deviation of 4.2°F. The least winter year to year variability for a given location takes place in the higher mountains and in extreme southeast Colorado (standard deviation of about 2.5°F). Meanwhile, summer temperatures are very stable. The greatest variability in summer seasonal temperatures occurs in east central Colorado where the combined June-August temperatures lie within 1.5°F of the average in ~68% of all years. In the San Luis Valley the standard deviation of the mean summer temperatures over the past 40 years is only 0.8°F.

Figures 1 and 2 begin to address the question of how well the seasonal temperatures for winter and summer across all areas of Colorado correlate with the temperatures in one particular region, the lower Arkansas Valley. If temperatures go up and down in an identical fashion from year to year, the computed correlation coefficient (r^2) is 1.0. If they are unrelated, the correlation coefficient is ~0. If temperature variations are out of phase (one area is colder when the other is warmer), the correlations are <u>negative</u> (between 0 and -1.0). You can see from these maps that temperatures are positively correlated with those of the lower Arkansas Valley throughout the state. Correlations deteriorate rapidly, however, in the mountains and western valleys. There is only a small relationship, for example, between seasonal temperatures in Lamar and those in Gunnison.

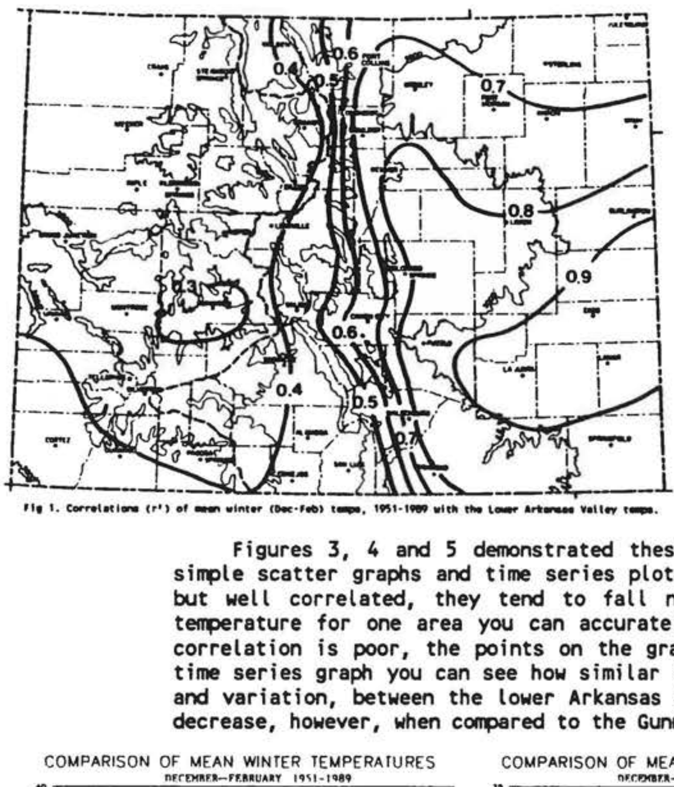


Fig 1. Correlations (r^2) of mean winter (Dec-Feb) temps, 1951-1989 with the Lower Arkansas Valley temps.

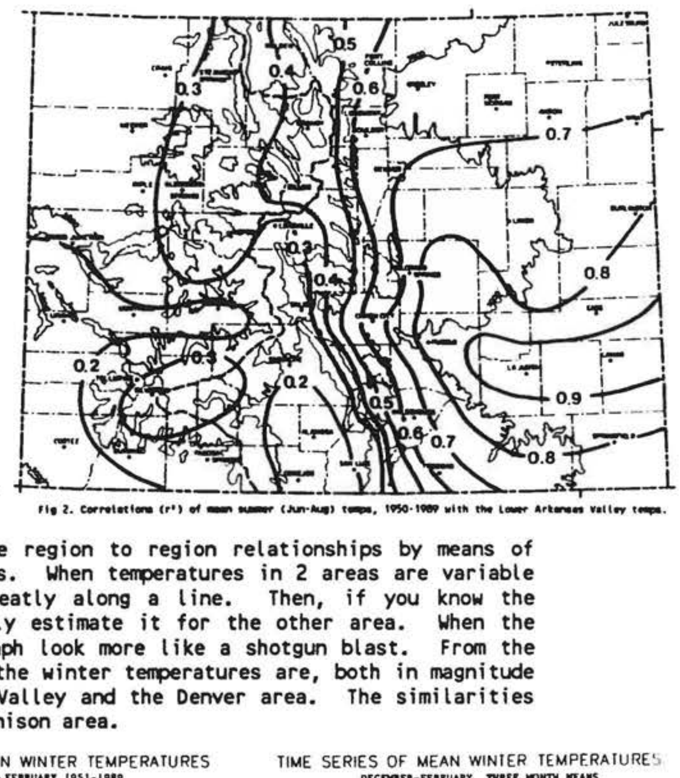


Fig 2. Correlations (r^2) of mean summer (Jun-Aug) temps, 1950-1989 with the Lower Arkansas Valley temps.

Figures 3, 4 and 5 demonstrated these region to region relationships by means of simple scatter graphs and time series plots. When temperatures in 2 areas are variable but well correlated, they tend to fall neatly along a line. Then, if you know the temperature for one area you can accurately estimate it for the other area. When the correlation is poor, the points on the graph look more like a shotgun blast. From the time series graph you can see how similar the winter temperatures are, both in magnitude and variation, between the lower Arkansas Valley and the Denver area. The similarities decrease, however, when compared to the Gunnison area.

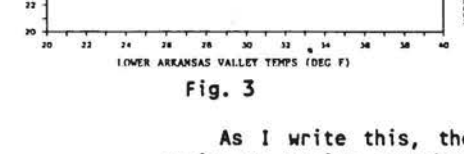


Fig. 3

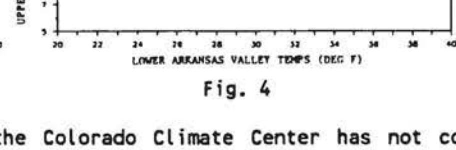


Fig. 4

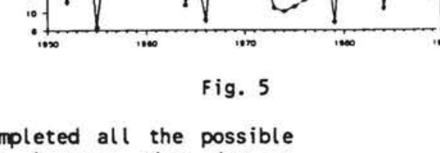


Fig. 5

As I write this, the Colorado Climate Center has not completed all the possible region to region correlations for each season. It is obvious, however, that what we probably always thought is indeed true. The temperatures we experience east of the mountains tells us very little, even in a relative sense, about what is happening in the mountains and on the Western Slope--even though we are influenced by nearly the same large-scale weather patterns. This may imply that if global warming should become a reality, temperature trends may be very different just within our own state borders.

WIND POWER

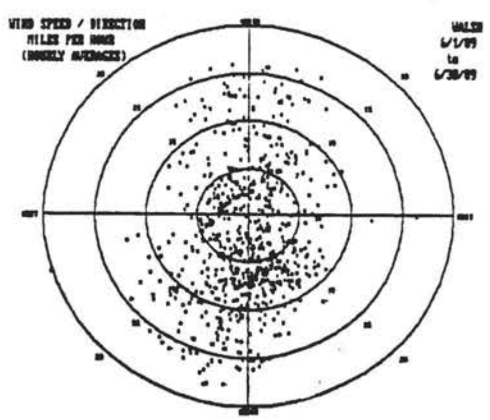
Wind power, like other renewable energy resources, is a virtually inexhaustible form of energy. Because the winds are generated by the sun, wind energy is an indirect form of solar energy. Theoretically, the energy content of the wind is as much as 2 X 10^13 watts. However, man cannot capture all this energy. If we can learn to use just 1% of that available, the wind could provide about 3% of the world energy consumption. In the U.S. alone, researchers feel that wind power could provide as much electricity as twice the consumption of our country in 1988. To help achieve this goal, wind machines have been and are being developed to provide an economically feasible way to convert wind energy to electricity.

There are two main forms of wind machines used for wind conversion. The more familiar of the two has a horizontal axis of rotation. Small wooden windmills of this type dotted the countryside to provide water pumping or to power small generators for radio use on many of the country farms. The second type of wind machine in use today is show at the right. Its rotating axis is vertical with the blades rotating around the central axis. This particular design allows the blades to be turned by the wind as it passes the machine from any direction. These descendants of early windmills have far outshone their ancestors both in size, efficiency and power output. They are up to 100 feet tall and are capable of producing from 0.8 to 3.2 megawatts of electricity (the average American household typically uses power at a rate of 1-2 kilowatts.)

A vane-axial type wind machine.

Power output by wind machines depends on various factors. The velocity of the wind plays the biggest role in determining this output - the power contained in the wind is proportional to the velocity raised to the third power. Other factors in power output determination include the density of the air and frictional and rotational losses in the wind machine. However, it is the cubed velocity that makes or breaks (literally and figuratively) the use of a wind machine. A rule of thumb in wind power design is that an average wind speed of 4 meters per second (about 9 miles per hour) is needed for the economic use of a wind machine. Conversely, when the wind velocity is too large, the stress put on the machine can cause excess damage. The placement of wind machines, then, must consider the year long average velocity as well as the maximum velocity at the proposed site.

Data taken from the WTHRNET station in Walsh, Colorado for June, 1989.



The figure to the left shows data collected by one of the WTHRNET stations. The data are in the form of a wind rose with each dot representing an hour of data regarding the wind speed and direction. This format directly shows the direction of the wind and the speed while giving the user a quick idea of the principle direction and speed of the majority of readings.

Wind power is still in its early stages as a source of energy. Much research is needed in areas such as structural stress, how the wind performs in specific terrain and the aerodynamics of rotor blades. The possibilities of this renewable power source are significant and make this an exciting and interesting area of research.

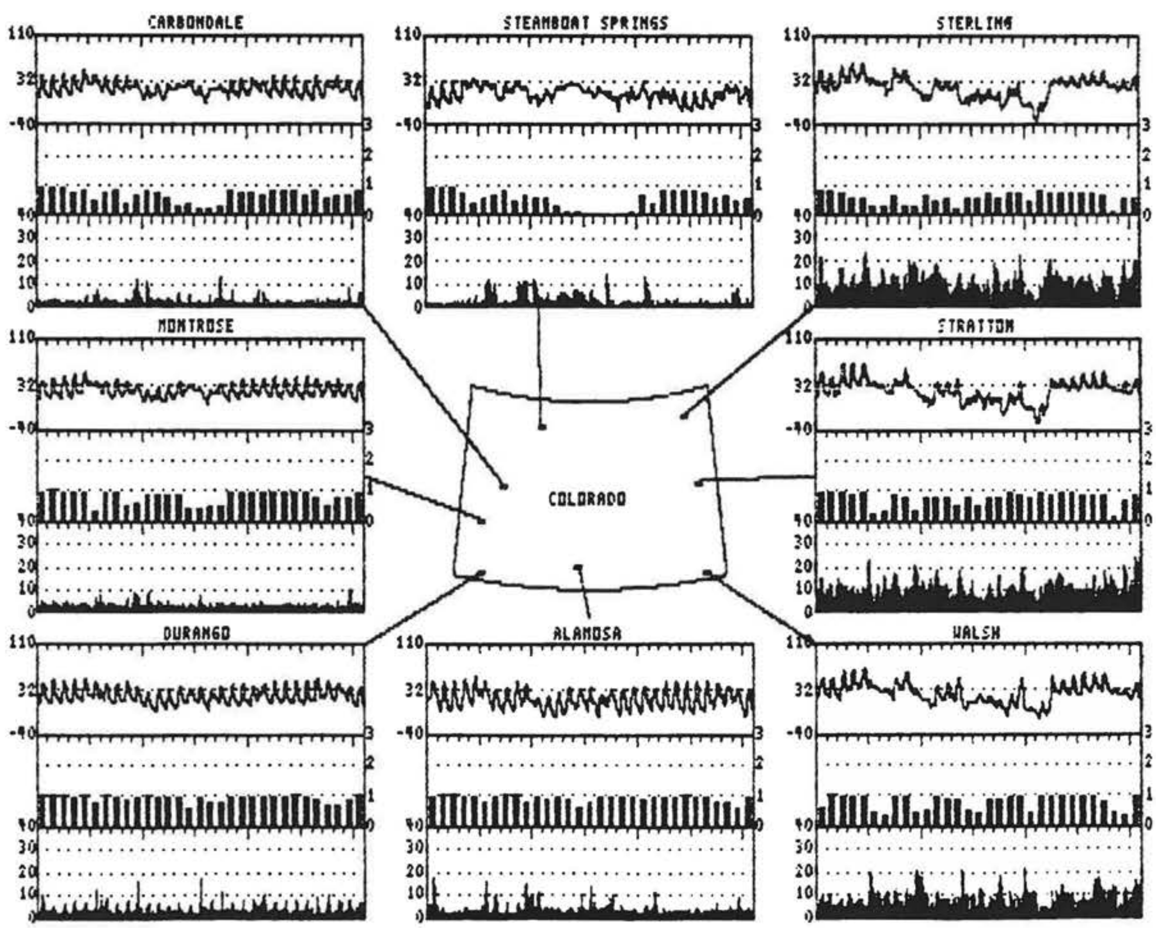
This paper was written by Mary Sutter of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder, Colorado, 80309-0428. Weather data may be purchased on a monthly basis for the stations shown on the WTHRNET summary. Contact Mary Sutter at this address for further information.

WTHRNET WEATHER DATA DECEMBER 1989

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)	18.1	23.9	20.5	24.4	12.4	22.7	23.7	27.0
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	56.5 5/15	52.3 5/15	48.4 5/14	54.1 5/15	38.1 5/13	63.9 5/14	70.9 3/15	67.3 5/15
minimum:	-11.0 17/ 7	-0.9 12/ 7	-0.8 17/ 3	3.7 17/ 7	-17.0 26/ 7	-32.6 22/ 5	-28.3 22/ 4	-15.0 22/ 7
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	73 / -3	60 / 2	91 / 10	75 / 10	90 / 4	61 / 5	70 / 9	66 / 7
11 AM	46 / 9	36 / 9	63 / 14	53 / 16	80 / 11	52 / 10	57 / 16	48 / 13
2 PM	30 / 8	27 / 9	47 / 14	42 / 16	63 / 12	44 / 10	51 / 16	39 / 12
5 PM	37 / 7	28 / 6	53 / 13	43 / 13	75 / 11	47 / 6	57 / 11	45 / 10
11 PM	60 / 0	50 / 2	83 / 13	68 / 11	92 / 8	58 / 5	70 / 10	61 / 8
monthly average wind direction (degrees clockwise from north)								
day	184	184	230	250	163	222	169	190
night	203	58	175	160	148	241	225	228
monthly average wind speed (miles per hour)	3.10	3.27	1.90	2.60	2.32	9.59	9.27	7.36
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	497	452	654	535	594	38	11	58
3 to 12	237	286	88	209	148	501	585	597
12 to 24	10	6	2	0	2	204	148	89
> 24	0	0	0	0	0	1	0	0
monthly average daily total insolation (Btu/ft²·day)	903	913	665	783	532	582	742	768
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	215	197	125	162	91	106	167	161
40-60%	49	54	49	44	60	61	40	45
20-40%	27	37	77	62	56	53	46	48
0-20%	9	6	40	13	69	51	22	27

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

JANUARY 1990

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 13 Number 4

January in Review:

A single snowstorm brought valuable moisture to all of eastern Colorado and ended, for the time being, immediate concerns over the threat of dust storms and expanding drought conditions on the plains. Unfortunately, mountain snows were on the light side again, and concern over shortages in surface water supplies for next summer continued to mount. Temperatures were warmer than average over most of the state, especially the northern portions. The state also enjoyed a fairly sunny but windy month.

Colorado's March Climate:

The battle between the seasons does not bring thunderstorms and tornadoes to Colorado in March (rarely) like it does over the central and southern portions of the U.S. But March is an exciting month with warming temperatures, quite a few clouds, frequent strong winds, dramatic temperature changes, heavy snows and possible blizzards. Last year (March 1989) was more placid than usual with dry and mild conditions dominating. In fact, for much of the State it has been 20 years since the last really cold March. Depending on how you like to use statistics you can either say we are tending toward warmer Marches or else you can say we're overdo for a cold one. Based on the 1961-1980 period, March temperatures at lower elevations below about 6000 feet average in the 50s during the afternoon with 20s at night. Most days, the temperatures decrease with elevation. Mountain areas expect average daily high temperatures in the 30s with lows in the single digits. At lower elevations, don't be surprised to see a few days with temperatures in the 70s or even higher. But also don't be surprised to have a few days with temperatures only climbing into the 20s or 30s. Subzero temperatures decrease in frequency but are still commonplace is many mountain valleys.

March precipitation is very important to Colorado. Normally, March snows contribute significantly to the mountain snowpack (statewide, March is responsible for close to 20% of the total winter snowpack accumulation on average). Most years March also brings a marked increase in low elevation precipitation both east and west of the mountains which is extremely beneficial for range plants and dryland wheat. Since March precipitation at low elevations typically falls in the form of wet snow on thawed or thawing soils, the moisture tends to soak into the soil. Precipitation averages for the month range from just 0.25-0.50" (4-10" snow) in the San Luis Valley and 0.50-1.00" (6-15" snow) on the Western Slope to 0.60-2.00" (7-30" snow) from the eastern plains into the foothills and 2-5" (30-80" snow) in the high mountains. With the dry weather pattern that has been dominant over Colorado for the past year, March precipitation will be especially important this year. And please remember to give eastern plains blizzards all the respect they deserve. Don't let them catch you unprepared.

The Seasonal Distribution of Precipitation in Colorado and What That Means for Drought Recovery (or drought development):

A unique feature of Colorado's climate is the variety of precipitation-producing mechanisms and the resulting variety of seasonal precipitation patterns that occur in different parts of the state. At almost any time of the year, one area of the state is experiencing their wettest time of year while other areas are dry. This feature is an asset to Colorado in many ways, but it also makes it very difficult to generalize climatic characteristics, especially those that relate to drought.

Using average monthly precipitation totals based on a minimum of 20 years of complete data we mapped the wettest and driest month of the year for about 250 locations in Colorado. The results are fascinating. In several mountain areas such as Steamboat Springs, Vail, Aspen and Wolf Creek Pass, December and January is the wettest time of year. March is the wettest month at a few central mountain locations including Breckenridge and the top of the Grand Mesa. From Long's Peak to Berthoud Pass, April is

(continued on Page -9-)

JANUARY 1990 DAILY WEATHER

Date	Event
1-5	A mild New Year's Day was followed by increasing clouds on the 2nd with late-day precipitation spreading across southwest Colorado. The storm gathered speed on the 3rd as it moved across southern Colorado. Durango received 0.58" of greatly-appreciated moisture (8" snow) from the storm. Alamosa got 4" of snow, and even southeastern Colorado received an inch or two. As skies cleared on the 4th, some parts of the State experienced their coldest temperatures of the month. Vail was a chilly -15°F. Taylor Park Dam reached -32°F. Clouds increased again from the northwest late on the 4th and the northern and central mountains received a light dusting of snow overnight. Hayden reported 3". Clearing again and very cold early on the 6th. Alamosa shivered with -25°F.
6-12	A warming trend began with a round of strong downslope winds along the Front Range late on the 6th. It was chilly west but mild east on the 7th and dry statewide. A low pressure area raced across the U.S. northern plains on the 8th. The northern and central mountains received an inch or two of snow, but the real excitement was the strong winds that lashed the eastern plains and foothills. Temperatures near 60° were reported east of the mountains, but winds in excess of 70 mph in some areas caused some minor building damage and created a frightening duststorm out on the plains. Temperatures stayed warm overnight (Buena Vista's overnight low was 38° and Denver stayed above 40°). It remained warm on the 9th and not quite as windy. Then on the 10th, temperatures rose even higher. Temperatures in the mountains climbed into the 40s, but on the plains 70° readings were common and many records were broken. Greeley hit 72°, Pueblo 74°, Las Animas 76°F. The 77° reading 7 miles south of Campo was the highest in the state. Cooler air slipped into eastern Colorado on the 11th, but the remainder of the State still enjoyed more warm weather. Telluride had a balmy 58° reading on the 11th and 57° on the 12th.
13-15	A weather change began as a storm hit the California coast early on the 13th. A burst of heavy snow raced into southwest Colorado on the afternoon of the 13th and by evening the chain law was in effect on some mountain passes. Snows abated and mild temperatures prevailed on the 14th as the storm reorganized over California. Then precipitation began again on the 15th in western Colorado with some low elevation rain showers. Totals were light except in a few areas. Dinosaur National Monument reported 8" of snow by the 16th with 0.71" water content.
16-18	Colder and unsettled period as the storm reorganized again over southern California and Arizona. Occasional mountain snowshowers fell, but accumulations were light. A little snow also fell along the Front Range. Greeley got close to 4" from a snowshower on the evening of the 17th.
18-21	Snow began in earnest across southern Colorado on the 18th as the storm finally began tracking eastward. Alamosa picked up 8" of snow. Snow became widespread over all of eastern Colorado on the 19th and put a uniform layer of 8-14" over almost all plains areas with excellent water content and little wind. Holyoke, for example, measured 1.38" of moisture in just over 24 hours. Such midwinter storms are rare and agriculturally very valuable. Snow ended early on the 20th. Temperatures did not drop much after the storm and plentiful sunshine 20-21st helped to quickly clear the roads.
22-31	The jet stream positioned itself over the Rocky Mountains for the rest of January bringing strong and steady west to northwest winds at mountain top level. This pattern brought dry and windy weather east of the mountains with seasonal temperatures. The mountains experienced several periods of snow as one disturbance after another crossed the state (23rd, 26th and 29th). The weather pattern was ideal for improving mountain snowpack, but total accumulations were surprisingly light. Very cold temperatures accompanied each disturbance. Climax reached a high of only 5° on the 24th and 8° on the 27th. As the month ended, another storm was affecting the Rockies, this time targeting the San Juans.

January 1990 Extremes

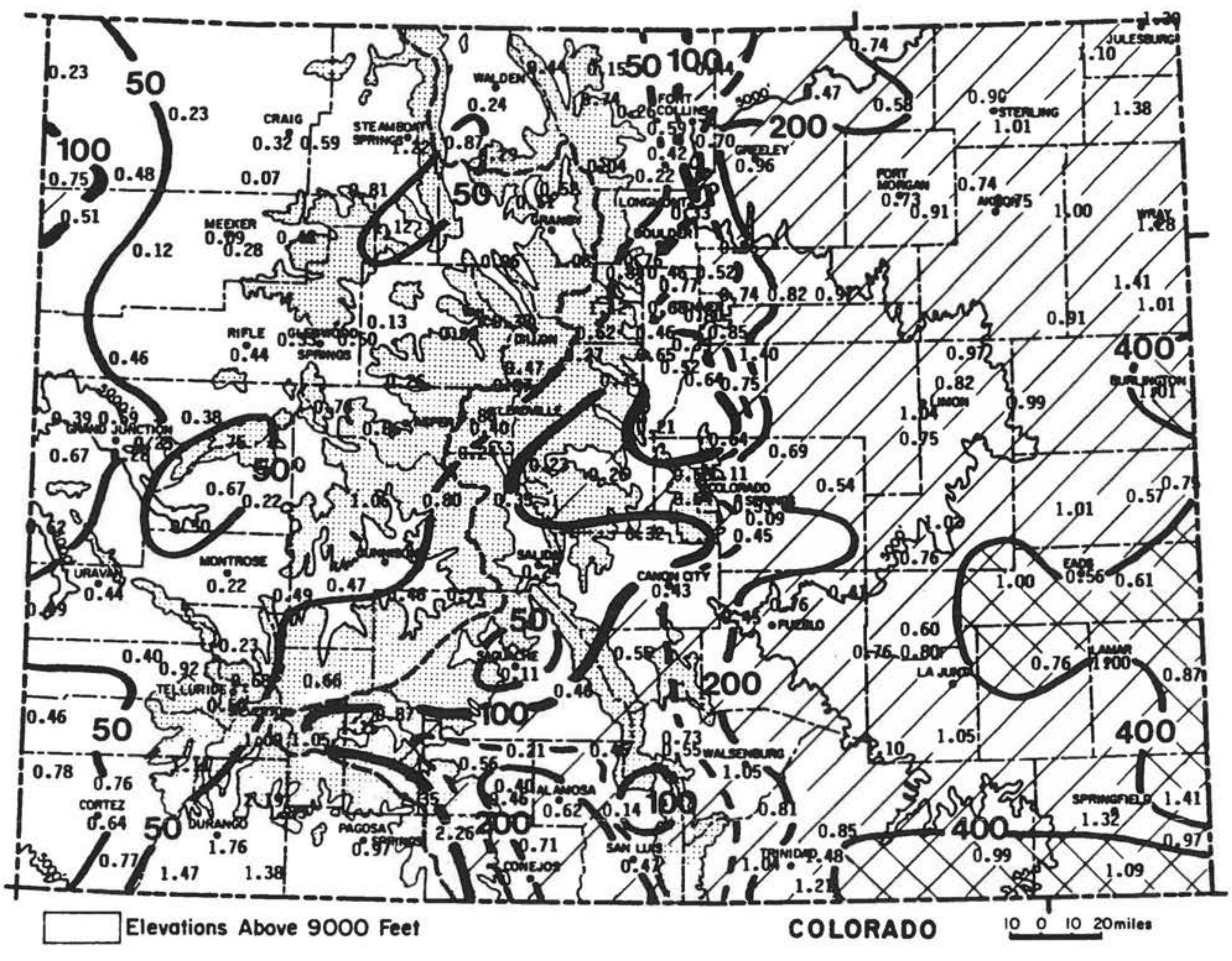
Highest Temperature	77°F	January 10	Campo 7S
Lowest Temperature	-32°F	January 4	Taylor Park Dam
Greatest Total Precipitation	2.75"		Bonham Reservoir
Least Total Precipitation	0.04"		Estes Park
Greatest Total Snowfall*	53"		Wolf Creek Pass 1E
Greatest Snowdepth*	52"	January 31	Rabbit Ears Pass

* For existing weather stations with complete daily records. Higher values are likely for unmonitored locations.

JANUARY 1990 PRECIPITATION

The eastern plains of Colorado enjoyed above average precipitation for January as a result of a single storm that dumped close to a foot of snow over the entire region on January 19th. The only other portion of the state that ended up above average was the San Luis Valley. The remainder of the state, including almost all of the mountains, were drier than average. Many locations received less than half of average. It was one of those rare and unusual winter months where precipitation totals (not percents of average) were as large or greater on the eastern plains than in the mountains. For example, Springfield totalled 1.32" and Burlington 1.01" in January while Aspen received only 0.86", Vail 0.90" and Steamboat Springs 1.11". Normally, those mountain towns receive 7 to 10 times more precipitation than the plains in January.

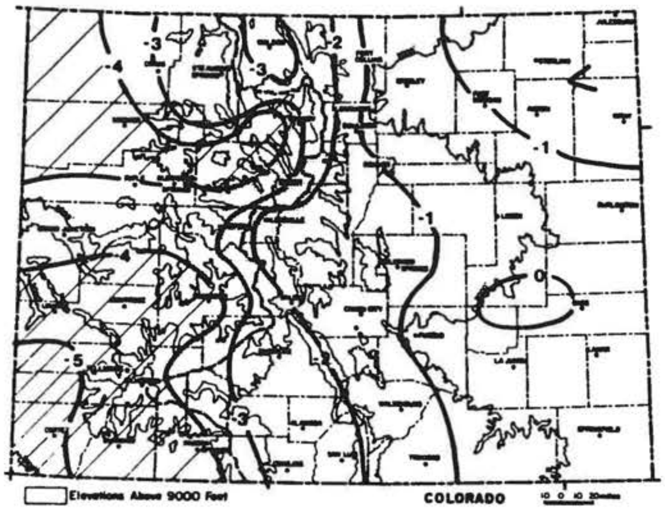
Greatest		Least	
Bonham Reservoir	2.75"	Estes Park	0.04"
Wolf Creek Pass 1E	2.35"	Williams Fork Dam	0.06"
Platoro Dam	2.26"	Hamilton	0.07"
Lemon Dam	2.19"	Meeker	0.09"
Vallecito Dam	1.85"		



Precipitation amounts (inches) for January 1990 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

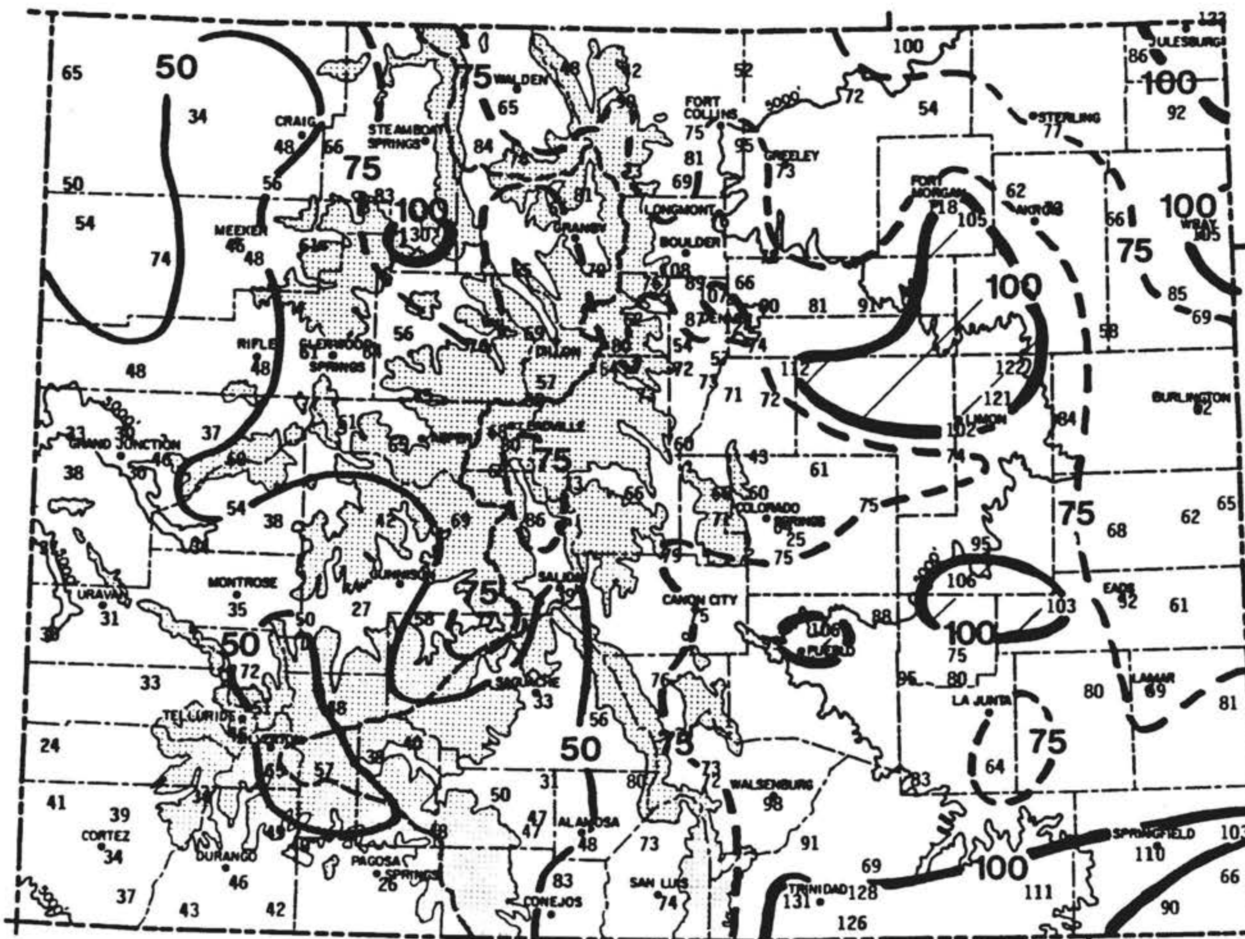
The accumulated precipitation for the first 4 months of the 1990 water year is well below average over most of the mountains and Western Slope. Over southwestern Colorado, precipitation has been less than 50% of average -- only slightly ahead of where they were in the severe drought year of 1977. Conditions are better in the northern and central mountains but are still 20% or more below average in most locations. East of the mountains, the heavy January storm helped a lot. A few plains areas are now near or above average. The map of the Palmer drought index, shown below, gives an idea of how soil moisture is faring across the state.



PALMER INDEX:
The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

Interpretation of Index

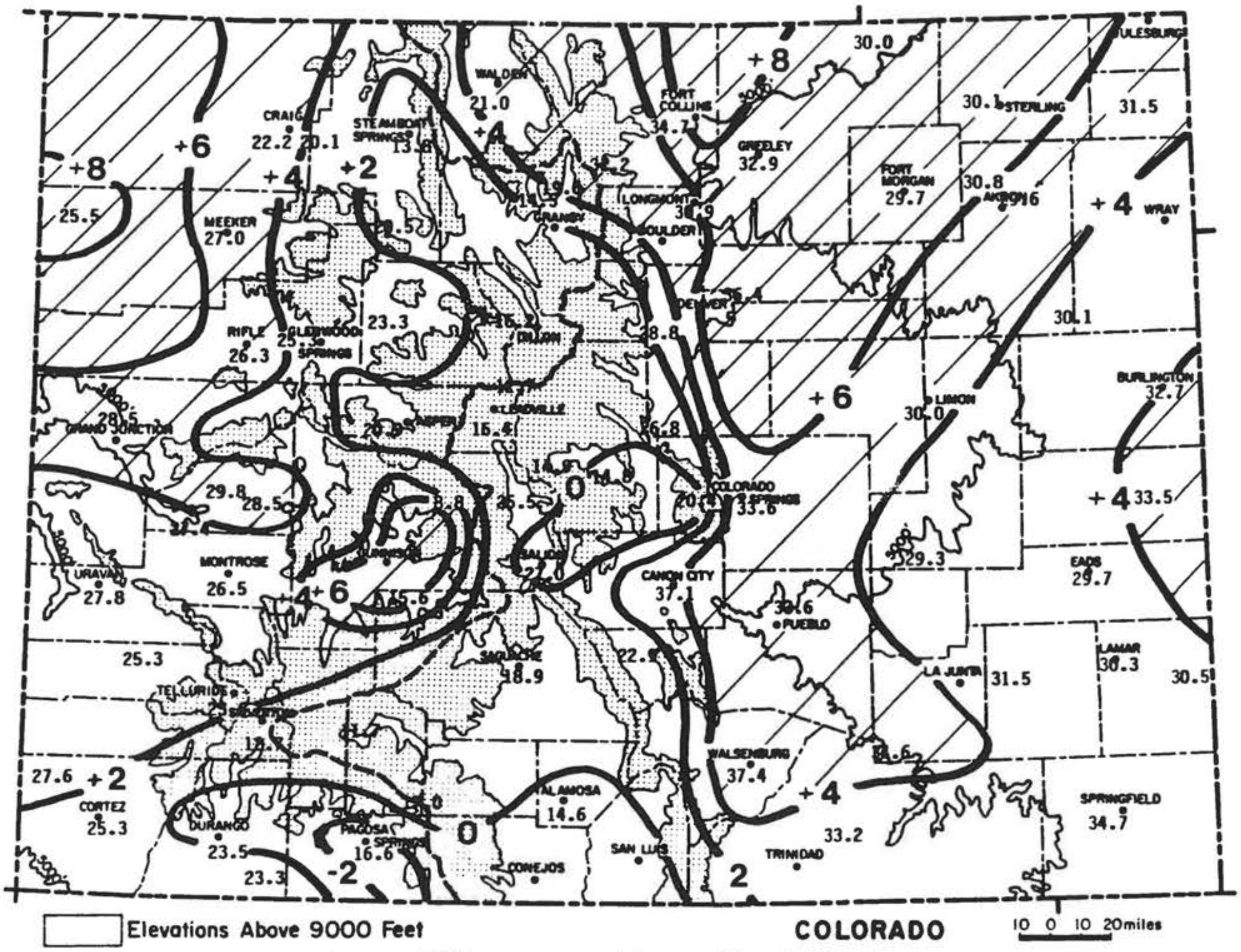
	extremely wet
+4	----------------
+3	ample moisture
+2	----------------
+1	
0	near normal
-1	
-2	----------------
	moderate drought
-3	----------------
	severe drought
-4	----------------
	extreme drought



Precipitation for October 1989 through January 1990
as a percent of the 1961-1980 average.

JANUARY 1990 TEMPERATURES AND DEGREE DAYS

Nearly all of the U.S. experienced a warmer than average January. In Colorado, a few spots in southern Colorado were close to average. Pagosa Springs monthly mean temperature of 16.6°F was more than 3 degrees colder than average. But for most of the state, it was a relatively mild month. There were the typical cold nights up in the mountains, but no outbreaks of severe cold visited the plains. There was even a day when many areas east of the mountains hit the 70-degree mark. For the month as a whole, temperatures averaged about 4 degrees warmer than usual statewide, but some locations along the Front Range and in northwest Colorado were 6 degrees or more above average. The eastern plains would have been warmer, but snowcover helped keep temperatures down during the last 1/3 of the month.



January 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

JANUARY 1989 SOIL TEMPERATURES

Lack of cold weather during January was apparent from the Fort Collins soil temperature data. The ground remained frozen only down to about 12". Snowcover helped keep temperatures steady 18-25th. Soil temperatures decreased again after the snow melted late in the month, despite only seasonal air temperatures.

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.

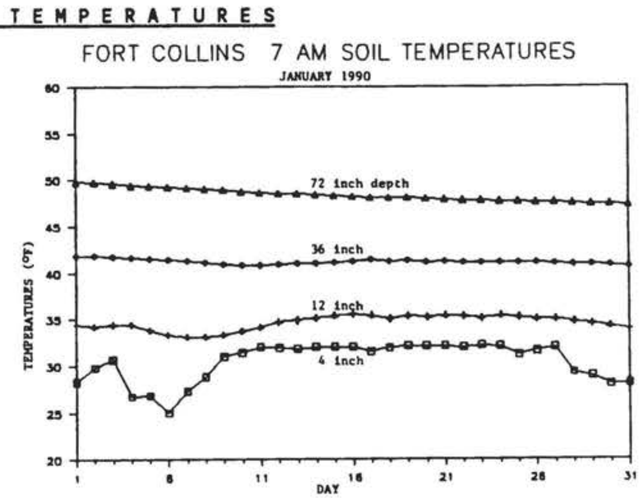


Table 1. Heating Degree Day Data through January 1990 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001	1400	1554						5023
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974	1365	1365						4922
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M	M	M						M
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812	1202	1184						4247
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684	1229	990						M
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584	1076	859						3029
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699	1163	966						3477
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850	1166	1222						3890
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892	1420	1319						4502
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M	M	1161						M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658	1160	879						3274
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124	1495	1506						6071
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789	1133	1278						3847
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896	1348	1286						4401
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818	1221	1115						4303
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711	1166	930						3437
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721	1285	1087						3667
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729	1103	1124						3312

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

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
	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132	1449	1401						5651
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729	1230	985						3567
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069	1574	1647						5596
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684	1176	1030						3312
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138	1507	1499						6266
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762	1252	1078						3811
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749	1302	1048						3793
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869	1261	1169						4081
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768	1156	1186						3669
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964	1298	1491						4825
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676	1204	964						3311
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M	1130	1191						M
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974	1533	1580						M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719	1254	1074						M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869	1264	1273						4567
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633	1153	980						3247
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075	1490	1359						5598
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581	1047	848						2940

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

JANUARY 1990 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	43.2	16.8	30.0	4.8	66	7	1076	0	34	0.74	0.43	238.7	2
STERLING	44.8	15.4	30.1	7.2	71	0	1074	0	38	0.90	0.56	265.0	1
FORT MORGAN	45.1	14.3	29.7	7.0	70	-4	1087	0	43	0.73	0.55	405.6	2
AKRON FAA AP	43.6	18.1	30.8	5.9	70	7	1051	0	35	0.74	0.46	264.3	2
AKRON 4E	43.5	15.8	29.6	4.8	72	5	1086	0	41	0.75	0.49	288.5	2
HOLYOKE	46.3	16.7	31.5	5.2	73	-2	1027	0	56	1.38	1.00	363.2	2
JOES	44.5	15.7	30.1	2.1	72	1	1074	0	46	0.91	0.61	303.3	2
BURLINGTON	45.0	20.5	32.7	4.0	72	6	990	0	41	1.01	0.77	420.8	2
LIMON WSMO	43.4	16.7	30.0	5.5	71	1	1078	0	35	1.04	0.75	358.6	3
CHEYENNE WELLS	48.2	18.9	33.5	5.4	68	3	968	0	54	0.57	0.41	356.2	1
EADS	44.3	15.1	29.7	2.0	73	-2	1086	0	43	0.56	0.29	207.4	2
ORDWAY 21N	45.4	13.2	29.3	1.4	71	-6	1099	0	41	0.76	0.53	330.4	3
LAMAR	48.1	12.4	30.3	2.1	73	-2	1068	0	69	1.00	0.62	263.2	3
LAS ANIMAS	49.3	13.6	31.5	3.2	76	-3	1030	0	76	1.18	0.97	561.9	4
HOLLY	46.5	14.5	30.5	3.6	73	-4	1060	0	58	0.87	0.67	435.0	3
SPRINGFIELD 7WSW	48.6	20.9	34.7	3.9	75	4	931	0	66	1.32	0.98	388.2	3
TIMPAS 13SW	47.7	21.5	34.6	4.3	69	8	934	0	63	1.10	0.73	297.3	4

Foothills/Adjacent Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	48.3	21.1	34.7	8.3	69	10	930	0	47	0.59	0.15	134.1	3
GREELEY UNC	46.6	19.3	32.9	6.8	72	3	985	0	42	0.96	0.58	252.6	2
ESTES PARK	40.5	21.9	31.2	4.4	58	8	1039	0	9	0.04	-0.40	9.1	1
LONGMONT 2ESE	46.8	15.0	30.9	5.2	67	0	1048	0	40	0.33	-0.08	80.5	2
DENVER WSFO AP	48.6	24.2	36.4	7.9	71	13	879	0	60	0.74	0.23	145.1	5
EVERGREEN	46.1	11.5	28.8	2.7	63	-2	1115	0	37	0.46	-0.02	95.8	3
CHEESMAN	45.5	8.2	26.8	0.4	68	-7	1175	0	34	0.21	-0.21	50.0	2
LAKE GEORGE 8SW	32.0	-2.4	14.8	-0.7	52	-20	1546	0	1	0.26	0.03	113.0	3
ANTERO RESERVOIR	32.7	-2.9	14.9	0.6	51	-28	1546	0	1	0.23	0.08	153.3	4
RUXTON PARK	34.0	6.8	20.4	-0.1	55	-13	1376	0	3	0.64	0.10	118.5	6
COLORADO SPRINGS	46.3	20.8	33.6	5.7	70	9	966	0	45	0.53	0.29	220.8	4
CANON CITY 2SE	49.7	24.4	37.1	3.6	70	10	859	0	69	0.43	0.15	153.6	3
PUEBLO WSO AP	49.0	18.2	33.6	4.6	74	1	964	0	59	0.76	0.54	345.5	3
WESTCLIFFE	38.1	7.6	22.9	0.9	54	-14	1298	0	4	0.55	0.17	144.7	4
WALSENBURG	49.1	25.6	37.4	5.5	67	6	848	0	54	1.05	0.51	194.4	5
TRINIDAD FAA AP	48.5	17.8	33.2	2.7	65	1	980	0	58	0.85	0.44	207.3	4

Mountains/Interior Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	32.8	9.2	21.0	5.9	49	-15	1359	0	0	0.24	-0.39	38.1	6
LEADVILLE 2SW	31.5	1.2	16.4	1.9	47	-18	1499	0	0	0.40	-0.80	33.3	13
SALIDA	41.0	13.0	27.0	-0.9	62	-3	1170	0	16	0.24	-0.11	68.6	5
BUENA VISTA	40.4	12.6	26.5	0.8	56	1	1184	0	9	0.35	0.08	129.6	4
SAGUACHE	34.5	3.2	18.9	1.0	54	-12	1420	0	2	0.11	-0.16	40.7	4
HERMIT 7ESE	30.0	-6.5	11.7	1.4	48	-24	1645	0	0	1.15	0.33	140.2	2
ALAMOSA WSO AP	34.2	-4.9	14.6	-0.2	50	-25	1554	0	0	0.62	0.37	248.0	4
STEAMBOAT SPRINGS	28.7	-1.2	13.8	-0.7	47	-17	1580	0	0	1.22	-1.51	44.7	15
YAMPA	32.2	8.7	20.5	1.6	51	-12	1369	0	1	1.12	0.05	104.7	7
GRAND LAKE 1NW	35.4	3.8	19.6	4.8	52	-19	1401	0	1	0.52	-1.47	26.1	5
GRAND LAKE 6SSW	29.5	-0.5	14.5	1.5	45	-22	1558	0	0	0.51	-0.60	45.9	10
DILLON 1E	31.7	0.7	16.2	0.7	54	-17	1506	0	2	0.38	-0.48	44.2	6
CLIMAX	24.8	0.6	12.7	-0.0	45	-17	1616	0	0	0.87	-1.36	39.0	12
ASPEN 1SW	34.5	7.2	20.9	0.9	49	-8	1365	0	0	0.86	-1.64	34.4	10
TAYLOR PARK	27.7	-10.1	8.8	6.7	44	-32	1734	0	0	0.80	-0.64	55.6	9
TELLURIDE	39.1	8.2	23.6	2.5	58	-7	1273	0	13	0.50	-1.20	29.4	7
PAGOSA SPRINGS	35.5	-2.3	16.6	-3.6	55	-17	1491	0	5	0.97	-0.91	51.6	8
SILVERTON	34.5	-9.1	12.7	1.3	52	-23	1614	0	2	1.09	-0.52	67.7	10
WOLF CREEK PASS 1	29.6	4.4	17.0	0.1	49	-11	1484	0	0	2.35	-1.38	63.0	9

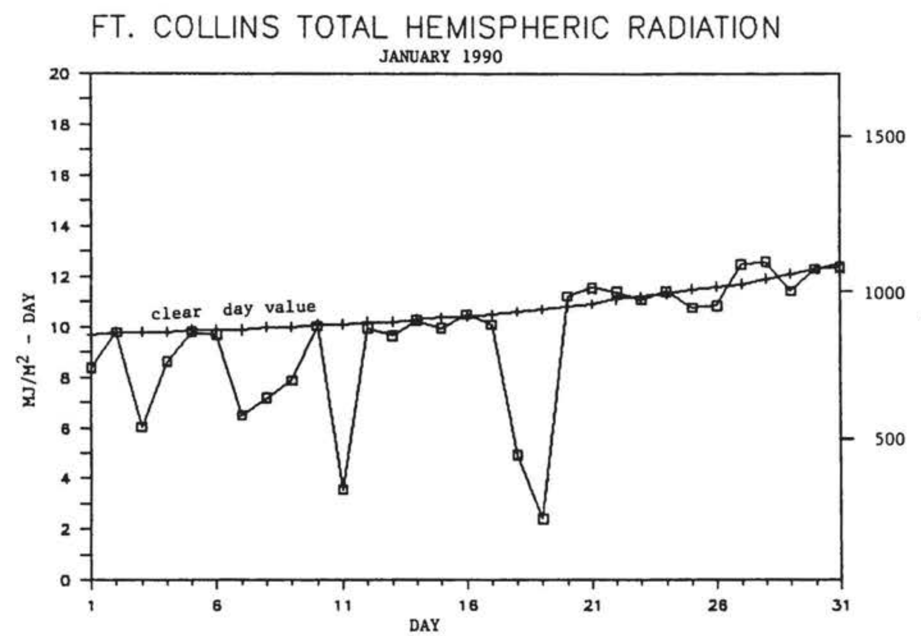
Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	34.5	9.8	22.2	5.2	50	-7	1319	0	0	0.32	-0.98	24.6	8
HAYDEN	31.5	8.6	20.1	3.8	45	-7	1385	0	0	0.59	-0.90	39.6	11
MEEKER NO. 2	39.5	14.4	27.0	4.8	56	-5	1169	0	6	0.09	-0.72	11.1	2
RANGELY 1E	39.1	12.0	25.5	9.9	53	-1	1216	0	5	0.51	-0.02	96.2	6
EAGLE FAA AP	37.9	8.7	23.3	5.2	56	-9	1286	0	8	0.13	-0.75	14.8	5
GLENWOOD SPRINGS	38.2	12.5	25.3	2.7	53	-1	1223	0	5	0.33	-1.25	20.9	9
RIFLE	41.0	11.6	26.3	5.3	56	-6	1191	0	11	0.44	-0.46	48.9	7
GRAND JUNCTION WS	39.1	17.9	28.5	4.8	52	4	1124	0	1	0.59	0.01	101.7	5
CEDAREDGE	43.1	16.4	29.8	4.4	57	-1	1086	0	15	0.67	-0.19	77.9	10
PAONIA 1SW	41.2	15.7	28.5	4.2	58	5	1125	0	19	0.22	-1.00	18.0	5
DELTA	43.0	11.8	27.4	2.4	59	-5	1161	0	17	0.50	0.15	142.9	2
GUNNISON	29.6	-6.3	11.6	3.3	48	-15	1647	0	0	0.41	-0.44	48.2	4
COCHETOPA CREEK	33.1	-2.0	15.6	7.0	49	-15	1525	0	0	0.46	-0.35	56.8	6
MONTROSE NO. 2	38.6	14.3	26.5	2.6	54	0	1186	0	5	0.22	-0.28	44.0	3
URAVAN	42.4	13.1	27.8	0.3	53	-2	1147	0	5	0.44	-0.56	44.0	8
NORWOOD	38.5	12.1	25.3	3.9	55	-4	1224	0	7	0.40	-0.68	37.0	4
YELLOW JACKET 2W	40.2	15.1	27.6	3.7	56	0	1153	0	8	0.78	-0.48	61.9	7
CORTEZ	41.3	9.3	25.3	0.8	60	0	1222	0	17	0.64	-0.39	62.1	4
DURANGO	37.5	9.5	23.5	-1.0	54	-5	1278	0	5	1.76	-0.04	97.8	8
IGNACIO 1N	41.5	5.1	23.3	2.6	54	-5	1286	0	6	1.38	0.01	100.7	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.

JANUARY 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	9	15	7	--	--
Denver	9	17	5	78%	72%
Fort Collins	11	16	4	--	--
Grand Junction	9	8	14	67%	58%
Pueblo	12	10	9	74%	75%



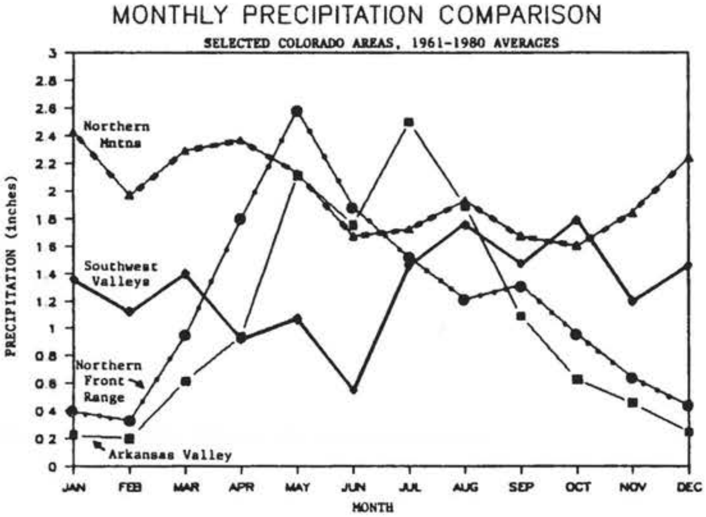
The Seasonal Distribution of Precipitation in Colorado and What That Means for Drought Recovery (or drought development): continued

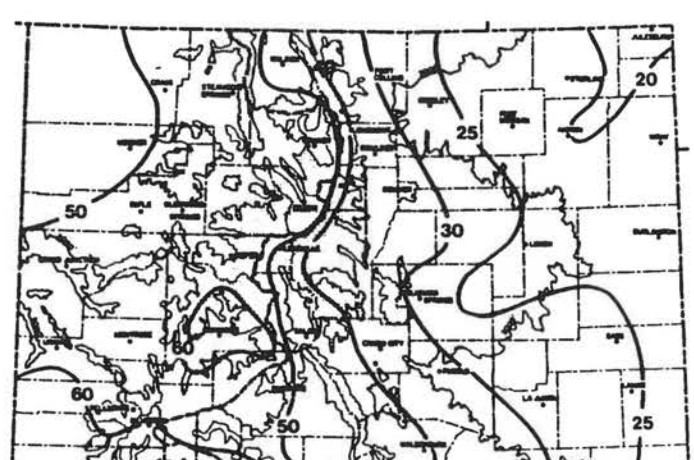
the wettest month. In May, many areas along the Front Range from Evergreen northward to Wyoming and east to Akron, and also an area near Cheyenne Wells enjoy their wettest month. June is the wettest month for a few locations in extreme eastern Colorado from Holyoke to Holly. Most of southeastern Colorado claims July as their wettest month and this extends up into South Park and parts of the San Luis Valley. The Southwest Monsoon helps make August the wettest month of the year for most of southwest Colorado and many of the mountain valleys as far north as Granby and Walden. Only 2 stations, Eagle and Glenwood Springs have their wettest month in September. October is the wettest month of the year for several locations near the Utah border. Only November and February are nobody's wettest month.

The driest times of year are a little more consistent. All areas east of the mountains tend to be dry in winter. December is the driest month of the year for just a small area east of the Continental Divide in Gilpin and Boulder counties. From Denver south to Trinidad, January is the driest month. February is the driest month from Fort Collins and Longmont out across most of the eastern plains. Spring is a period with more systematic precipitation, and no areas experience their driest time of year until June when much of the southwestern quarter of the state receives their minimum. July brings a great deal of moisture to Colorado in general, but for some areas near the northern mountains such as Hayden and Steamboat Springs, it is their driest month of the year. There are no local minimums in August or September, but in October a few northern mountain areas such as Grand Lake and Breckenridge experience their driest month. November is the driest month of the year for some adjacent lower elevation areas including Craig, Eagle and Dillon.

To help visualize these differences, look at the graph below which shows seasonal distributions of precipitation for 4 selected regions of Colorado. When considering drought -- the likelihood of going into a drought or recovering from drought -- these seasonal patterns become very important. Winter and spring precipitation in the mountains is obviously of huge importance since that is the source of most of Colorado's surface water supplies. A wet summer will never compensate for a dry winter in the mountains in terms of runoff. Likewise, you can have 300% of average precipitation east of the mountains from December to February and it won't make up for a dry April-June in terms of wheat and range conditions. The small map below describes this in a different way. Most critical moisture, both for surface water supplies and also for soil moisture and plant growth, falls from late September into June. (Summer precipitation is certainly beneficial, but the vast majority usually is quickly evaporated.) The map shows how much of this critical Oct-June moisture has already fallen by March 1 in an average year. If you are in southwestern Colorado you are already more than halfway through your climatological allotment by March 1, but in northeastern Colorado you still have 80% of your moisture season still ahead of you. Thus, if you are currently in a drought, your chances of recovery are much better where more of the expected precipitation is still ahead of you. Of course, the reverse is also true.

MONTHLY PRECIPITATION COMPARISON





HYDRO-ELECTRIC POWER

Mankind has used rivers and streams to do work for him for centuries. The old watermill used to grind grain was a common sight. With the advent of electricity, water was again put to use in the production of power. At the turn of this century, nearly half of the production of electricity in the U.S. was from turbines turned by the movement of water. Fossil fuels, being cheaper, soon took over the job of electrical production. Those fuels also allowed electricity to be produced in areas without rivers and the expansion of towns and commerce did not have to rely on the location of water. With current prices of fossil fuels increasing and concern emerging regarding the impact of burning those fuels, the circle is beginning to close as we once again look to rivers and streams to produce electricity. However, the old watermill will not make a comeback. New technology allows greater efficiency and streamlined production. Hyrdro-electric plants can produce thousands of kilowatts of electricty or micro-hydro-systems can produce from one to 100 kilowatts.

The city of Boulder's hydro facilities are examples of larger scale hydroelectric production. The situation here is a marvelous blending of usage of water. The water supply for the city is high in the mountains. Barker Reservoir, located approximately 3000 feet above Boulder near Nederland, is one location where water is stored prior to being piped down to Boulder. Until recently, this energy potential of the water behind Barker Dam was being thrown away by using energy-disapating valves. Between March 1985 and December 1987, 5 hydro-electric facilities were brought on line and are using this excess energy to produce electricity. The water continues to be used by the city for all the original purposes, yet it also creates clean energy which is sold to the Public Service Company and benefits all Boulderites. Small-scale hydro can be found on many homesites in the mountains. The production and consumption of electricity on site has major economic benefits for people who are located far from electrical grids.

The two components of power production are flow and head. Flow in a stream is the measure in cubic feet per second of how much water passes a spot in a specific time. Head is the vertical drop of the stream. The unit of head is in feet and can be thought of as the potential power in the water. As water flows downstream, it can be diverted into a pipe which runs into a nozzle. This nozzle creates high velocity. By placing a turbine into the path of the high velocity stream, the water turns the turbine whose rotating axis is attached to a generator thereby creating electricity. The efficiencies of small-scale-hydro can vary from 25 to 80 percent depending on the type of turbine or water wheel used and how the power is transmitted.

Hydropower plants are clean sources of energy which can be installed into existing water piplines or constructed in a stand alone environment. Hydropower can possibly supply all of the electricity consumed by a household. However, in many micro-hydro cases, the supply of water from the nearby stream is variable with the seasons and the year. The knowledge of annual flow along with possible lows and dry years allows for proper sizing of the equipment to assure high efficiencies.

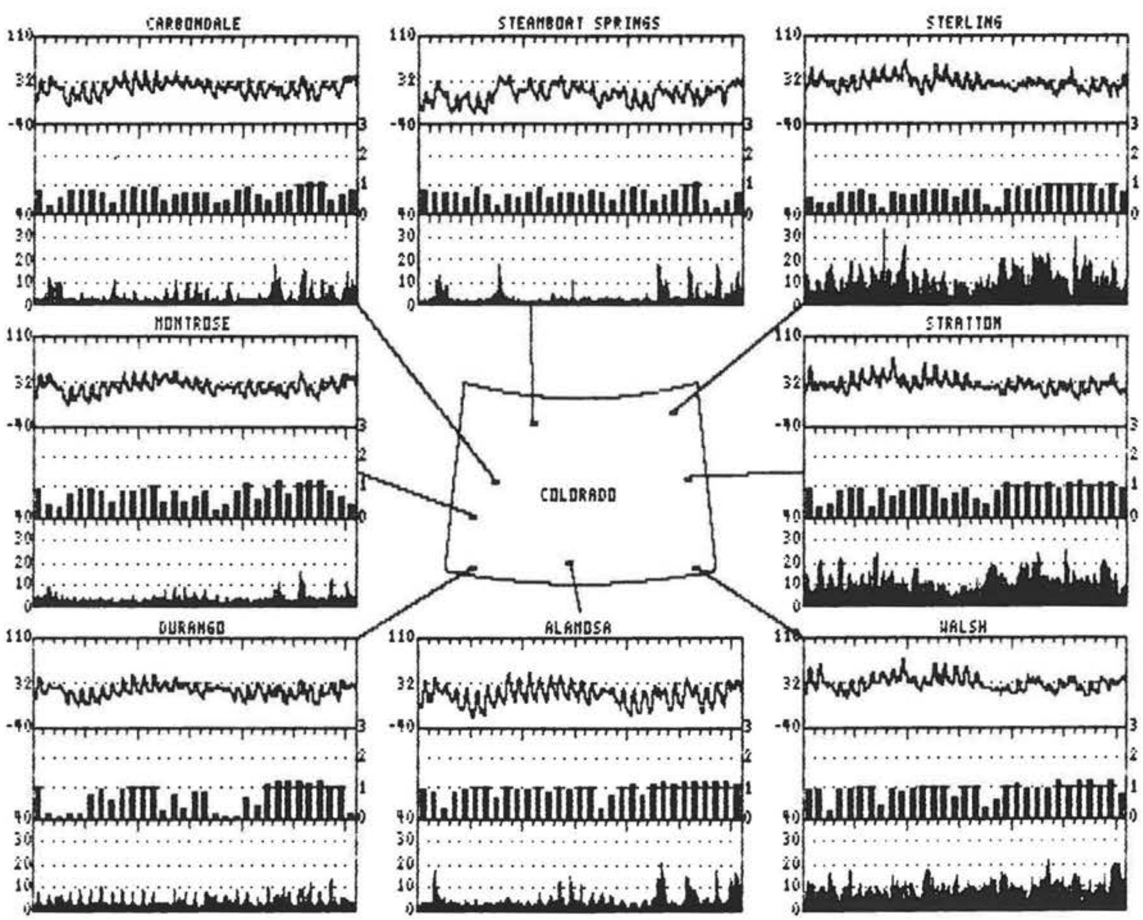
This paper was written by Mary Sutter of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder, CO 80309-0428. Monthly data from the stations shown on our summary can be purchased. Contact Mary Sutter for further information.

WTHRNET WEATHER DATA JANUARY 1990

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)								
	14.7	20.6	22.6	25.3	11.6	29.5	29.3	32.9
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	51.4 11/16	47.5 12/13	52.3 10/15	51.8 14/15	41.9 14/13	68.5 10/15	71.6 9/13	75.0 10/14
minimum:	-23.8 6/ 7	-4.7 28/ 8	-7.4 4/ 8	-4.7 4/ 6	-19.8 6/ 7	7.3 28/ 6	2.5 27/ 7	9.1 5/ 4
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	81 / -3	79 / 7	83 / 10	74 / 10	87 / 1	57 / 9	64 / 11	61 / 12
11 AM	63 / 10	63 / 15	58 / 13	56 / 16	78 / 9	43 / 13	49 / 17	45 / 17
2 PM	45 / 12	58 / 17	41 / 13	45 / 15	62 / 12	36 / 13	42 / 17	42 / 19
5 PM	45 / 10	57 / 16	44 / 12	46 / 14	70 / 11	40 / 12	47 / 14	48 / 18
11 PM	74 / 3	80 / 12	78 / 14	71 / 13	86 / 6	50 / 9	61 / 13	57 / 15
monthly average wind direction (degrees clockwise from north)								
day	187	189	242	240	165	238	196	218
night	183	70	190	165	134	263	237	261
monthly average wind speed (miles per hour)								
	3.77	3.13	3.07	3.11	2.87	10.03	9.98	8.36
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	434	468	517	441	562	42	12	17
3 to 12	267	273	217	300	160	463	539	611
12 to 24	43	3	10	3	22	234	190	116
> 24	0	0	0	0	0	5	3	0
monthly average daily total insolation (Btu/ft²·day)								
	970	697	740	775	704	740	869	931
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	196	106	116	111	93	134	170	194
40-60%	70	40	59	62	81	66	49	57
20-40%	19	37	82	67	74	45	51	41
0-20%	16	92	23	27	22	39	12	16

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

FEBRUARY 1990

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 13 Number 5

February in Review:

When compared to average, February 1990 was unusually cool and snowy in southeastern Colorado, cool and dry over northeastern Colorado, near average along the Front Range, drier and warmer than usual in most mountain areas and quite close to average in extreme western Colorado.

Colorado's April Climate:

April leaves no doubt that spring has arrived -- warm, sunny days, melting snows, brisk winds, billowing clouds, lengthening days and occasional showers with a few peels of thunder. But also remember that springtime in the Rockies can mean abrupt changes, heavy snows, a few strong thunderstorms and sometimes lengthy episodes of cloudy, dreary weather.

April temperatures normally warm noticeably but erratically through the month typically ending up about 10 degrees ahead of where they started. For the month as a whole, lower elevation (below 7,500 feet) temperatures average in the 50s and 60s during the day with 30s at night. Be ready to enjoy a few days in the 70s with even a few 80s (most likely in SE Colorado). But also don't be disappointed by a few days that stay in the 30s and 40s. Except near Grand Junction, farmers and gardeners can expect periodic nighttime freezes all the way through April. Mountain temperatures have a much harder time warming up. Daytime temperatures usually rise well above the freezing point but subfreezing temperatures are normal at night. Some mountain valleys may even dip to zero or below, but that becomes rare by mid-month.

April is another very important month for Colorado's water resources. Precipitation is normally quite abundant, and river levels begin to rise as mountain snowpack begins to melt. Most years, April snowmelt is slow and sporadic and mountain snowpack above 10,000 feet reaches its maximum for the year. But in unusually warm and dry springs (like last year) much melting can occur. April is often the wettest month of the year in parts of the central mountains. Mountain areas can expect 2-5" of moisture. Totals east of the mountains average between 1-2" but can be higher. April precipitation west of the mountains averages between 0.75" and 1.5". At lower elevations, most April precipitation falls as rain, but above 6,500 feet snow predominates. Snowfall averages just 1-3" in the western valleys and southeastern plains but increases to 6-12" along the Front Range and 2-3 feet in the mountains and eastern foothills.

Colorado Climate and Science Fair Projects:

I regret to say that when I went to school in the 1950s and 60s we had no science fairs. Had I had the chance, I assure you that even in 3rd grade I would have done a climate project. The first science fair I ever visited was here in Colorado when I was invited to serve as a judge. I loved what I saw -- enthusiastic kids, crayons and cardboard, hypotheses and conclusions (not always correct). Obviously some projects had been done primarily by parents. Others had the authentic look of a true kid's science project -- simple, sloppy but sincere.

(continued on Page -9-)

FEBRUARY 1990 DAILY WEATHER

Date	Event
1-2	An arctic air mass settled down over the Great Plains as a weak upper level low over New Mexico merged with an approaching disturbance. A period of heavy snow ensued over the southwest mountains with only light precipitation over the rest of the mountains and southern Front Range. Wolf Creek Pass received 23" of snow (1.35" moisture).
3-7	Sunny and cold on the 3rd with subzero temperatures at many locations in the mountains. Then partly cloudy and warmer on the 4th. Temperatures remained cold on the 5th as an upper level low pressure area moved across southern Colorado. Almost no precipitation fell, however. Mostly sunny on the 6th, then warmer with increasing clouds on the 7th.
8-9	A storm progressed quickly across Colorado. A burst of moderate snow early on the 8th left 3" of new snow at Montrose, 6" at Rifle and 7" at Aspen. Blustery, cold weather followed with intermittent mountain snows. Subzero temperatures were again common in the mountains early on the 9th.
10-12	Strong winds on the 10th along the Front Range marked the beginning of a brief episode of unusual warmth, especially east of the mountains. Low elevation temperatures east of the mountains reached into the 60s on the 11th and soared into the 70s in parts of southeast Colorado on the 12th. The 76° reading at Las Animas was the warmest in the state.
13-16	Eastern Colorado experienced a sudden return to winter as polar air wedged quickly southward early on the 13th. Also a Pacific storm approached from the west. Light upslope snows fell along the Front Range 13-14th and diminished 15th. Denver and Colorado Springs each measured about 4" of new snow, but Canon City and Fort Collins reported 11" and 14" of new fluffy snow, respectively. It stayed warm on the west slope on the 13th, but heavy snows developed as cold air spilled southward. Craig was pleasantly surprised by 18" of snow and Wolf Creek Pass added 20". As skies cleared, very cold temperatures were noted on the 16th. Cortez (-11°F) and Meeker (-13°F) reported their coldest readings of the winter. Taylor Park Reservoir's -32° was the coldest in the State.
17-21	A new storm already began forming over the western U.S. A low pressure trough swung through Colorado on the 17th with moderating temperature and a period of strong winds and blowing snow. As the storm organized on the 18th, cool and unsettled weather was noted over much of western Colorado with heavy snows in some southwestern areas. Crested Butte, long overdue for a heavy snow, received 18". The storm moved eastward, and late on the 19th snow began to dump on southeast Colorado. By the time the storm ended on the 20th, areas from Trinidad to Holly had received a foot or more of snow. The northeastern plains only had a light dusting. Some dense fog formed overnight 20-21st.
22-26	A few snowshowers on the 22nd in the northern mountains. Otherwise it was a dry period with a warming trend interrupted briefly on the 25th by an intrusion of cooler air onto the eastern plains.
27-28	Cool, damp air was pushed up against the Front Range by easterly winds as a weak upper level low pressure area moved across southern Colorado. Flurries and freezing drizzle made driving hazardous along the Front Range. Some pockets of moderate snow fell in the mountains, primarily south, and some quite heavy snows fell on parts of the southeast plains. Pueblo and Trinidad got 1-2" of snow, but Holly measured 8" and Lamar was bombed by a foot. For Lamar, this was their third 12" plus storm since January 19th.

February 1990 Extremes

Highest Temperature	76°F	February 12	Las Animas
Lowest Temperature	-32°F	February 16	Taylor Park Dam
Greatest Total Precipitation	5.01"		Wolf Creek Pass 1E
Least Total Precipitation	0.01"		Fort Morgan
Greatest Total Snowfall*	82"		Wolf Creek Pass 1E
Greatest Snowdepth**	61"		Rabbit Ears Pass

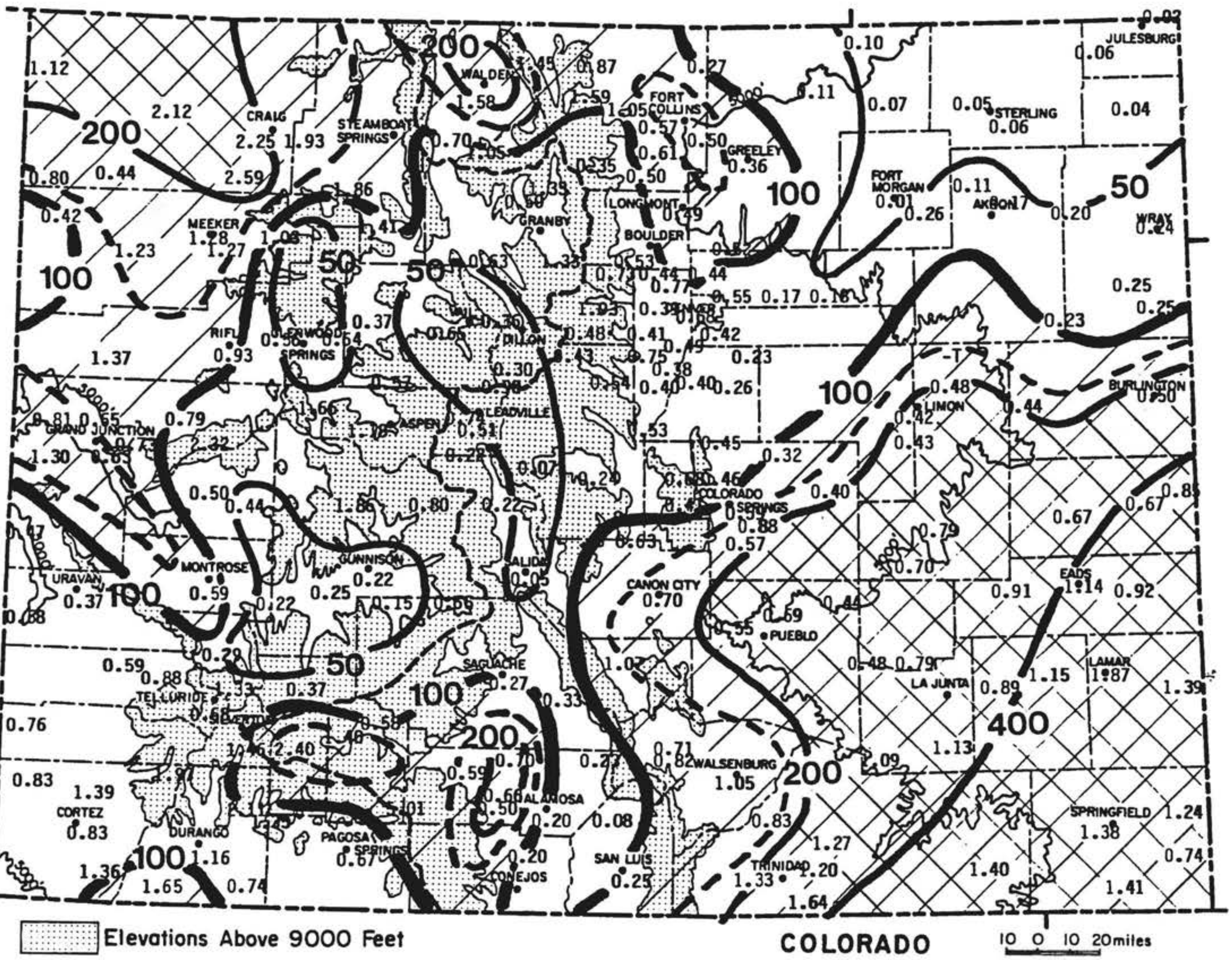
* For existing weather stations with complete daily records. Higher values are likely for unmonitored locations.

** From Soil Conservation Service snowpack measurements.

FEBRUARY 1990 PRECIPITATION

A procession of storm systems in February contributed beneficially to the winter snowpack but did not affect all areas of Colorado. Above average precipitation was noted in northwestern and west central Colorado, in parts of the San Juan mountains and Rio Grande Valley, along the northern Front Range and over most of the southeast quarter of the state. Lamar totalled 1.87" of moisture for February -- the 3rd wettest in 102 years of record. Unfortunately, much of the mountains were considerably drier than average including the upper Colorado basin upstream from Glenwood Springs, the Gunnison basin and the upper Arkansas. An interesting contrast was also evident on the eastern plains. While the southeast was enjoying one of the wettest February's on record, the northeastern plains were very dry. From Holyoke and Julesburg to Fort Morgan less than 0.10" of moisture fell.

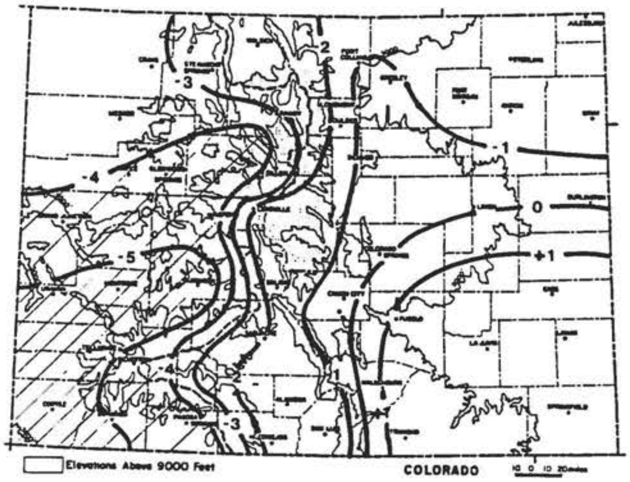
Greatest		Least	
Wolf Creek Pass 1E	5.01"	Fort Morgan	0.01"
Hamilton	2.59"	Julesburg	0.02"
Rio Grande Reservoir	2.40"	Holyoke	0.04"
Bonham Reservoir	2.32"	Salida	0.05"
Craig 4SW	2.25"	Sterling	0.05"



Precipitation amounts (inches) for February 1990 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

Colorado's eastern plains have shown marked improvement in moisture conditions over the last two months. Some of the San Juan mountain area also improved from earlier precarious conditions. Still, the majority of Colorado continues to be considerably drier than average 5 months into the 1990 water year. Palmer index values of less then -4 in southwestern Colorado suggest that extreme drought conditions are still prevalent with very short soil moisture supplies. While not looking favorable, surface water supplies in western Colorado are considerably ahead of where they were at this point in 1977.

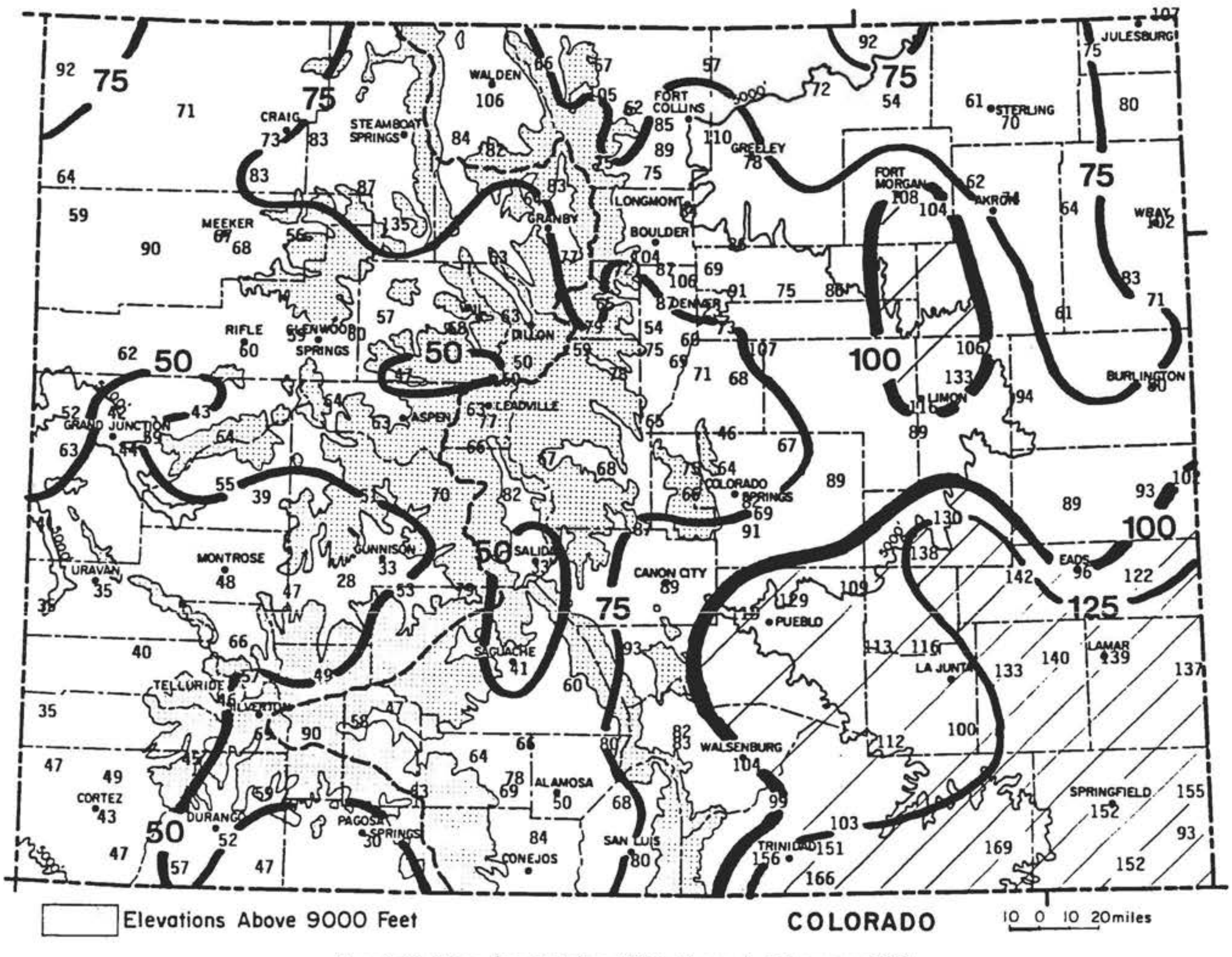


PALMER INDEX:

The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

Interpretation of Index

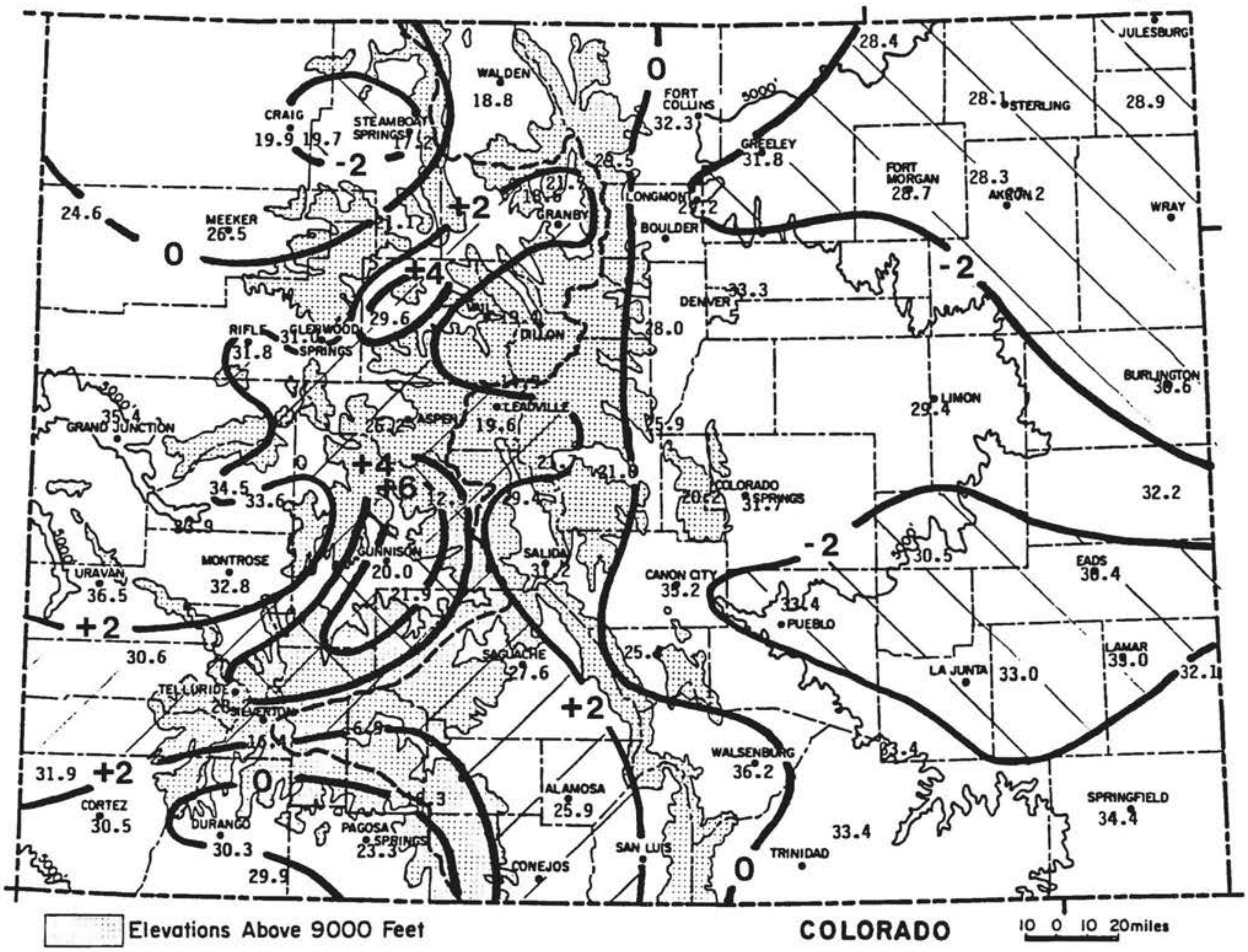
	extremely wet
+4	----------------
+3	ample moisture
+2	----------------
+1	
0	near normal
-1	
-2	----------------
	moderate drought
-3	----------------
	severe drought
-4	----------------
	extreme drought



Precipitation for October 1989 through February 1990
as a percent of the 1961-1980 average.

FEBRUARY 1990 TEMPERATURES AND DEGREE DAYS

The month of February produced cooler than average temperatures east of the mountains and near average temperatures along the Front Range. While the mountains and Western Slope were predominately warmer than average, the most unusual temperatures were found in the upper Gunnison valley with three stations more than 6 degrees above average. Warm weather has become the rule in western Colorado of late. Ten of the past 12 months have been above average over most of western Colorado.



February 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

FEBRUARY 1990 SOIL TEMPERATURES

Mid-month snow cover held soil temperatures steady through most of February. No deep frost penetration was noted this year, and by the end of February the ground was thawed at all 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.

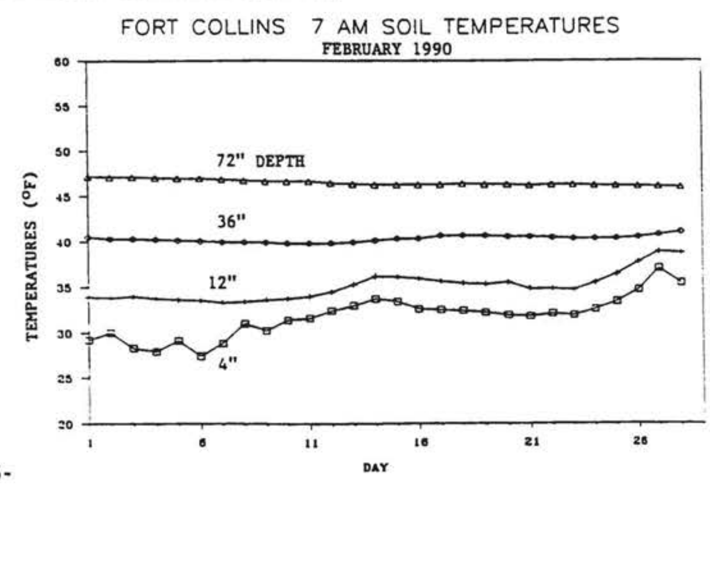


Table 1. Heating Degree Day Data through February 1990 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001	1400	1554	1089					5023
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974	1365	1365	1086					4922
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M	M	M	M					M
BUENA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
VISTA	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812	1202	1184	991					4247
BURLING-	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
TON	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684	1229	990	957					M
CANON	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
CITY	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584	1076	859	827					3029
COLORADO	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
SPRINGS	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699	1163	966	928					3477
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850	1166	1222	959					3890
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892	1420	1319	1257					4502
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M	M	1161	865					M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658	1160	879	882					3274
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124	1495	1506	1271					6071
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789	1133	1278	965					4812
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896	1348	1286	986					4401
EVER-	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
GREEN	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818	1221	1115	1030					4303
FORT	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
COLLINS	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711	1166	930	910					3437
FORT	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
MORGAN	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721	1285	1087	1010					3667
GRAND	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
JUNCTION	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729	1103	1124	820					3312

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

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

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
LAKE	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132	1449	1401	1205					5651
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729	1230	985	922					3567
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069	1574	1647	1254					5596
LAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
ANIMAS	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684	1176	1030	887					3312
LEAD-	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
VILLE	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138	1507	1499	1265					6266
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762	1252	1078	991					3811
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749	1302	1048	994					3793
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869	1261	1169	1071					4081
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768	1156	1186	895					3669
PAGOSA	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
SPRINGS	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964	1298	1491	1160					4825
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676	1204	964	877					3311
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M	1130	1191	923					M
STEAMBOAT	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
SPRINGS	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974	1533	1580	1332					M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719	1254	1074	1026					M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869	1264	1273	1023					4567
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633	1153	980	874					3247
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075	1490	1359	1287					5598
WALSEN-	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
BURG	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581	1047	848	105					2940

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

FEBRUARY 1990 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	41.4	15.5	28.4	-2.2	62	-15	1016	0	30	0.10	-0.03	76.9	3
STERLING	40.5	15.6	28.1	-2.8	60	-8	1026	0	21	0.05	-0.12	29.4	2
FORT MORGAN	41.4	16.0	28.7	-2.2	56	-12	1010	0	21	0.01	-0.13	7.1	1
AKRON FAA AP	38.8	17.9	28.3	-2.6	56	-4	1018	0	16	0.11	-0.07	61.1	3
AKRON 4E	38.4	16.0	27.2	-2.0	57	-5	1051	0	17	0.17	-0.04	81.0	5
HOLYOKE	40.2	17.5	28.9	-3.7	61	1	1003	0	22	0.04	-0.30	11.8	2
BURLINGTON	40.2	20.9	30.6	-4.0	61	7	957	0	24	0.50	0.30	250.0	1
LIMON WSMO	40.7	18.1	29.4	-1.7	63	-1	991	0	22	0.42	0.24	233.3	4
CHEYENNE WELLS	44.3	20.2	32.2	-1.3	63	4	908	0	34	0.67	0.51	418.7	2
EADS	42.8	17.9	30.4	-4.3	65	4	963	0	35	1.14	0.91	495.7	3
ORDWAY 21N	44.3	16.6	30.5	-2.9	71	-5	959	0	45	0.70	0.49	333.3	3
LAMAR	46.4	19.6	33.0	-2.5	68	7	888	0	50	1.87	1.58	644.8	3
LAS ANIMAS	46.5	19.5	33.0	-3.3	76	2	887	0	61	0.89	0.63	342.3	3
HOLLY	44.6	19.6	32.1	-1.6	68	6	915	0	44	1.39	1.13	534.6	3
SPRINGFIELD 7WSW	46.9	21.9	34.4	-1.4	74	-1	849	0	62	1.38	1.05	418.2	4
TIMPAS 13SW	46.7	20.2	33.4	-1.4	73	-3	877	0	64	1.09	0.70	279.5	3

Foothills/Adjacent Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	45.2	19.3	32.3	-0.2	67	-5	910	0	41	0.57	0.20	154.1	6
GREELEY UNC	44.3	19.3	31.8	-2.0	61	-11	922	0	33	0.36	0.08	128.6	5
ESTES PARK	39.6	19.4	29.5	0.1	56	-10	988	0	11	0.39	0.01	102.6	5
LONGMONT 2ESE	44.6	13.9	29.2	-2.7	68	-20	994	0	40	0.49	0.12	132.4	4
DENVER WSFO AP	45.2	21.3	33.3	-0.4	66	-4	882	0	43	0.55	-0.03	94.8	8
EVERGREEN	43.3	12.7	28.0	-1.0	64	-6	1030	0	31	0.41	-0.35	53.9	6
CHEESMAN	45.1	6.6	25.9	-3.3	62	-11	1091	0	32	0.53	-0.04	93.0	5
LAKE GEORGE 8SW	37.6	4.4	21.0	1.3	51	-10	1225	0	4	0.24	-0.07	77.4	4
ANTERO RESERVOIR	38.0	5.3	21.7	4.4	53	-15	1206	0	6	0.07	-0.16	30.4	3
RUXTON PARK	33.6	6.8	20.2	-1.8	52	-10	1247	0	1	0.41	-0.48	46.1	6
COLORADO SPRINGS	43.7	19.7	31.7	-0.8	67	-5	928	0	36	0.59	0.29	196.7	5
CANON CITY 2SE	49.1	21.3	35.2	-2.0	69	-8	827	0	74	0.70	0.28	166.7	5
PUEBLO WSO AP	48.1	18.6	33.4	-2.0	72	-6	877	0	54	0.69	0.44	276.0	6
WESTCLIFFE	41.2	9.6	25.4	-0.3	55	-18	1102	0	10	1.07	0.50	187.7	4
WALSENBURG	48.8	23.7	36.2	0.7	69	-6	800	0	62	1.05	0.23	128.0	5
TRINIDAD FAA AP	47.6	19.2	33.4	-1.6	72	-7	874	0	55	1.27	0.86	309.8	6

Mountains/Interior Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	32.7	4.9	18.8	0.4	48	-18	1287	0	0	1.58	1.12	343.5	8
LEADVILLE 2SW	34.3	4.9	19.6	3.1	48	-14	1265	0	0	0.51	-0.49	51.0	7
SALIDA	45.6	16.7	31.2	1.0	62	-3	941	0	31	0.05	-0.59	7.8	2
BUENA VISTA	42.4	16.3	29.4	0.7	57	-5	991	0	20	0.22	-0.13	62.9	3
SAGUACHE	43.8	11.5	27.6	2.7	57	-8	1040	0	14	0.27	0.01	103.8	2
HERMIT 7ESE	31.5	2.3	16.9	2.4	39	-24	1341	0	0	1.40	0.68	194.4	3
ALAMOSA WSO AP	44.2	7.5	25.9	3.5	59	-9	1089	0	18	0.20	-0.10	66.7	5
STEAMBOAT SPRINGS	31.1	3.3	17.2	-2.3	44	-14	1332	0	0	1.80	-0.24	88.2	11
YAMPA	33.4	8.8	21.1	0.7	46	-14	1222	0	0	1.41	0.54	162.1	7
GRAND LAKE 1NW	37.9	5.5	21.7	3.6	48	-8	1205	0	0	1.33	-0.07	95.0	13
GRAND LAKE 6SSW	33.0	4.2	18.6	2.5	51	-15	1293	0	1	0.50	-0.31	61.7	11
DILLON 1E	34.1	4.6	19.4	0.9	46	-9	1271	0	0	0.36	-0.53	40.4	7
CLIMAX	28.2	1.6	14.9	0.0	44	-18	1397	0	0	0.90	-0.94	48.9	10
ASPEN 1SW	39.9	12.5	26.2	3.5	53	-6	1086	0	5	1.18	-0.92	56.2	8
TAYLOR PARK	31.9	-6.1	12.9	6.9	42	-32	1450	0	0	0.80	-0.26	75.5	6
TELLURIDE	43.5	12.9	28.2	4.2	60	-11	1023	0	17	0.68	-0.79	46.3	9
PAGOSA SPRINGS	42.4	4.3	23.3	-2.4	57	-17	1160	0	11	0.67	-0.67	50.0	7
SILVERTON	35.9	-3.2	16.4	2.5	55	-30	1356	0	7	1.46	-0.13	91.8	12
WOLF CREEK PASS 1	30.9	5.8	18.3	0.2	49	-16	1302	0	0	5.01	1.10	128.1	13

Western Valleys

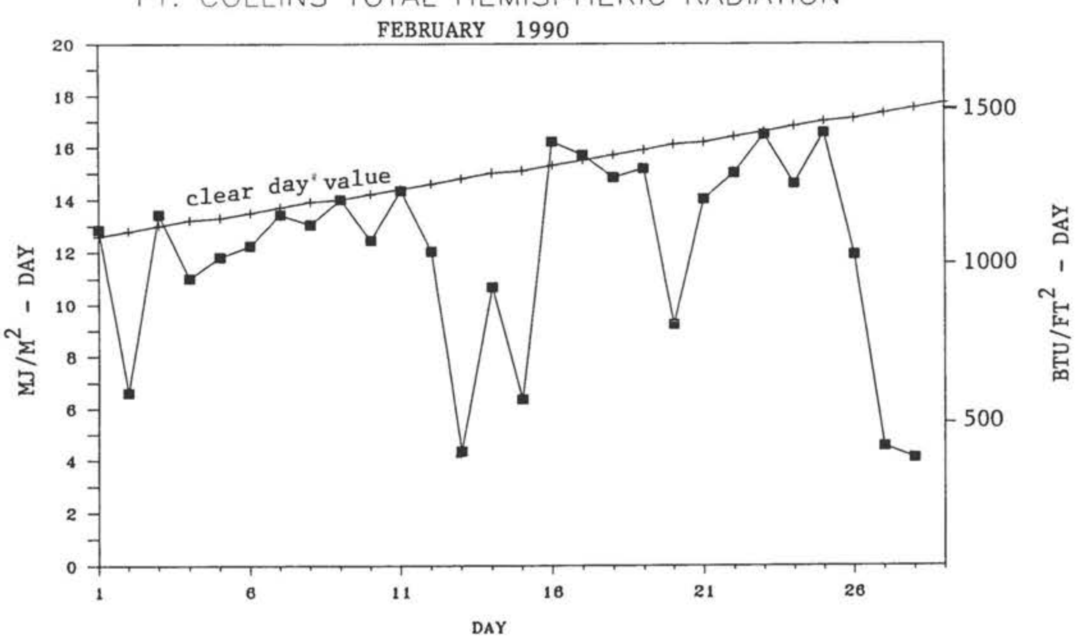
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	32.2	7.6	19.9	-2.0	47	-6	1257	0	0	2.25	1.05	187.5	7
HAYDEN	32.3	7.1	19.7	-2.0	46	-10	1262	0	0	1.93	0.78	167.8	7
MEEKER NO. 2	40.0	12.9	26.5	-1.0	55	-13	1071	0	9	1.28	0.59	185.5	6
RANGELY 1E	37.5	11.7	24.6	0.3	49	-10	1125	0	0	0.42	-0.07	85.7	6
EAGLE FAA AP	44.6	14.5	29.6	4.7	58	-5	986	0	21	0.37	-0.23	61.7	5
GLENWOOD SPRINGS	44.4	17.6	31.0	1.2	61	2	944	0	24	0.56	-0.57	49.6	5
RIFLE	46.6	17.0	31.8	2.1	65	-5	923	0	33	0.93	0.18	124.0	6
GRAND JUNCTION WS	46.6	24.2	35.4	1.4	63	4	820	0	37	0.55	0.08	117.0	5
CEDAREDGE	48.4	20.7	34.5	2.3	65	5	845	0	41	0.50	-0.32	61.0	6
PAONIA 1SW	46.3	21.0	33.6	1.7	64	1	871	0	34	0.44	-0.64	40.7	6
DELTA	51.7	16.0	33.9	0.3	67	0	865	0	68	0.13	-0.28	31.7	2
GUNNISON	38.2	1.8	20.0	6.2	50	-13	1254	0	0	0.22	-0.44	33.3	3
COCHETOPA CREEK	39.7	4.1	21.9	7.6	52	-14	1200	0	1	0.15	-0.48	23.8	2
MONTROSE NO. 2	46.6	19.0	32.8	1.3	62	-1	895	0	32	0.59	0.18	143.9	5
URAVAN	51.1	21.9	36.5	0.7	68	4	789	0	63	0.37	-0.19	66.1	4
NORWOOD	43.2	18.0	30.6	3.0	57	-4	958	0	13	0.59	-0.11	84.3	4
YELLOW JACKET 2W	43.8	20.1	31.9	2.6	58	-1	920	0	15	0.83	-0.28	74.8	10
CORTEZ	44.3	16.8	30.5	0.0	61	-11	959	0	25	0.83	-0.10	89.2	7
DURANGO	44.8	15.7	30.3	-0.6	61	-5	965	0	23	1.16	-0.22	84.1	8
IGNACIO 1N	47.4	12.4	29.9	1.9	62	-5	974	0	24	0.74	-0.20	78.7	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.

FEBRUARY 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	10	7	11	--	--
Denver	8	8	12	65%	72%
Fort Collins	7	12	9	--	--
Grand Junction	6	9	13	72%	58%
Pueblo	10	5	13	64%	75%

FT. COLLINS TOTAL HEMISPHERIC RADIATION



Colorado Climate and Science Fair Projects: continued

I was surprised, the first time I went to a local science fair, at how many weather projects there were. There were studies of clouds, pressure, wind, sunshine, climate change, acid rain, lightning, snow, etc. Even in the categories of behavioral science, biology and medicine, weather and climate crept in. There were studies of the effect of weather on people's moods, pressure changes and anger, weather and headaches, weather and the common cold, plant response to weather, plant response to climate change, animal response to weather, animal and human birth statistics related to weather patterns, etc. etc.

I really should not have been surprised, should I. We don't have to have a fancy computer with color graphics, sophisticated laboratories, parents with Ph.D.'s, and millions of dollars worth of equipment before we can appreciate science and perform experiments. All we need is a little curiosity. We already live in a marvelous laboratory where weather changes -- day to day, season to season, year to year -- affect all aspects of our lives. As adults perhaps we are too busy trying to secure control of our schedules, our lives and our environment. It becomes all too easy to close our eyes to the marvels that each new day brings. Fortunately, unless we suppress them by our own bad examples, our children are naturally curious and are thrilled and amazed by the natural world around them. The weather is something we all share in common -- and it will be with us until we die. It is a great topic to catch children's attention with and lead them to love, not fear, science.

Here at the Colorado Climate Center we do get many phone calls each year concerning science projects. For your information, here are some of our policies:

1) We do not give out science project ideas.

2) If an idea has been selected (hopefully primarily by the child) we will be happy to discuss it with you (I much rather prefer to talk with the child, not the parent).

3) If weather data are needed for your project, we may be able to help. There may be a small charge for copying and mailing materials to you.

4) We would very much like to have a copy of project reports pertaining to the climate of Colorado. We have seen numerous examples of excellent studies by elementary and secondary students that may never have been researched by anyone else. The conclusions need not match our own or be scientifically perfect for us to be interested.

5) We might be able to publish the results of one or two excellent projects each year in the Colorado Climate publication.

Winter of 1989-90 Temperature:

We have survived another winter. Temperatures for December through February ranged from 1 to 2 degrees F cooler than average over the eastern plains to a little above average along the Front Range and increased to 1 to 4 degrees above average on the Western Slope. The coldest low temperature on any date during the winter was the -38°F reading at Briggsdale on December 22. The was the coldest day of the winter for most of eastern Colorado. The coldest temperatures of the winter were all unusually mild in western Colorado. Examples include +4° at Grand Junction (a big change from the -18° that damaged fruit trees the previous year), -1°F at Glenwood Springs, -5° at Durango, -8° at Aspen, -9° at Eagle and -17° at Dillon. In terms of extreme minimums this was one of the mildest winters on record for western Colorado.

State Fair Water Display:

This year's featured educational display in the Science and Technology Pavilion at the Colorado State Fair in Pueblo (August 24-September 3, 1990) will be focusing on Colorado's precious water resources. Dozens (maybe hundreds) of water experts from many organizations are working together to make this possible. Everything from Colorado's water law to aquatic biology, from drought to flood, from transmountain diversions to modern irrigation efficiency will be included. This will be a great opportunity for adults and children alike to learn about this marvelous resource that we have. Plan on attending!

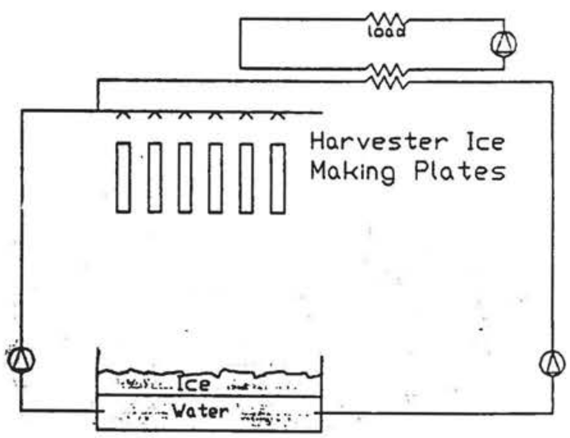
ICE STORAGE

A recent strategy for energy saving cooling systems uses the concept of thermal storage, the ability to store heating or cooling energy for later use. The concept of thermal storage for cooling has been employed for at least 70 years in the dairy industry. There are many media in use in thermal storage. A few of these include water storage, phase change material storage, and ice storage. Ice storage is currently the most frequently utilized form of cold storage in the HVAC industry. Approximately 30 manufacturers offer cold storage hardware; of these 27 are ice storage units. The remaining three are water storage systems.

The ability to decrease operating costs of a cooling system is the aim of ice storage. Much of the cost of cooling a building results from peak cooling loads (i.e. those loads that occur when the building is fully occupied and using all machinery and lighting available during a period when the outside air temperature is warm). Peak loads usually occur during the middle of the day in the cooling season, creating the greatest demand on the cooling system and on the electrical utility. The concept behind ice storage is the use of a phase change to store cooling capability. The superiority of phase change storage is shown by comparing water and ice. Water can store only 1 BTU/LB. for every Fahrenheit degree change while ice can store 144 BTU/LB. as it changes from liquid to solid. This phenomena lead to the idea of making ice during the night to cool a building during the next day. What makes the method attractive is the differences in utility expenses Generally the cost of electricity consumption during the night is less than the electricity charges during the day. With ice storage most of the electricity costs are shifted to the night rates.

Three different systems may be chosen for ice storage. The harvester system is the most popular available. This system manufactures ice by cooling "harvesting" plates to a temperature below the freezing point of water. These plates are flooded with water and form ice on the plate surfaces. The ice is "harvested" by circulating the remaining unfrozen water in the tank to the building. As the water is circulates, it absorbes heat from the building spaces and cools the building. The warmed water is then returned to the tank and sprayed over the plates to melt the remaining ice and become cool again.

Harvester Ice Storage System



Economics is the driving force behind the use of ice storage. The savings from electricity demand charges are the initial attraction. Utilities may also supplement these savings with cash incentives. Utilities may pay from $150 to $350 for each kilowatt avoided by the installation of an energy saving HVAC system. Utilities are offering incentives because of the looming costs of building new nuclear and coal power plants to meet future peak loads. Government policies, interest rates, construction costs and insurance are making construction of new generating facilities impractical. The use of ice storage helps level the demand on the utilities, increasing the use of stagnant night generated energy and reduce peak demand. This trend is also evident in Europe, where the incentives are replaced by restrictions on the kilowatts allowed per square meter of new building construction. The restrictions are such that ice storage becomes very appealing.

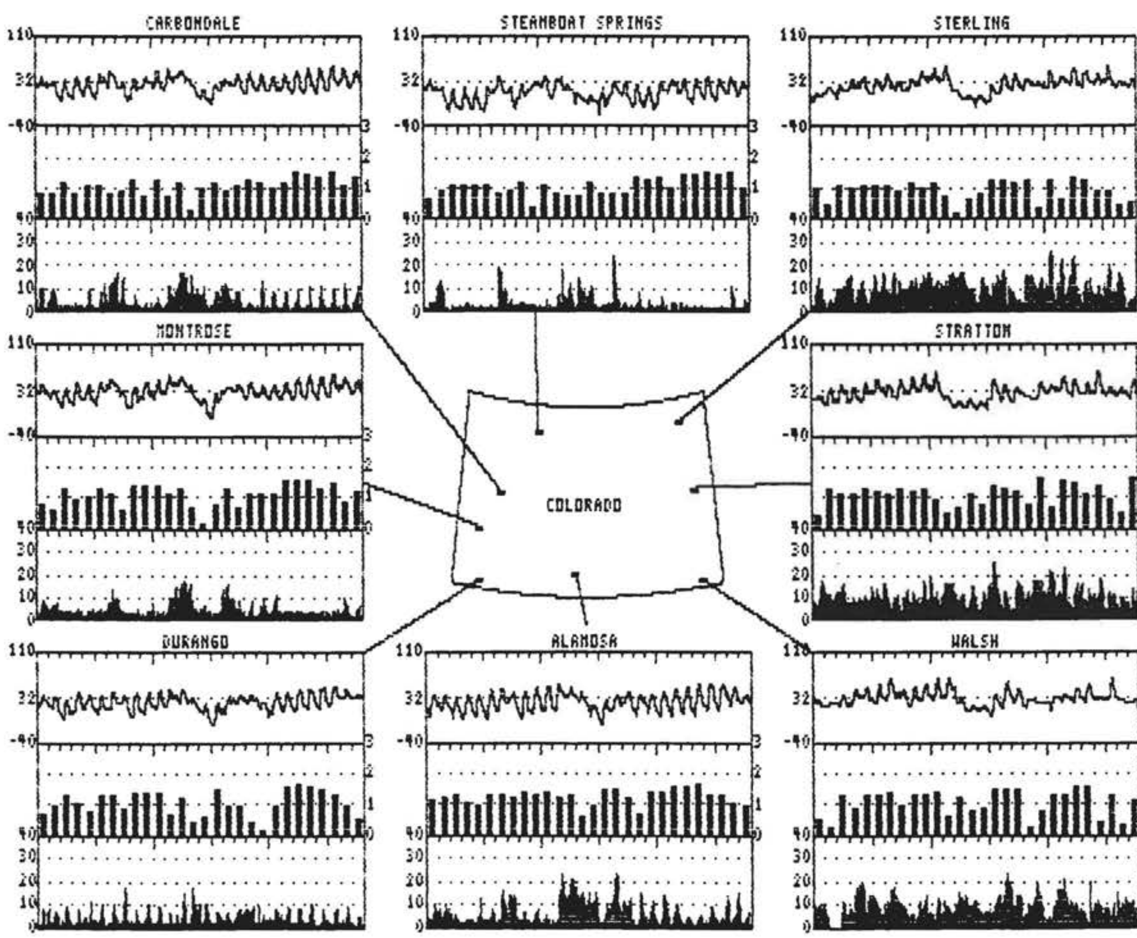
Ice Storage has so many positive effects that may be commonplace in the future. The savings in utility costs, reduction of equipment size, utility incentives, and system reliability make ice storage an effective energy saving air cooling system. Currently ice storage systems are being utilized in large buildings. The concept is also applicable for homes but economic factors prevent it from being widely used at this time. Efforts are being made to decrease the initial costs of an ice storage system for the home and allow this innovation to be introduced to all applications.

This paper was written by Rob Deevy of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder , CO 80309-0428. Monthly data from stations shown in our summary can be purchased. Contact Mary Sutter at the above address for further information.

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)	26.3	26.0	29.2	31.7	15.4	27.7	29.9	32.4
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	58.3 12/13	52.5 26/15	58.6 26/15	60.6 26/16	43.0 11/13	61.0 12/14	63.3 11/14	66.2 12/16
minimum:	-10.3 16/ 6	-10.8 16/ 7	-2.0 16/ 6	-11.6 16/ 5	-20.9 16/ 7	-8.0 15/ 3	3.6 15/ 3	5.0 16/ 5
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	76 / 6	81 / 12	81 / 15	71 / 14	91 / 5	65 / 12	79 / 16	75 / 18
11 AM	43 / 13	53 / 17	49 / 15	48 / 18	73 / 13	50 / 15	54 / 20	55 / 20
2 PM	32 / 12	50 / 19	34 / 14	38 / 17	57 / 14	47 / 16	46 / 19	47 / 19
5 PM	31 / 10	50 / 18	34 / 13	37 / 15	62 / 14	48 / 15	51 / 18	50 / 19
11 PM	58 / 9	76 / 15	69 / 15	63 / 15	91 / 10	64 / 13	73 / 19	71 / 19
monthly average wind direction (degrees clockwise from north)								
day	199	207	253	242	183	188	168	155
night	177	91	194	164	143	221	205	206
monthly average wind speed (miles per hour)	5.49	3.45	4.09	4.16	2.89	9.62	9.84	8.06
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	274	400	373	321	491	41	7	64
3 to 12	313	262	268	320	159	438	490	496
12 to 24	85	10	31	31	21	190	173	112
> 24	0	0	0	0	1	3	2	0
monthly average daily total insolation ($Btu/ft^2 \cdot day$)	1242	1045	1082	1085	1062	940	1097	1050
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	191	79	136	116	116	123	121	131
40-60%	51	49	76	60	71	61	54	55
20-40%	34	61	57	55	49	56	53	54
0-20%	10	61	22	34	27	38	20	40

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 $Btu/ft^2/day$, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

MARCH 1990

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 13 Number 6

March in Review:

A potent storm in early March brought drought relief in the form of rain, thunderstorms and heavy, wet snow to several parts of Colorado. The remainder of the month produced a normal variety of springlike weather but with an unusual abundance of cloudcover. The month ended up wetter than average over most of the state with near average temperatures east of the mountains and warm temperatures west. Unfortunately, some of the driest areas of western Colorado again missed the brunt of the March storms.

Colorado's May Climate:

May is a lovely month in many ways. Leafing trees, emerging crops, blooming lilacs, tumbling streams all are proof that spring has arrived. But for those who crave constant sunshine and warm temperatures, you'll just have to wait a few more weeks or travel to southwestern Colorado. For much of eastern Colorado May is a month of high humidity, moderate winds, frequent rains, some severe storms, a few frosts and plenty of clouds. Snows still occur with some reliability in the northern and central mountains. Every few years a storm may even spread snow down to the lower elevations. With warmer temperatures beginning to reach into the high country, the snowmelt also accelerates. With lower than average snowpack this year, water users will be very attentive to this year's runoff.

May precipitation patterns are quite different than at other times of the year. For one month of the year, the climate of northeastern Colorado seems more like the Midwest than the Great Plains. The wettest areas of the state in May are normally found on the northeastern plains, along the northern Front Range and in isolated high mountain locations from Aspen northward. In these areas, precipitation averages 2.50" to 3.50". Southeastern Colorado averages between 1.25" and 2.60". Decent moisture can fall in the southern mountains but it is not reliable from year to year. May averages are mostly 1-2" in the southern mountains and the northern valleys. The driest areas of the state are typically the San Luis Valley, the upper Gunnison Valley and other low elevation areas of southwest Colorado where averages are generally 0.50" to 1.00". These are the same areas that could most benefit from extra moisture this year. May storms have the potential for producing 3" or more of rainfall in 24 hours over portions of eastern Colorado. This means flooding can be a possibility even in low snowpack years. Also be on the lookout for hail. Small hail is quite common in eastern Colorado and by late May, larger damaging hail becomes a good possibility. A few tornadoes should also be expected.

Despite some cloudy, chilly days, most days in May should feel pretty nice. The mountains will see mostly 40s and 50s during the day with 20s at night. Most low elevation areas reach the 70s during the day with 40s at night. A few heatwaves can be expected where 80s and maybe even a few 90s occur. During these heatwaves high water from mountain snowmelt can also be anticipated.

Climate Change on the Great Plains?

I have written about global warming and climate change before -- and it is not my favorite topic. Almost everything we hear is speculative. There are many other things that I can report on factually that are not only interesting but can be helpful in design, operations and planning -- record snowstorms, flood-producing rainfalls, hail probabilities, drought, etc., etc. But the steady media bombardment of stories about global warming and climate change make me feel obligated to respond.

(continued on Page -9-)

MARCH 1990 DAILY WEATHER

Date	Event
1-4	The jet stream split north and south of Colorado leaving Colorado with mild temperatures and light winds aloft. Dry weather prevailed except for a disturbance which crossed the state late on the 3rd. Wet snows fell in many mountain areas (generally 1-5"), and Steamboat Springs picked up 0.54" of moisture. A few light rainshowers dampened the lower elevations.
5-8	A major storm developed rapidly over the Great Basin on the 5th. Most of Colorado was quite warm ahead of the storm (Grand Junction reached 62° on the 5th). But much colder air snuck into northeastern Colorado during the morning and pushed slowly southward. Thunderstorms (unusual for this time of year) erupted along the Front Range late on the 5th and spread northeastward. There were many reports of hail, and there was apparently even a small tornado near Elbert. By morning, temperatures had dropped over much of the state and a deep low pressure was centered over southern Colorado. Rains changed to snow in some areas and a severe snowstorm developed along the Sangre de Cristo Mountains and along the Front Range. The heaviest precipitation fell in a 36-hour period from late afternoon on the 5th into the morning of the 7th. Storm totals were generally less than 0.50" of water equivalent in western and southern Colorado except for portions of the San Juan Mountains (Telluride picked up 27" of snow and Wolf Creek Pass 22") and the west side of the Sangre de Cristo Mountains (Crestone reported 19" of snowfall. The heaviest precipitation fell north of Colorado Springs to southern Wyoming and ranged from 1.01" (4" snow) at Colorado Springs to more than 5" of moisture and 50"+ of snow in the foothills of Larimer County. 4.17" fell on Fort Collins (17" snow) with 3.48" falling in 24 hours. The snow was so dense along the Front Range that snowplows bogged down and many trees and powerlines (and even a few roofs) were damaged. Temperatures remained cold on the 7th with little melting. A warmup then started on the 8th although a few areas near Fort Collins and Greeley stayed in the 30s with fog.
9-16	A large low pressure trough over the western U.S. kept Colorado's weather unsettled. One disturbance triggered rain and snow showers in southwest Colorado on the 10th which spread northeastward 11-12th. Then a larger storm system tracked methodically across Colorado 12th-15th bringing sharply colder temperatures with more widespread light to moderate snows from the Utah border to the Front Range. The Denver area received 4-9" of melting snow on the 13th. Six consecutive days with fresh snow in parts of the southern and central mountains raised the morale of springbreak skiers. As the trough moved overhead on the 14th, subzero temperatures greeted many folks in the mountains. Antero Reservoir dipped to -17°F, the coldest in the State this March. Skies began to clear 15-16th, but strong northwesterly winds behind the trough kept a chill in the air.
17-22	Springlike weather finally arrived but was briefly interrupted 17-18th by another weak disturbance crossing northern and eastern parts of the State. But beginning on the 19th, temperatures began to approach the 70° mark with mountain temperatures near 50°. Some showers and wind gusts darted across northern Colorado on the 21st, but most of Colorado enjoyed a lovely warm day. Holly hit 81° on the 21st to claim the State's hot spot award for the month.
22-26	Dry, warm weather continued in western Colorado, but the picture was much different east of the mountains. A shallow, very cold air mass slipped into Colorado from the north late on the 22nd dropping temperatures by about 40 degrees. Fog, low clouds, light snow and freezing drizzle developed 23-24th making travel hazardous as temperatures stayed in the teens and 20s (compared to 60s and 70s on the Western Slope).
27-31	Pleasantly warm on the 27th but then a large but diffuse storm system spread low clouds, cool temperatures and rain and snow over the whole state for the rest of the month. Moisture was welcomed in southwestern Colorado as several areas received more than 1" of water content (21" of snow at Wolf Creek Pass). The Front Range, eastern plains and parts of west central Colorado also received well over 0.50". Skies cleared on the 31st.

March 1990 Extremes

Highest Temperature	81°F	March 21	Holly
Lowest Temperature	-17°F	March 14	Antero Reservoir
Greatest Total Precipitation	7.01"		Buckhorn Mountain 1E
Least Total Precipitation	0.20"		Monte Vista Refuge
Greatest Total Snowfall*	90"		Wolf Creek Pass 1E
Greatest Snowdepth**	85"		Cameron Pass

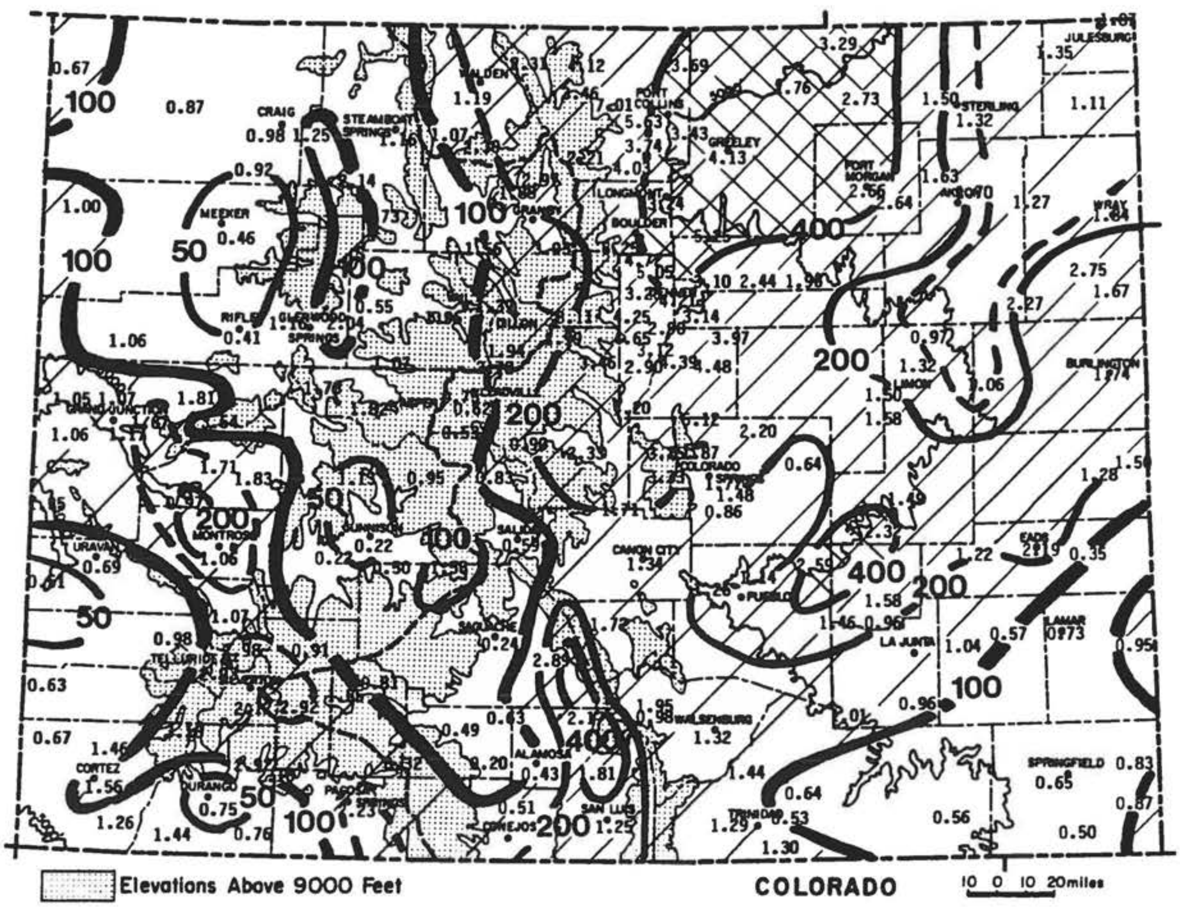
* For existing weather stations with complete daily records.
Higher values are likely for unmonitored locations.

** From Soil Conservation Service snowpack measurements.

MARCH 1990 PRECIPITATION

The storm of March 5-7 dropped record-breaking precipitation amounts along portions of the Colorado Front Range and single-handedly lifted March precipitation totals above the monthly average over much of northeastern Colorado. The 24-hour precipitation total at Fort Collins on the 6th, 3.48", was more than the previous record for the entire month, 3.38" in 1961. Subsequent storms in mid and late March added to the record-breaking totals. But as is often the case, not all of the State was in the same boat. The southeast corner of Colorado missed the big storm and ended up a little drier than average. Western Colorado experienced spotty precipitation. Above average precipitation was observed near Grand Junction, Montrose, much of the San Juan Mountains and along the west slopes of the Sangre de Cristo Mountains east of Alamosa. At the same time, areas from Craig to Rifle, the upper Arkansas Valley near Leadville, and much of the lower elevations surrounding the San Juans were very dry once again. At Crested Butte, in the last 13 months, only July and August of last year brought more than the average moisture.

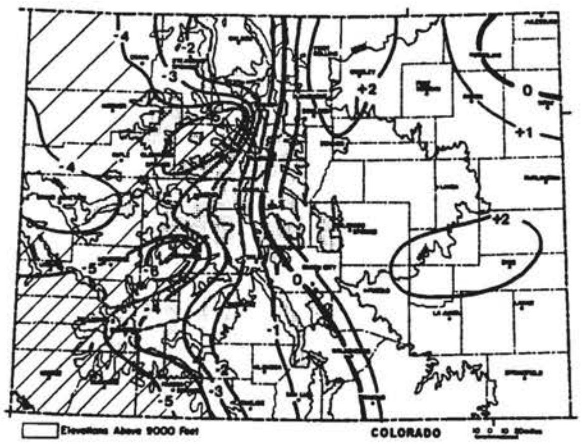
Greatest		Least	
Buckhorn Mountain 1E	7.01"	Monte Vista Refuge	0.20"
Coal Creek	6.57"	Gunnison	0.22"
Wolf Creek Pass 1E	6.32"	Blue Mesa Lake	0.22"
Fort Collins	5.63"	Saguache	0.24"
Brighton 1NE	5.25"	Brandon	0.35"
Gross Reservoir	5.25"	Rifle	0.41"



Precipitation amounts (inches) for March 1990 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

Halfway through the 1990 water year there is now a clear line of demarkation running north-south through the center of Colorado. Areas east of the line (which runs roughly from Walden to Alamosa) are now near average or somewhat wetter than average, but areas west of that line continue to be much drier than average. With the help of the early March storm, the northern Front Range and adjacent plains including Morgan and Weld counties are now more than 50% wetter than average. At the same time, the majority of western Colorado is less than 75% of average for the year. In southwestern Colorado, a number of locations have had less than half their average moisture. The Palmer Index confirms this pattern. The most severe drought conditions appear to now be in the Gunnison Valley near Gunnison.

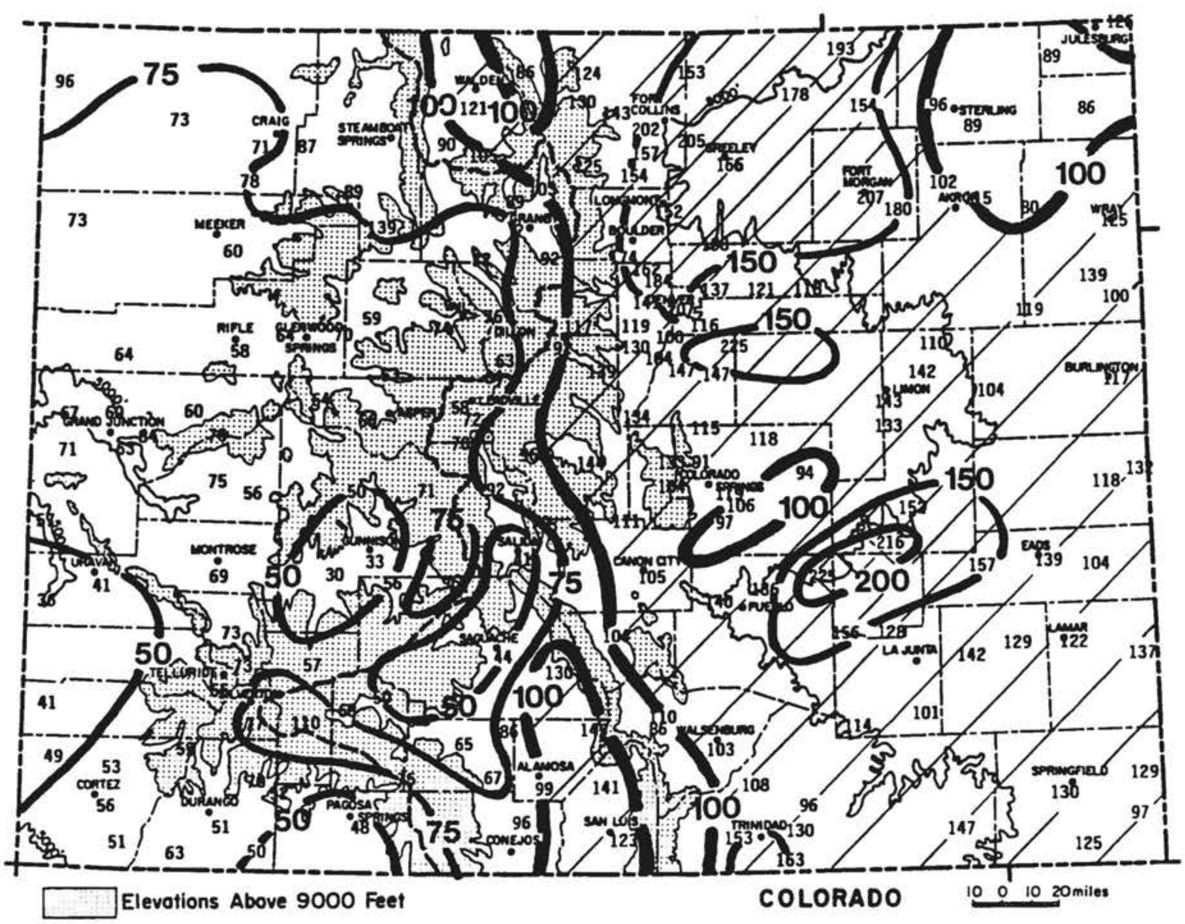


PALMER INDEX:

The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

Interpretation of Index

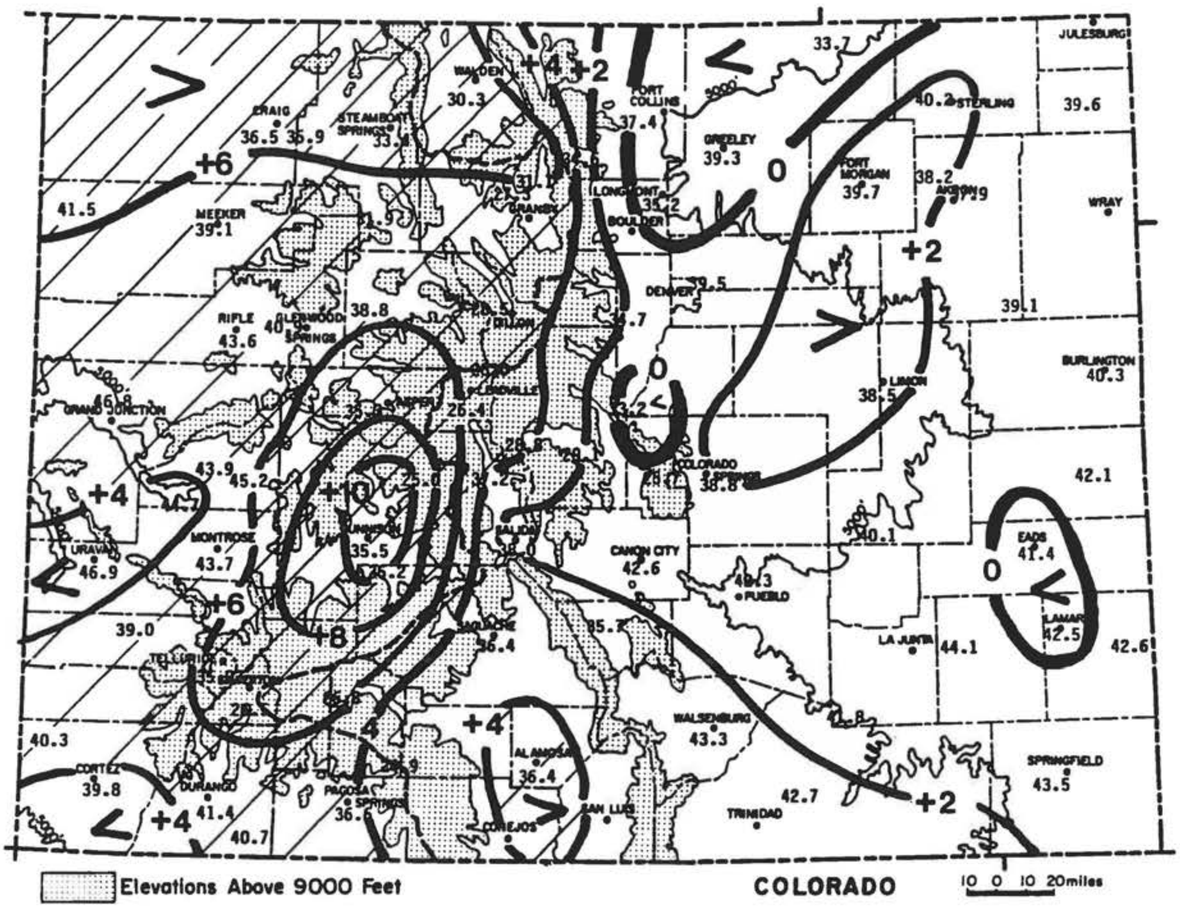
Index	Interpretation
	extremely wet
+4	----------------
+3	ample moisture
+2	----------------
+1	
0	near normal
-1	
-2	----------------
	moderate drought
-3	----------------
	severe drought
-4	----------------
	extreme drought



Precipitation for October 1989 through March 1990
as a percent of the 1961-1980 average.

MARCH 1990 TEMPERATURES AND DEGREE DAYS

A small area along the Front Range experienced slightly cooler than average temperatures in March. Otherwise, the month was abnormally mild over most of the state. Temperatures ranged from 2 degrees F cooler than average near Longmont, and 0 to 3 degrees above average over most of the plains to 4 to 10 degrees above average over most of western Colorado. The warmest areas were some of the higher valleys of western Colorado which normally retain snowcover throughout the month. In Telluride, for example, despite 59" of much-appreciated March snowfall, the ground was bare by the 23rd.



March 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

MARCH 1990 SOIL TEMPERATURES

The heavy, wet snow that buried Fort Collins cooled soil temperatures and significantly retarded the normal spring warm up of the topsoil.

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.

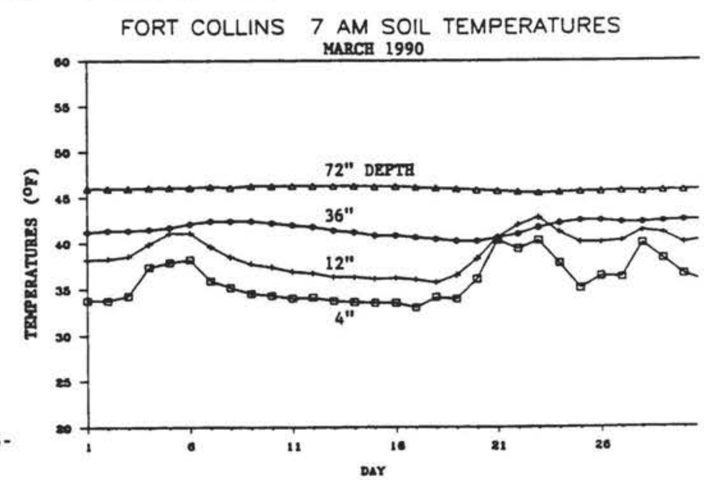


Table 1. Heating Degree Day Data through March 1990 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001	1400	1554	1089	880				6992
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974	1365	1365	1086	915				6923
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M	M	M	M	M				M
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812	1202	1184	991	857				6095
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684	1229	990	957	757				M
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584	1076	859	827	687				4543
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699	1163	966	928	805				5210
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850	1166	1222	959	776				5625
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892	1420	1319	1257	879				6638
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M	M	1161	865	626				M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658	1160	879	882	781				4937
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124	1495	1506	1271	1124				8466
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789	1133	1278	965	724				5536
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896	1348	1286	986	806				6193
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818	1221	1115	1030	932				6265
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711	1166	930	910	848				5195
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721	1285	1087	1010	776				5453
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729	1103	1124	820	557				4689

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

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
	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132	1449	1401	1205	1043				7899
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729	1230	985	922	787				5276
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069	1574	1647	1254	906				7756
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684	1176	1030	887	638				4837
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138	1507	1499	1265	1188				8719
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762	1252	1078	991	815				5617
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749	1302	1048	994	917				5704
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869	1261	1169	1071	795				5947
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768	1156	1186	895	654				5218
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964	1298	1491	1160	873				6858
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676	1204	964	877	695				4883
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M	1130	1191	923	657				M
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974	1533	1580	1332	971				M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719	1254	1074	1026	760				M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869	1264	1273	1023	922				6512
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633	1153	980	874	681				4802
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075	1490	1359	1287	1068				7953
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581	1047	848	800	666				4406

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

MARCH 1990 CLIMATIC DATA

Eastern Plains

Name	Temperature						Degree Days			Precipitation			
	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
NEW RAYMER 21N	44.7	22.7	33.7	-1.5	68	7	963	0	52	3.29	2.65	514.1	14
STERLING	53.0	27.4	40.2	3.4	72	12	760	0	110	1.50	0.70	187.5	7
FORT MORGAN	51.8	27.5	39.7	2.3	74	12	776	0	107	2.66	2.10	475.0	10
AKRON FAA AP	50.3	26.1	38.2	1.9	70	10	823	0	89	1.63	0.76	187.4	10
AKRON 4E	50.1	25.7	37.9	2.5	71	9	832	0	89	1.70	0.88	207.3	11
HOLYOKE	51.6	27.5	39.6	1.0	75	11	782	0	100	1.11	-0.02	98.2	8
JOES	51.2	27.0	39.1	1.1	73	12	796	0	93	2.27	1.47	283.7	6
BURLINGTON	52.1	28.5	40.3	0.3	72	12	757	0	104	1.74	0.92	212.2	6
LIMON WSMO	49.8	27.2	38.5	2.3	68	18	815	0	81	1.50	0.76	202.7	8
CHEYENNE WELLS	55.5	28.8	42.1	2.7	73	12	702	0	125	1.28	0.59	185.5	5
EADS	54.0	28.7	41.4	-0.1	75	15	725	0	134	2.19	1.35	260.7	5
ORDWAY 21N	53.5	26.7	40.1	1.3	74	17	764	0	126	2.32	1.79	437.7	7
LAMAR	56.9	28.1	42.5	-0.2	79	3	691	0	166	0.73	-0.20	78.5	6
LAS ANIMAS	58.8	29.5	44.1	0.6	79	14	638	0	175	1.04	0.42	167.7	6
HOLLY	58.2	27.0	42.6	1.9	81	4	685	0	176	0.95	0.25	135.7	6
SPRINGFIELD 7WSW	58.9	28.1	43.5	1.9	76	11	659	0	177	0.65	-0.26	71.4	5
TIMPAS 13SW	54.9	28.8	41.8	0.6	74	19	713	0	136	1.01	0.17	120.2	5

Foothills/Adjacent Plains

Name	Temperature						Degree Days			Precipitation			
	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	48.7	26.0	37.4	-0.1	69	11	848	0	65	5.63	4.53	511.8	14
GREELEY UNC	51.2	27.5	39.3	-0.7	73	11	787	0	98	4.13	3.18	434.7	10
ESTES PARK	46.1	23.0	34.6	2.1	60	10	938	0	34	2.21	1.48	302.7	4
LONGMONT 2ESE	49.0	21.5	35.2	-2.2	72	2	917	0	78	3.24	2.33	356.0	6
DENVER WSFO AP	51.3	27.7	39.5	1.1	70	14	781	0	91	3.10	1.96	271.9	12
EVERGREEN	49.0	20.4	34.7	2.5	67	0	932	0	62	4.25	2.95	326.9	8
CHEESMAN	49.5	16.8	33.2	-0.5	67	-8	978	0	72	4.20	2.98	344.3	8
LAKE GEORGE 8SW	42.7	15.5	29.1	2.6	56	-2	1106	0	11	2.33	1.78	423.6	6
ANTERO RESERVOIR	43.7	13.9	28.8	5.4	55	-17	1113	0	12	0.90	0.49	219.5	8
RUXTON PARK	39.6	11.7	25.7	0.1	55	-4	1211	0	7	3.33	1.78	214.8	12
COLORADO SPRINGS	50.4	27.3	38.8	2.2	68	18	805	0	79	1.77	0.97	221.2	9
CANON CITY 2SE	55.0	30.2	42.6	1.9	73	21	687	0	135	1.34	0.51	161.4	6
PUEBLO WSO AP	56.1	28.6	42.3	1.3	76	20	695	0	142	1.14	0.41	156.2	8
WESTCLIFFE	50.5	21.0	35.7	4.2	64	10	900	0	62	1.72	0.47	137.6	7
WALSENBURG	57.1	29.5	43.3	3.4	75	19	666	0	148	1.32	-0.00	100.0	8
TRINIDAD FAA AP	57.8	27.6	42.7	2.4	74	17	681	0	150	0.64	-0.25	71.9	5

Mountains/Interior Valleys

Name	Temperature						Degree Days			Precipitation			
	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	42.5	18.1	30.3	6.2	53	-8	1068	0	7	1.19	0.62	208.8	13
LEADVILLE 2SW	39.4	13.4	26.4	5.4	49	-5	1188	0	0	0.62	-0.68	47.7	16
SALIDA	52.8	23.3	38.0	1.8	66	14	829	0	91	0.59	-0.19	75.6	6
BUENA VISTA	51.3	23.0	37.2	3.6	62	15	857	0	72	0.83	0.20	131.7	6
SAGUACHE	49.0	23.8	36.4	3.5	63	16	879	0	60	0.24	-0.18	57.1	3
HERMIT 7ESE	39.7	13.9	26.8	7.5	50	2	1177	0	0	1.55	0.09	106.2	5
ALAMOSA WSO AP	52.6	20.1	36.4	4.8	66	4	880	0	91	0.43	0.00	100.0	6
STEAMBOAT SPRINGS	45.5	21.3	33.4	6.6	60	9	971	0	21	1.51	-0.41	78.6	12
YAMPA	41.8	22.0	31.9	4.8	53	5	1020	0	8	1.73	0.65	160.2	9
GRAND LAKE 1NW	46.3	15.9	31.1	7.9	72	0	1043	0	28	2.97	1.57	212.1	12
GRAND LAKE 6SSW	41.2	13.5	27.3	4.9	59	-9	1161	0	5	1.88	1.03	221.2	15
DILLON 1E	41.5	15.5	28.5	5.2	53	-4	1124	0	4	1.39	0.28	125.2	13
CLIMAX	35.3	10.6	23.0	4.6	46	-12	1298	0	0	2.70	0.57	126.8	18
ASPEN 1SW	46.9	23.8	35.3	7.8	60	6	915	0	30	1.82	-0.38	82.7	16
TAYLOR PARK	40.0	10.0	25.0	12.8	49	-14	1233	0	0	0.95	-0.31	75.4	9
TELLURIDE	48.7	21.2	35.0	6.6	62	3	922	0	50	2.93	0.98	150.3	12
PAGOSA SPRINGS	52.5	20.7	36.6	4.3	66	4	873	0	89	2.23	0.79	154.9	10
SILVERTON	43.3	9.7	26.5	6.5	54	-2	1187	0	11	2.12	0.21	111.0	13
WOLF CREEK PASS 1	36.0	13.7	24.9	3.7	49	-8	1236	0	0	6.32	1.46	130.0	15

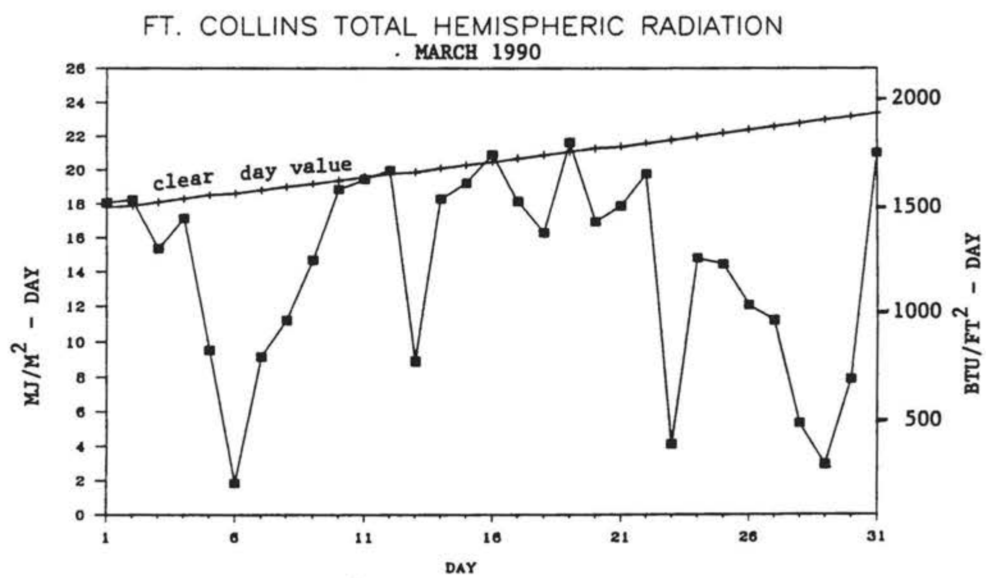
Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	47.5	25.4	36.5	6.1	65	13	879	0	56	0.98	-0.57	63.2	9
HAYDEN	47.1	24.6	35.9	7.5	61	9	894	0	35	1.25	0.07	105.9	12
MEEKER NO. 2	51.5	26.8	39.1	4.5	65	5	795	0	75	0.49	-0.83	37.1	4
RANGELY 1E	54.3	28.8	41.5	6.5	67	5	720	0	110	1.00	0.23	129.9	7
EAGLE FAA AP	52.9	24.6	38.8	5.9	68	6	806	0	94	0.55	-0.22	71.4	6
GLENWOOD SPRINGS	54.0	27.8	40.9	4.8	69	14	740	0	114	1.16	-0.08	93.5	10
RIFLE	58.6	28.5	43.6	5.9	75	18	657	0	165	0.41	-0.44	48.2	6
GRAND JUNCTION WS	58.3	35.3	46.8	4.6	74	16	557	0	156	1.07	0.25	130.5	7
CEDAREDGE	57.1	30.8	43.9	5.1	72	13	648	0	145	1.71	0.71	171.0	6
PAONIA 1SW	57.9	32.5	45.2	6.3	73	16	604	0	155	1.83	0.55	143.0	11
DELTA	60.8	28.5	44.7	3.7	77	11	626	0	188	0.97	0.49	202.1	7
GUNNISON	51.5	19.6	35.5	10.0	64	9	906	0	69	0.22	-0.47	31.9	3
COCHETOPA CREEK	50.5	19.8	35.2	10.2	63	8	917	0	63	0.50	-0.16	75.8	8
MONTROSE NO. 2	56.0	31.4	43.7	5.1	72	18	654	0	133	1.06	0.53	200.0	9
URAVAN	61.6	32.2	46.9	3.7	77	18	553	0	204	0.69	-0.28	71.1	12
NORWOOD	51.1	26.9	39.0	5.2	70	0	799	0	80	1.05	-0.06	94.6	4
YELLOW JACKET 2W	52.0	28.7	40.3	5.3	68	9	757	0	91	0.67	-0.39	63.2	5
CORTEZ	54.0	25.5	39.8	2.5	69	10	776	0	111	1.56	0.22	116.4	7
DURANGO	56.4	26.3	41.4	4.1	69	10	724	0	129	0.75	-0.88	46.0	10
IGNACIO 1N	55.4	25.9	40.7	5.5	66	12	747	0	114	0.76	-0.44	63.3	10

* 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 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	5	10	16	--	--
Denver	6	11	14	47%	71%
Fort Collins	4	12	15	--	--
Grand Junction	3	13	15	58%	64%
Pueblo	6	10	15	52%	75%



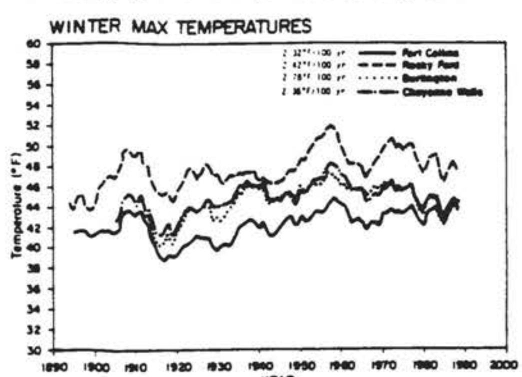
Climate Change on the Great Plains? continued

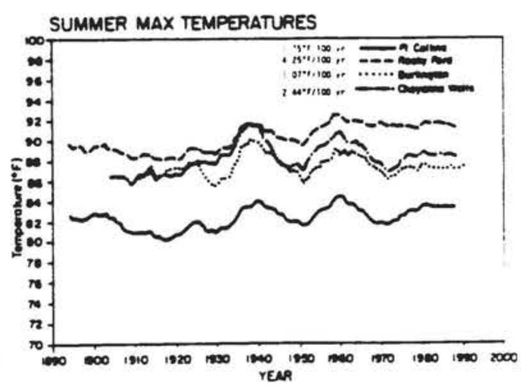
I turned on the TV earlier this week while eating breakfast and heard a one-sentence news story with no editorial comment. The story went something like this, "Scientists report that as a result of global warming the area from Denver to the Missouri River may become a region of sand dunes similar to those in the San Luis Valley." I waited to hear more -- but that was it. They didn't say if that was a forecast for a million years from now or for 1991. They also failed to say who the scientists were and what their area of expertise was. Fortunately, having just returned from a very stimulating conference on the topic of climate change on the Great Plains (sponsored by the Center for Great Plains Studies at the University of Nebraska in Lincoln), I had a reasonable perspective from which to evaluate that remark.

There has been bare sand on the Great Plains in the not too distant past -- perhaps several times during the past 10,000 years. The beautiful Sand Hills region of western Nebraska demonstrates this most vividly. Eastern Colorado also has sandy areas. These tend to be the first areas that become susceptible to wind erosion in times of drought, high winds and/or inappropriate agriculture practices. The assumption that some scientists are making is that global climatic change resulting from human activities (namely, increased greenhouse gases -- carbon dioxide, methane, etc) will produce a more drought-prone Great Plains. This could occur as a result of less precipitation, higher temperatures, stronger winds, or any combination of these. If drought becomes more common, the vegetation that currently holds these sandy areas in place will become sparse, and wide-spread erosion will begin.

Should residents of eastern Colorado and other portions of the Great Plains be worried? I think not. Worrying doesn't do much good. However, I think we should all be aware of the issue, be knowledgeable about the natural variations in our climate and be prepared to make some changes in how we live. A healthy variety of different perspectives on climate change were offered at the conference in Nebraska -- geologists, economists, geographers, soil scientists, sociologists, ecologists, climate modellers, climatologists and others contributed useful information. There is no doubt that dramatic changes to the earth's landform can occur, they have taken place in the past, and they don't require millions of years to happen. Serious droughts have occurred in the recent past. As recently as the 1930s the Great Plains ecosystem was seriously altered by a combination of drought and inappropriate management. Climate is not the only factor that affects the viability of the Great Plains. Transportation systems, pollution problems, international energy and grain markets, interest rates -- these are also very important. Just as we don't know what lies ahead for our economy (but changes are inevitable), we truly do not know what changes in climate may be ahead of us no matter what we may read in the paper or see on TV. The computer models that have been used to project global warming are improving but remain necessarily very crude for resolving local and regional climatic conditions and do not take into account many of the complex interactions the take place between the atmosphere, oceans, earth, vegetation, animals, insects and humans.

Despite the uncertainty, there is growing agreement among a wide range of scientists that the climate of the immediate future (the next few decades on ahead for at least a few centuries) will definitely show the influence of human activities on the earth's surface even though our abilities to anticipate these changes are still limited. Who would have projected 100 years ago that the Arizona desert would blossom with industry, golf courses and hundreds of thousands of silver-greyhaired people? And who would have known in the 1920s that Keota, Stoneham and any of dozens of other eastern Colorado towns would disappear long before the end of the century. Even though we are uncertain, it is appropriate that we think ahead to what the climate of the 21st century may be and how we can prepare. The uncertainty is leading to greater cooperation among scientists worldwide and greater understanding of the importance of protecting our natural resources. Regardless of what we may think of the global warming issue, it makes sense for each of us to do what we can to protect the quality of our resources. On the Great Plains, that especially means protecting the soil and water and doing the best we can to adapt to the ever-changing and always-interesting climate.





NOTE: We have recently completed a report describing several aspects of temperature variability on the Great Plains during the past century. If you would like a copy, please send a check for $7.50 payable to the Colorado Climate Center.

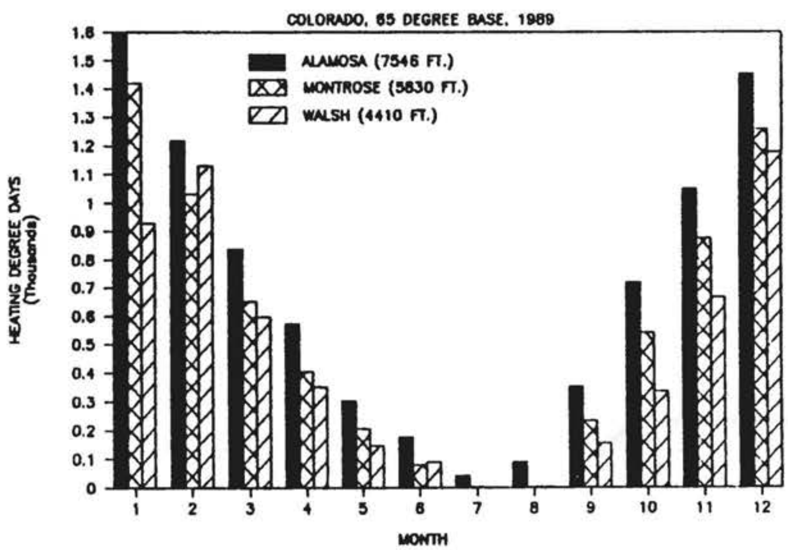
HOME ENERGY RATING SYSTEM

The average American homeowner moves approximately every 7 years. This means that new homes, along with new mortgages, are being considered by families on a regular basis. Most people tend to want to move to a larger home, or a "better" home. The mortgage is then higher. Without a respective raise in salary, how can one afford to buy a bigger home? One way is to provide the financing company with information on the energy usage of the new home. At times, this can let the owner carry a larger mortgage because the estimated utility bills will be smaller.

In June of 1988 the Colorado Office of Energy Conservation set up a three year program aimed at developing a home energy rating system. The office called for companies and universities around the state to provide the research to gain the goal of "a technically credible, user-friendly, voluntary and market-driven home energy rating system for the state of Colorado". (Quoted from the Technical Issues Paper by Franklin Stern of the Colorado Office of Energy Conservation.) Five main areas were determined to need more research. These areas were: climate data, infiltration rates, effective U-values of windows, heating system efficiencies and thermostat data.

The Joint Center for Energy Management (JCEM) at the University of Colorado, Boulder is currently using its database to contribute to the research being carried out on the climate data section of the Home Energy Rating System (HERS). The 8 weather stations located around the state can provide hourly data which can then be used in the HERS. However, as the climate around the state is variable, how can one determine the energy use of a home located in an area that does not have one of the 8 weather stations? Efforts are being made to correlate the use of energy with the number of heating degree days. Since Colorado uses relatively little cooling, cooling degree days are not taken into account. When heating degree days are coupled with the elevation and latitude of a site, an R-squared value of 0.82 is received. (The value showing correlation. If R-squared is 1.0, there is a 1:1 relationship; as R-squared goes down, there is less chance that items are related or effect each other.) An example of this relationship is shown in the graph below. Three WTHRNET stations, along with their respective elevations, are shown. Alamosa, the highest of the three, consistently has the largest total heating degree days. Walsh, the lowest, has the smallest total heating degree days with the exception of February and June. Since heating degree days indicates the amount of time the furnace needs to work, they can be a good energy usage approximator when other items such as furnace efficiency are taken into account. When the elevation and latitude are known at any site in Colorado, the heating degree days (and energy) can be estimated.

HEATING DEGREE DAYS FOR THREE TOWNS



With a target date of June, 1991, the Office of Energy Conservation may soon be able to provide a tool which would give homeowners and potential homeowners an added edge when trying to buy a home just a tad larger than the salary would normally allow.

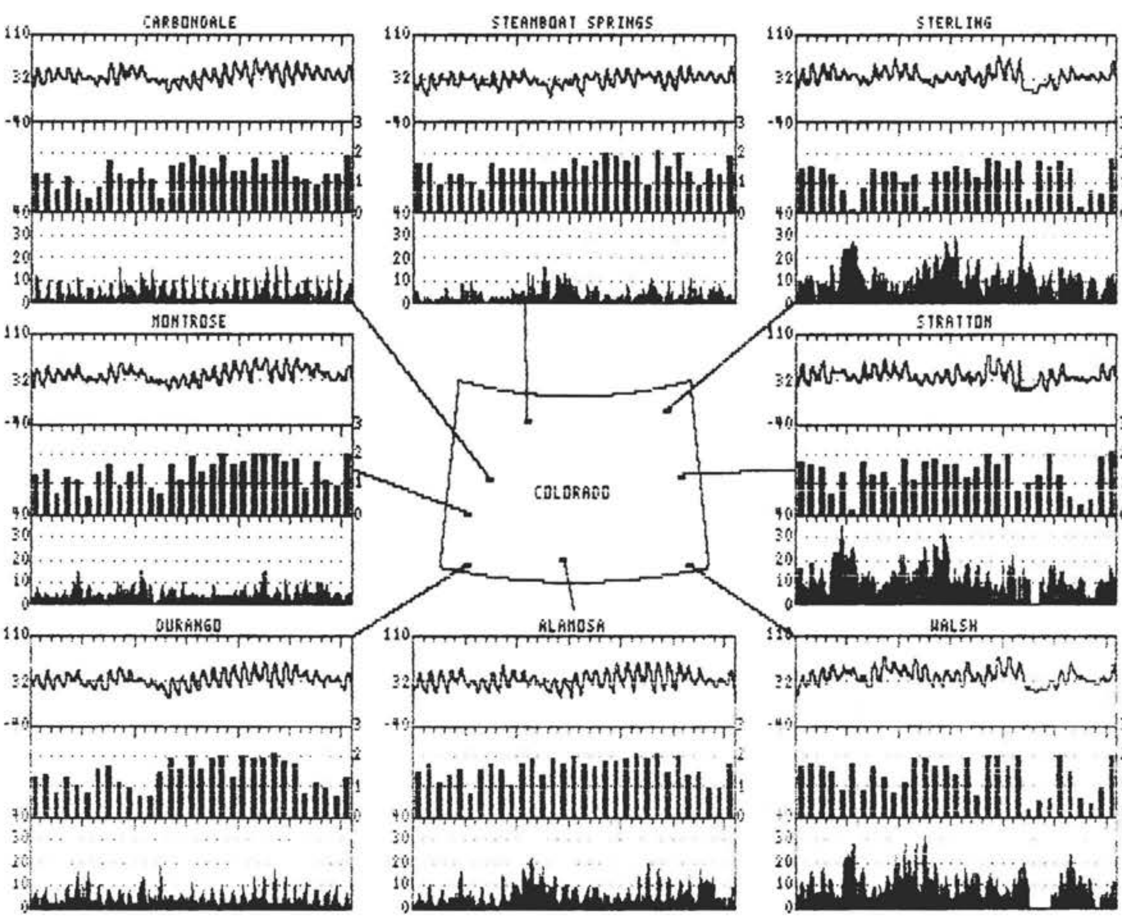
This paper was written by Mary Sutter of the Joint Center for Energy Management, Campus Box 428, University of Colorado, Boulder, 80309-0428. Weather data can be purchased for any of the eight stations we manage. Contact Mary Sutter at the address above for information.

WTHRNET WEATHER DATA MARCH 1990

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)	36.5	36.7	38.6	41.9	31.5	37.7	40.1	42.0
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	66.6 22/15	64.6 21/15	66.4 22/15	70.2 26/15	56.8 26/15	71.8 20/14	72.7 19/15	75.9 9/13
minimum:	6.8 16/ 6	6.1 14/ 6	9.1 14/ 6	16.9 14/ 7	3.9 14/ 5	9.3 24/ 6	16.2 23/ 7	12.2 1/ 6
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	80 / 18	79 / 20	89 / 25	73 / 23	95 / 22	69 / 20	78 / 25	74 / 25
11 AM	41 / 20	48 / 23	44 / 23	44 / 25	58 / 24	49 / 23	53 / 27	50 / 26
2 PM	29 / 16	40 / 22	33 / 20	35 / 22	50 / 24	39 / 21	41 / 25	41 / 24
5 PM	31 / 15	45 / 22	36 / 19	38 / 22	55 / 25	40 / 20	41 / 23	40 / 23
11 PM	61 / 17	71 / 23	65 / 23	60 / 23	86 / 25	63 / 21	72 / 26	62 / 24
monthly average wind direction (degrees clockwise from north)								
day	211	212	270	249	189	207	134	182
night	165	101	183	155	141	206	197	214
monthly average wind speed (miles per hour)	5.63	3.90	3.90	4.15	2.85	10.07	10.74	9.13
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	244	393	424	290	489	68	57	72
3 to 12	432	330	292	439	245	451	421	433
12 to 24	68	21	28	15	10	198	236	185
> 24	0	0	0	0	0	27	30	18
monthly average daily total insolation ($Btu/ft^2 \cdot day$)	1607	1401	1310	1421	1476	1231	1368	1356
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	157	80	112	115	109	156	143	163
40-60%	73	76	90	67	94	56	60	53
20-40%	62	86	89	75	61	63	55	67
0-20%	14	49	36	39	24	72	61	64

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 $Btu/ft^2/day$, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

APRIL 1990

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 13 Number 7

April in Review:

Abundant cloudiness covered Colorado in April, but precipitation was still below average over much of eastern and northern counties of the State. Fortunately, the area in greatest need of precipitation -- the southwest quarter of Colorado -- was doused by 2 to 5 times their average precipitation. Temperatures were again warmer than average for the month, especially in western Colorado, but the frequent clouds made it feel less springlike than the thermometer indicated.

Colorado's June Climate:

The heat of summer makes a bold arrival in June. Mountain residents especially enjoy June weather with its long days and plentiful sunshine which finally melts the remaining snow. Each year in early to mid-June the episodic storm systems quietly vanish that had spread clouds and moisture over Colorado and held down our temperatures throughout the spring. A consistent summer weather pattern then sets in that includes potent morning sunshine, hot middays with low humidity, scattered afternoon cloud buildups, maybe a burst of wind or a brief thunderstorm and then a calm and pleasant evening. But the transition in early June that leads up to these placid summer doldrums can make living in Colorado interesting and frightening. Crackling thunderstorms, especially east of the mountains, often pour out shafts of damaging hail and occasionally spawn tornadoes. The Denver area has had its share of these storms in the past decade, most of them in the first two weeks of June. Flooding can occur, both from melting snow in the mountains and also from widespread thunderstorms. This year marks the 25th anniversary of the June 1965 floods. And don't forget about snow. Just last year a significant snowfall was reported in the mountains and foothills west of Denver on June 21-22 and caught many tourists by surprise.

Early June temperatures remain coolish, often only rising into the 70s and sometimes staying in the 60s (especially in northeastern parts of the State) with lows in the 40s. But after June 20th, lower elevation areas can expect 50s at night with 80s and 90s nearly every day. Don't be surprised by some 100-degree reports from the lower Arkansas Valley and the Grand Junction area. Meanwhile, mountain temperatures become pleasant with 60s and 70s during the day except above 10,000 feet where temperatures still only average in the 50s during the day and below freezing at night.

June precipitation is normally very light in southwestern Colorado where it is often the driest month of the year (less than 1.00" expected). Totals increase to 1-2" in the mountains, 1.50-2.00" along the Front Range and close to 3" in extreme northeastern Colorado where June is frequently the wettest month of the year. This is a sharp contrast to the winter season when plains moisture is so scanty. This seasonal distribution of precipitation is largely responsible for the good wheat harvests that northeast Colorado farmers often enjoy even though their annual precipitation only averages about 16".

Hydrologic Cycle -- Part I. The Lord Giveth and the Lord Taketh Away:

You've all heard about the hydrologic cycle -- one of nature's marvelous recycling programs. Children find the concept fascinating: water transported by the air, distributed as precipitation (like a giant's sprinkling can), collected by trickling streams connected to growing rivers and then quietly evaporated back into the air to begin the process once again. But the rest of us often take the cycle for granted. It seems so simple, yet it is so complex.

(continued on page -9-)

APRIL 1990 DAILY WEATHER

Date	Event
1-3	Predominantly dry and mild but a weak upper level low pressure area over Arizona directed some clouds and light showers into southern Colorado 1-2nd.
4-6	A surge of polar air plunged southward across the Great Plains 4-5th while mild conditions prevailed west of the mountains. Upslope rains developed in northeast Colorado late on the 4th, changed to snow and advanced southward on the 5th. By midday on the 5th, 1-2 foot snowfalls were common from Sterling all the way to the Oklahoma panhandle. 7" of snow was reported at Boulder. Highs reached only into the 20s and 30s while Western Slope areas enjoyed 60s. Clearing overnight with the coldest temperatures of the month for many areas. Springfield dipped to 14°F early on the 6th. Florrisant Fossil Beds slipped to -5°, the coldest in the State for April.
7-10	Sunny and warmer on the 7th. Nice spring weather east of the mountains on the 8th, but clouds, showers and thunderstorms spread into western Colorado. The storm passed quickly over Colorado on the 9th leaving chilly temperatures in its wake. Western temperatures rebounded on the 10th, but highs stayed in the low 40s in northeast Colorado. The storm deposited beneficial moisture over western valley 8-9th. Yellow Jacket reported 0.69", Rifle 0.91" and Meeker totalled 0.93". Portions of the San Juan region received more than 1 inch.
11-15	Northwesterly winds aloft blew throughout this period. Sunny and mild west on the 11th but still cool northeast. Mild statewide early on the 12th, but some light snow developed over northern and central mountain areas as a cold front crossed the region. Some showers spread into eastern Colorado. Cool on the 13th, then much warmer again on the 14th. Easter Sunday (15th) brought slightly cooler temperatures east of the mountains but some of the warmest air of the month to western Colorado. Denver enjoyed a high of 67° but Montrose reached 77° that afternoon -- fine bonnet weather.
16-19	Pleasant weather continued west of the mountains but sharply colder air marched southward across the plains all the way to Texas on the 16th. Light upslope precipitation developed along the Front Range and changed to snow or freezing drizzle in some areas by midnight. It remained chilly east and turned cooler west on the 17th. Clouds and showers spread into western Colorado and became quite heavy in the southwest. Montrose received a soaking of 1.32" of rain mostly on the 18th. Telluride got 18" of wet snow. The storm system then spread into eastern Colorado late on the 18th and 19th. Buena Vista recorded 0.84" of moisture. Canon City got almost 0.70".
20-23	A narrow high pressure ridge brought a return of warm and dry conditions to Colorado 20-21st. Then another low pressure trough took aim on Colorado 22-23rd. Temperatures remained mild (60s and 70s with some 80s in southeast Colorado, but scattered thunderstorms became more numerous.
24-30	A series of storm systems brought April to a cold, windy and damp close. Widespread rains and high elevation snows hit most of western Colorado 24-25th. Many areas got more than 0.50" of moisture. Scattered thunderstorms traversed the plains. Limon was hit by a 1.33" downpour. Cool, showery weather with mountain snows on the 26th gave way to drier conditions on the 27th. Strong winds accompanied a sudden warm up on the 28th. Las Animas soared to 91°, the warmest in the State. Later on the 28th, strong winds gusting to 60 mph or more ushered in very cold air. On the 29th and 30th the entire state was quite cold. Heavy snow surprised residents of Alamosa (9") and blanketed much of the Colorado high country. Mabel Wright, one of Colorado's oldest volunteer weather observers, measured 24" of new snow at her home on the Rio Grande. Aspen reported 14". Even Denver had 2" of snow. April ended with temperatures in the teens and single digits in the high country.

April 1990 Extremes

Highest Temperature	91°F	April 28	Las Animas
Lowest Temperature	-5°F	April 6	Florrisant Fossil Beds
Greatest Total Precipitation	6.26"		Wolf Creek Pass 1E
Least Total Precipitation	0.08"		Kit Carson 6S
Greatest Total Snowfall*	46"		Telluride
Greatest Snowdepth**	77"	April 30	Cameron Pass

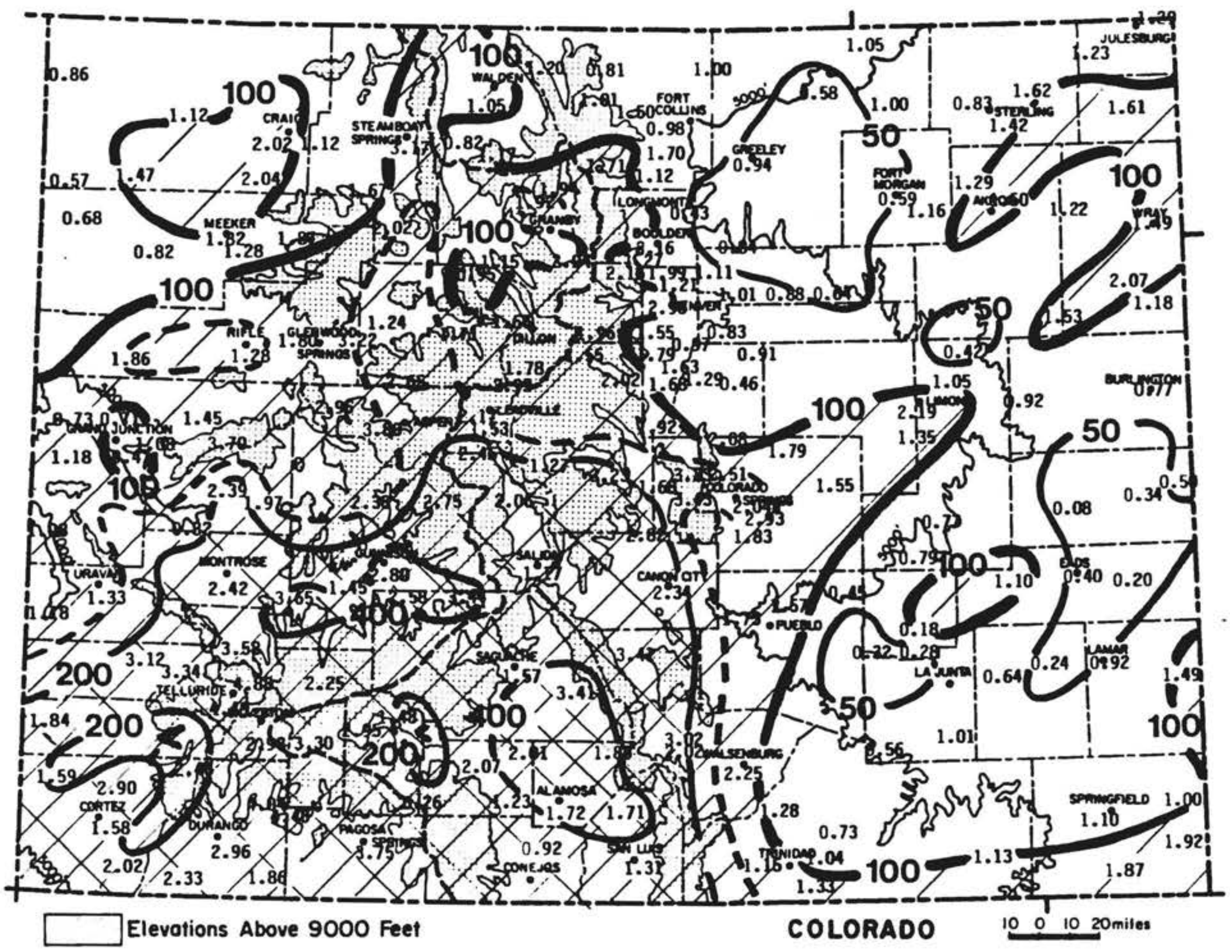
* For existing weather stations with complete daily records. Higher values are likely for unmonitored locations.

** From Soil Conservation Service snowpack measurements.

APRIL 1990 PRECIPITATION

Three major stormy episodes were responsible for most of the month's precipitation. Southwestern Colorado, including the San Luis Valley and the upper Gunnison Valley, enjoyed their wettest month in a long time. Most of the southwestern quarter of the State received from 200% to 500% of the April average. Precipitation tapered off, however, both to the north and to the east. Several areas on the Eastern Plains recorded less than half of average. All in all, it was a good month for Colorado. The areas that needed precipitation the most received a plentiful dose, and the areas that stayed dry in April were generally locations where moisture had been plentiful. Gunnison, for example, received 2.80" of moisture, 500% of average. They had previously received a total of only 1.47" since October 1. In comparison, Brighton got 0.82" of moisture in April, 42% of average, but accumulated water year precipitation was still more than 2.5" ahead of average.

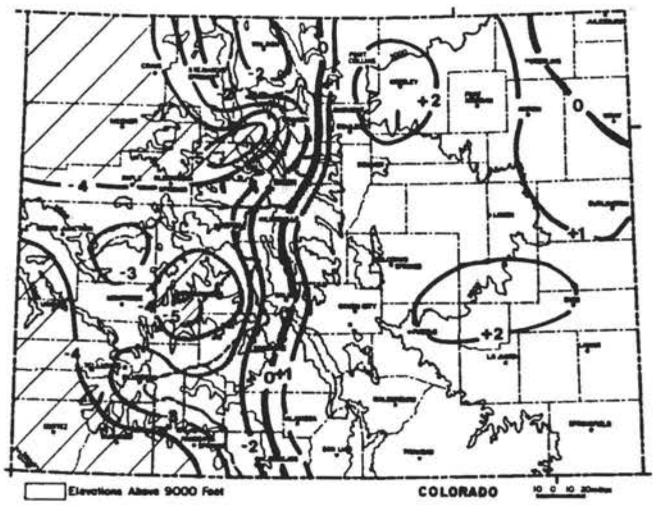
Greatest		Least	
Wolf Creek Pass 1E	6.26"	Kit Carson 6S	0.08"
Ouray	4.88"	Brandon	0.20"
Telluride	4.49"	John Martin Dam	0.24"
Vallecito Dam	4.46"	Rocky Ford 2SE	0.28"
Lemon Dam	4.04"	Fowler 1SE	0.32"
Aspen 1SW	3.80"	Cheyenne Wells	0.34"



Precipitation amounts (inches) for April 1990 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

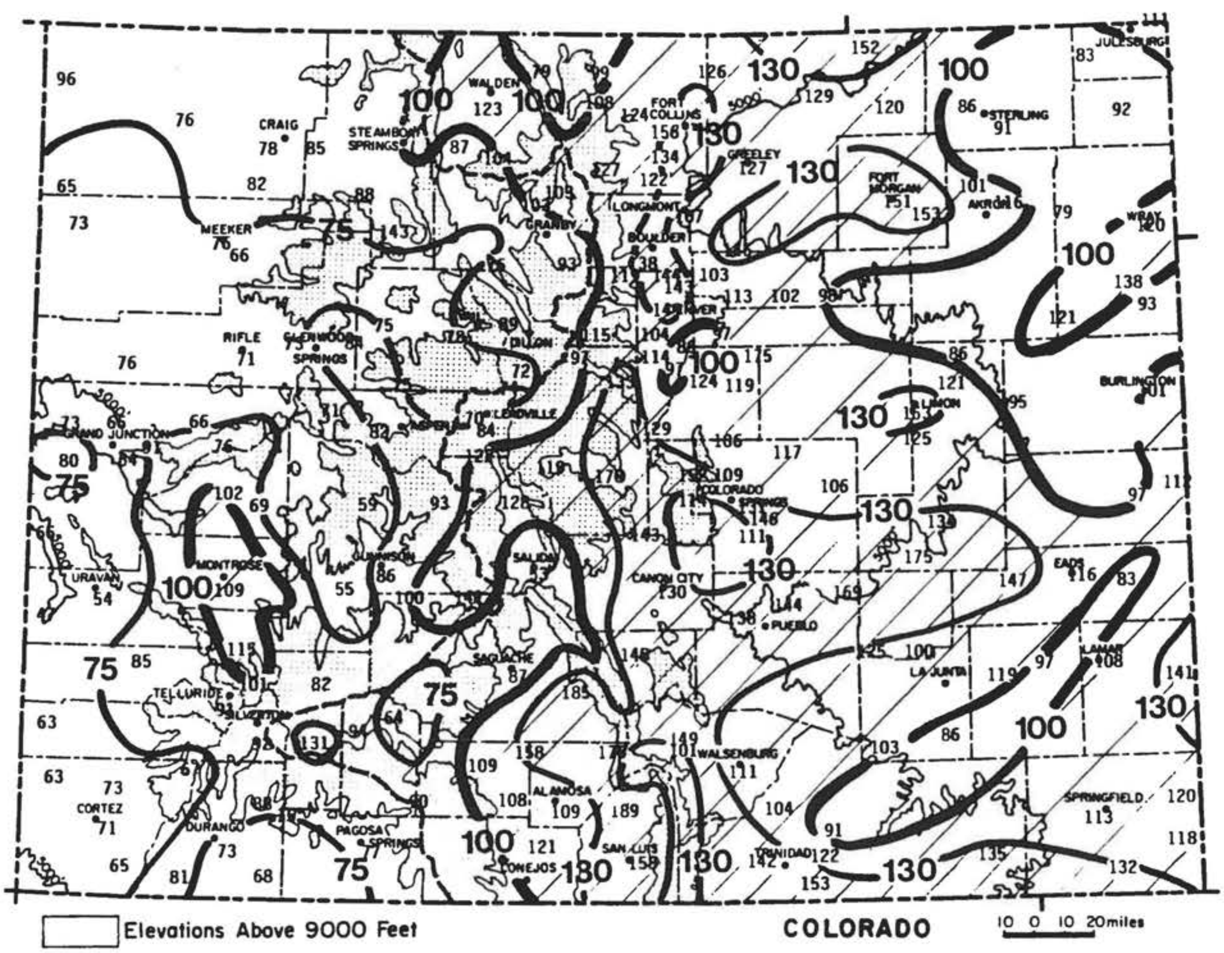
Heavy April precipitation in southwest Colorado did not add greatly to snowpack totals but did raise accumulated water year precipitation totals (and morale) across the area. The areas that have received less than 75% of average water year precipitation decreased noticeably but still included locations from Kremmling and Eagle west to Meeker and Rangely and southward to Grand Junction and Cortez. The 100% contour slipped westward to include most of the San Luis Valley and even an area from Ouray to Cedaredge. However, the Palmer Drought Index still indicated extreme drought in several western areas, suggesting that the recent precipitation had not saturated far into the soils. Conditions on the Eastern Plains continue to look very good, especially in comparison to last year at this time.



PALMER INDEX:

The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

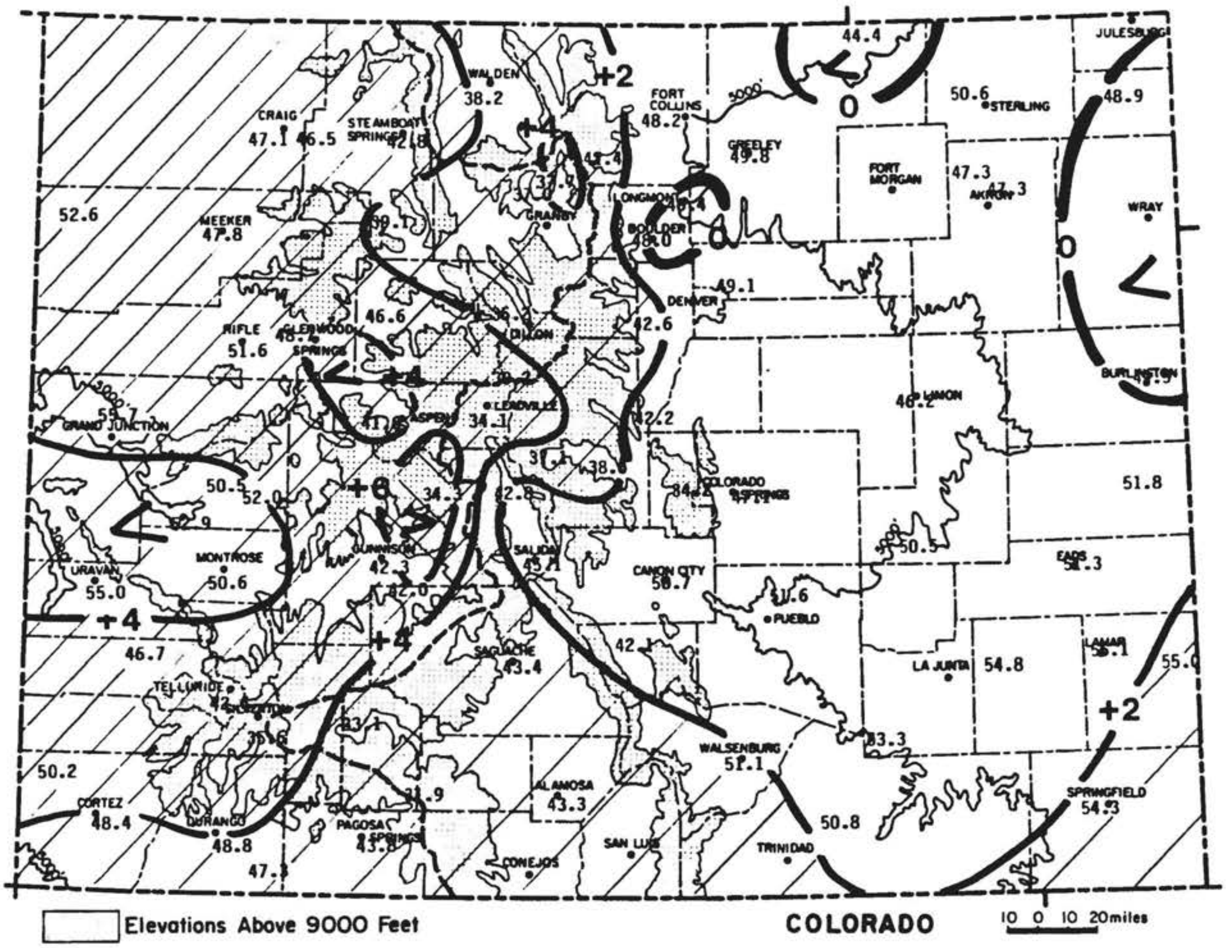
Interpretation of Index		
		extremely wet
	+4	----------------
	+3	ample moisture
	+2	----------------
	+1	
	0	near normal
	-1	
	-2	----------------
		moderate drought
	-3	----------------
		severe drought
	-4	----------------
		extreme drought



Precipitation for October 1989 through April 1990
as a percent of the 1961-1980 average.

APRIL 1990 TEMPERATURES AND DEGREE DAYS

Temperatures for the month as a whole were again considerably warmer than average in western Colorado. From Steamboat Springs southward to Leadville, Gunnison and Durango, most locations in the mountains and on the Western Slope were at least 3 degrees Fahrenheit above average for the month. Much of that area has been consistently above average since last fall. East of the mountains experienced temperatures much closer to average, but most locations remained slightly on the warm side. The only spots where temperatures ended up a bit cooler than average were found in northeast Colorado.



April 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

APRIL 1990 SOIL TEMPERATURES

Soil temperatures rose fairly steadily until they temporarily leveled off late in the month. For this time of year, soil temperatures remained a little cooler 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.

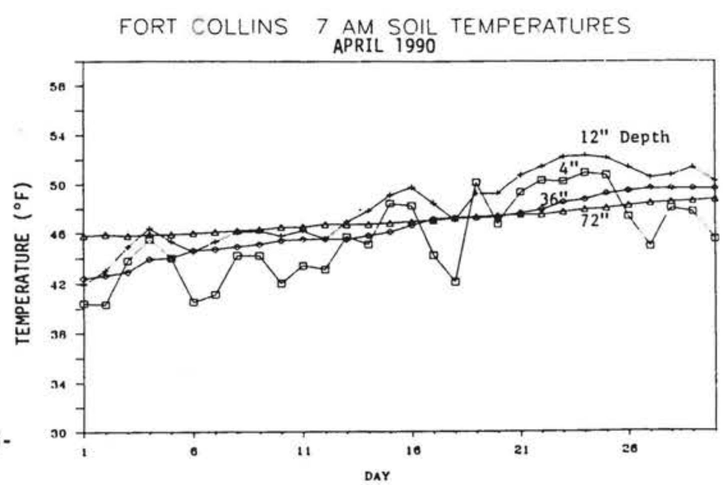


Table 1. Heating Degree Day Data through April 1990 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001	1400	1554	1089	880	640			7632
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974	1365	1365	1086	915	697			7620
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M	M	M	M	M	502			M
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812	1202	1184	991	857	660			6755
BURLINGTON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684	1229	990	957	757	459			M
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584	1076	859	827	687	421			4964
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699	1163	966	928	805	526			5736
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850	1166	1222	959	776	490			6115
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892	1420	1319	1257	879	530			7168
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M	M	1161	865	626	355			M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658	1160	879	882	781	469			5406
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124	1495	1506	1271	1124	886			9352
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789	1133	1278	965	724	479			6015
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896	1348	1286	986	806	545			6738
EVERGREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818	1221	1115	1030	932	662			6927
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711	1166	930	910	848	495			5690
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721	1285	1087	1010	776	M			M
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729	1103	1124	820	557	271			4960

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

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
	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132	1449	1401	1205	1043	833			8732
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729	1230	985	922	787	449			5725
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069	1574	1647	1254	906	672			8428
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684	1176	1030	887	638	309			5146
LEADVILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138	1507	1499	1265	1188	920			9639
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762	1252	1078	991	815	555			6172
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749	1302	1048	994	917	552			6256
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869	1261	1169	1071	795	507			6454
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768	1156	1186	895	654	425			5643
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964	1298	1491	1160	873	630			7488
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676	1204	964	877	695	394			5277
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M	1130	1191	923	657	392			M
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974	1533	1580	1332	971	658			M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719	1254	1074	1026	760	427			M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869	1264	1273	1023	922	664			7176
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633	1153	980	874	681	420			5222
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075	1490	1359	1287	1068	796			8749
WALSENBURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581	1047	848	800	666	408			4814

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

APRIL 1990 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	58.7	30.1	44.4	-1.1	77	12	610	0	168	1.05	-0.14	88.2	9
STERLING	65.5	35.6	50.6	2.8	85	22	427	1	257	0.83	-0.45	64.8	5
AKRON FAA AP	61.5	33.2	47.3	0.6	83	16	525	2	196	1.29	-0.03	97.7	10
AKRON 4E	61.5	33.1	47.3	1.1	84	18	525	0	206	1.50	0.23	118.1	8
HOLYOKE	61.5	36.2	48.9	-0.5	85	24	479	3	210	1.61	0.09	105.9	8
BURLINGTON	63.5	35.6	49.5	-0.7	82	22	459	2	232	0.77	-0.43	64.2	3
LIMON WSMO	59.9	32.6	46.2	1.1	76	17	555	0	180	2.19	1.14	208.6	6
CHEYENNE WELLS	67.3	36.3	51.8	1.9	86	23	393	3	269	0.34	-0.54	38.6	2
EADS	66.1	36.5	51.3	-0.6	84	25	405	5	263	0.40	-0.58	40.8	2
ORDWAY 21N	66.2	34.8	50.5	1.6	83	26	429	0	264	0.79	-0.14	84.9	5
LAMAR	72.0	38.2	55.1	1.1	89	27	307	16	341	0.92	-0.34	73.0	6
LAS ANIMAS	71.6	37.9	54.8	1.0	91	26	309	9	334	0.64	-0.36	64.0	8
HOLLY	72.0	38.0	55.0	2.5	90	29	310	16	342	1.49	0.52	153.6	7
SPRINGFIELD 7WSW	72.1	36.5	54.3	2.7	85	14	320	5	337	1.10	-0.36	75.3	6
TIMPAS 13SW	69.6	36.9	53.3	2.0	84	24	349	5	310	0.56	-0.36	60.9	4

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	60.6	35.9	48.2	1.2	75	27	495	0	175	0.98	-0.81	54.7	9
GREELEY UNC	62.7	36.9	49.8	1.0	80	28	449	0	209	0.94	-1.00	48.5	6
ESTES PARK	55.4	29.4	42.4	2.7	67	9	669	0	105	1.71	0.41	131.5	9
LONGMONT 2ESE	62.0	30.8	46.4	-0.9	79	19	552	0	201	0.43	-1.49	22.4	7
BOULDER	60.6	35.4	48.0	-0.8	74	16	502	0	177	2.16	-0.00	100.0	17
DENVER WSFO AP	61.1	37.1	49.1	1.4	80	26	469	0	188	1.01	-0.81	55.5	10
EVERGREEN	57.1	28.2	42.6	2.2	70	10	662	0	136	1.55	-0.72	68.3	11
CHEESMAN	59.3	25.1	42.2	0.2	72	16	677	0	161	1.92	0.22	112.9	10
LAKE GEORGE 8SW	52.0	25.2	38.6	2.1	83	8	784	0	70	2.23	1.31	242.4	8
ANTERO RESERVOIR	50.8	23.3	37.1	3.9	61	3	831	0	49	1.27	0.64	201.6	9
RUXTON PARK	48.0	20.3	34.2	0.5	61	4	915	0	38	3.43	0.94	137.8	11
COLORADO SPRINGS	59.5	34.7	47.1	0.8	78	24	526	0	178	2.04	0.76	159.4	10
CANON CITY 2SE	64.2	37.2	50.7	0.9	81	25	421	0	229	2.34	1.22	208.9	8
PUEBLO WSO AP	67.1	36.1	51.6	0.0	85	26	394	0	277	1.57	0.63	167.0	8
WESTCLIFFE	56.8	27.5	42.1	1.7	72	17	678	0	125	3.41	2.45	355.2	12
WALSENBURG	66.2	36.0	51.1	2.7	80	20	408	0	257	2.25	0.62	138.0	12
TRINIDAD FAA AP	67.2	34.4	50.8	1.1	82	18	420	0	266	0.73	-0.28	72.3	10

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	53.1	23.3	38.2	3.8	66	9	796	0	82	1.05	0.26	132.9	9
LEADVILLE 2SW	46.4	21.8	34.1	5.1	55	6	920	0	8	1.53	0.13	109.3	15
SALIDA	59.9	30.4	45.1	0.9	73	19	588	0	165	1.17	-0.08	93.6	6
BUENA VISTA	56.7	28.9	42.8	1.7	69	20	660	0	115	2.06	1.36	294.3	7
SAGUACHE	57.0	29.8	43.4	2.2	71	21	642	0	126	1.57	1.06	307.8	8
HERMIT 7ESE	44.5	21.7	33.1	2.5	52	10	951	0	1	2.95	1.79	254.3	4
ALAMOSA WSO AP	59.4	27.2	43.3	2.6	72	19	640	0	152	1.72	1.30	409.5	11
STEAMBOAT SPRINGS	57.7	28.0	42.8	4.8	70	13	658	0	140	3.17	1.02	147.4	16
YAMPA	52.1	26.0	39.1	2.6	61	12	515	0	41	2.02	0.79	164.2	9
GRAND LAKE 1NW	51.7	23.7	37.7	5.0	63	9	814	0	58	1.94	0.02	101.0	12
GRAND LAKE 6SSW	51.1	22.8	37.0	3.7	63	12	833	0	53	1.92	0.82	174.5	16
DILLON 1E	48.3	22.2	35.2	2.5	59	14	886	0	32	1.65	0.53	147.3	15
CLIMAX	43.3	17.1	30.2	4.5	52	6	1035	0	2	2.93	0.53	122.1	15
ASPEN 1SW	53.6	29.6	41.6	3.6	67	19	697	0	78	3.80	1.50	165.2	19
TAYLOR PARK	46.6	22.0	34.3	11.0	56	2	911	0	11	2.75	1.66	252.3	13
TELLURIDE	57.1	28.1	42.6	6.0	70	19	664	0	125	4.49	2.59	236.3	15
PAGOSA SPRINGS	59.7	27.9	43.8	3.2	74	21	630	0	156	3.75	2.72	364.1	11
SILVERTON	50.7	20.6	35.6	5.9	65	12	872	0	54	2.98	1.54	206.9	14
WOLF CREEK PASS 1	45.4	18.3	31.9	2.9	58	4	988	0	15	6.26	3.31	212.2	11

Western Valleys

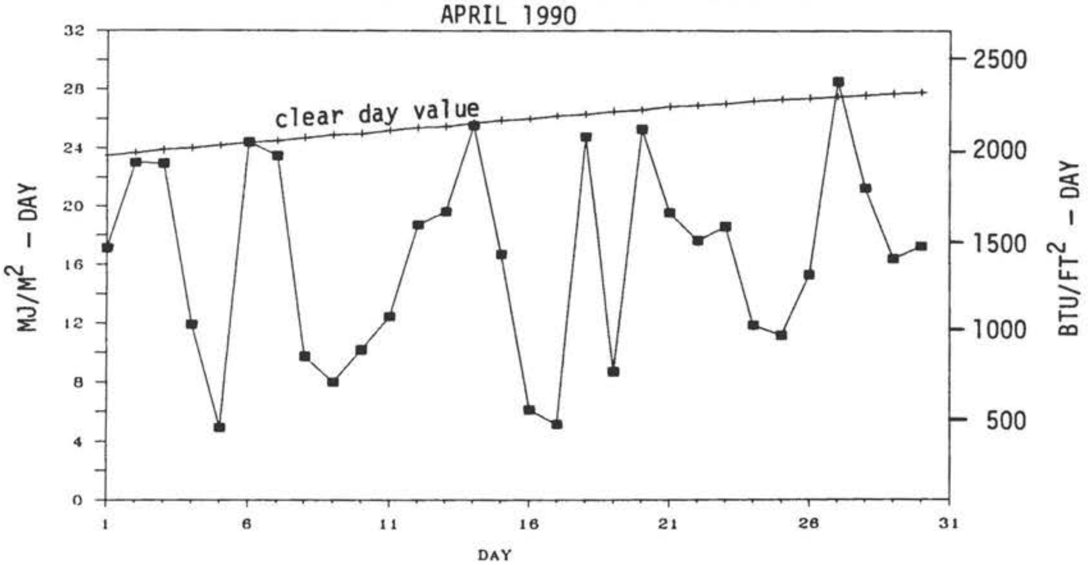
Name	Max	Min	Temperature Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	61.3	32.9	47.1	5.1	74	20	530	0	183	2.02	0.22	112.2	11
HAYDEN	60.9	32.1	46.5	5.0	73	19	549	0	175	1.12	-0.37	75.2	9
MEEKER NO. 2	62.7	32.9	47.8	5.2	75	20	507	0	200	1.82	0.61	150.4	9
RANGELY 1E	67.7	37.5	52.6	5.8	80	24	360	0	276	0.68	-0.26	72.3	5
EAGLE FAA AP	62.0	31.2	46.6	4.9	73	19	545	0	194	1.24	0.57	185.1	9
GLENWOOD SPRINGS	63.5	33.9	48.7	3.4	75	24	482	0	213	1.80	0.32	121.6	14
RIFLE	67.6	35.6	51.6	5.3	80	26	392	0	270	1.28	0.52	168.4	6
GRAND JUNCTION WS	68.0	43.4	55.7	4.3	82	31	271	1	283	0.71	-0.03	95.9	7
CEDAREDGE	64.9	36.2	50.5	3.6	77	24	430	0	235	2.39	1.58	295.1	6
PAONIA 1SW	66.0	38.0	52.0	4.8	80	28	383	0	250	1.97	0.63	147.0	15
DELTA	69.8	36.1	52.9	3.1	83	28	355	0	307	0.82	0.36	178.3	9
GUNNISON	58.2	26.4	42.3	4.9	71	19	672	0	138	2.80	2.24	500.0	7
COCHETOPA CREEK	58.2	25.9	42.0	6.0	70	18	680	0	138	2.59	1.96	411.1	14
MONTROSE NO. 2	64.7	36.6	50.6	3.5	77	3	425	0	239	2.42	1.68	327.0	12
URAVAN	70.3	39.8	55.0	3.5	86	32	293	0	314	1.33	0.28	126.7	11
NORWOOD	60.1	33.4	46.7	5.2	73	24	539	0	164	3.12	2.16	325.0	9
YELLOW JACKET 2W	64.8	35.6	50.2	6.9	77	28	437	0	228	1.59	0.74	187.1	7
CORTEZ	64.2	32.7	48.4	3.6	78	23	490	0	220	1.58	0.84	213.5	12
DURANGO	64.5	33.1	48.8	4.0	79	28	479	0	230	2.96	1.91	281.9	12
IGNACIO 1N	61.8	32.8	47.3	3.8	74	26	522	0	182	1.86	1.07	235.4	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.

APRIL 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days: clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	2	8	20	--	--
Denver	3	10	17	53%	67%
Fort Collins	2	12	16	--	--
Grand Junction	3	10	17	57%	67%
Pueblo	5	10	15	63%	74%

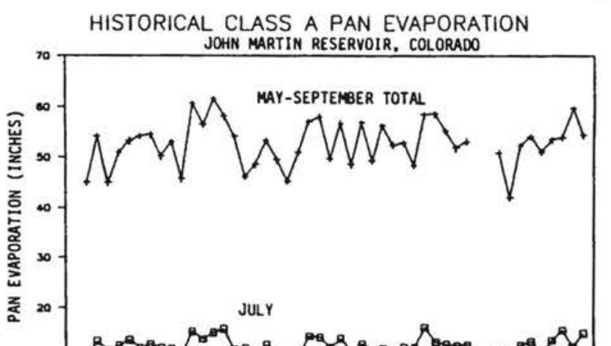
FT. COLLINS TOTAL HEMISPHERIC RADIATION
APRIL 1990

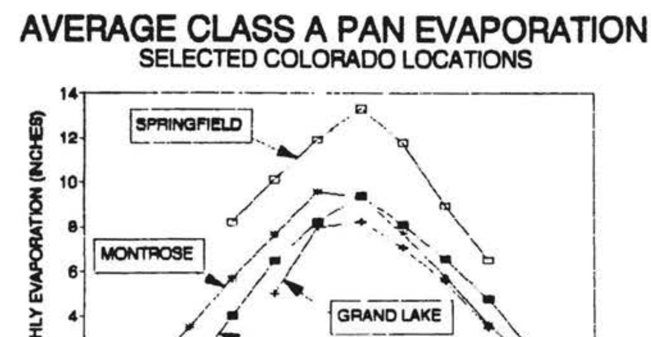


Here in Colorado we are perched atop the crest of the Continental Divide -- the highest elevation state in the U.S. Many wonderful rivers are born here: the Platte, the Arkansas, the Rio Grande and the Colorado. It is a pleasure to live near the scenic source of these rivers, but there is one problem. They carry our water away. Therefore, our only real source of water is precipitation. We've written a great deal about precipitation in the past. If you have any questions or need data, please call us. Let it suffice to say that averaged over the entire State, we get about 17" of moisture a year. In a bad drought year, precipitation may total less tha 12" statewide. A very wet year may supply more than 22". If my computations are correct, if we could channel all 17" over the entire state into Dillon Reservoir, we could fill it about 400 times. That is quite a bit of water (100 million acre-feet), but it is less than much of the rest of the country gets. Furthermore, we lose most of it. Some of the water leaves the State as streamflow (typically no more than about 10%). Some water is held in reservoirs (on the average we store about 6 million acre-feet of water). Some soaks into the soil and becomes groundwater (that's not really the same as losing it) but we're not really sure how much. The remainder leaves quitely and unnoticed as evaporation.

Evaporation includes both the direct loss from water surfaces to the atmosphere but also the water released by plants which is called transpiration. They are both affected by the amount of sunshine, the temperature and humidity of the air and the speed of the wind. Transpiration is especially tricky because plants can regulate their own rates of water consumption. I will not go into detail here about ET (evapotranspiration). Thousands of pages have been written on the topic, much of it written by researchers here in Colorado. Evapotranspiration is difficult and expensive to try to measure so most people try to estimate it from other variables. Several formulas have been developed to estimate ET. In general, here at the Colorado Climate Center we provide basic climatic information that relate to ET, but we let our users decide how they want to estimate their values. However, there is one source of evaporation information that we do monitor. For many years a device called a Class A pan has been used by the National Weather Service and other organizations to attempt to estimate evaporation. It looks like a small stock tank -- 4 feet in diameter and about 1 foot deep. The change in depth of the water in the pan from one day to the next is measured and adjusted for any precipitation that may have fallen. At the current time we receive data each month through the growing season from about 15 locations across Colorado.

Monthly average pan evaporation are shown below for 4 locations in Colorado based on about 30 years of data. In general, all areas have similar distributions of evaporation through the year -- little during the winter and most during the early summer. During hot and dry weather, more than 0.50" of water can evaporate in a single day in several parts of Colorado. At that rate, we could evaporate all 17" of annual precipitation in a single month. Most areas of Colorado experience maximum evaporation rates during July, but Montrose (and other locations in southwest Colorado) reach their maximum in June. Even though air temperatures remain warm in August, pan evaporation begins to drop quickly. This is primarily a result of decreasing solar radiation. Evaporation continues during the winter months but is normally not measured since expanding ice can break the pans. Where measurements have been attempted, midwinter values of less than 1" per month have been observed.





How does pan evaporation relate to actual evaporation? First of all, remember that pan evaporation is an indication of potential evaporation, not actual evaporation. You have to have water before you can lose it. It has been found that in most cases the evaporation from the Class A pan is greater than the actual evaporation from lakes and streams or the ET from plants. The relationship between pan evaporation and lake evaporation also changes as a function of time of year. Still, pan evaporation is useful in comparing relative evaporation losses from one location to another or from one year to the next. The graph above shows nearly 40 years of evaporation data from John Martin Reservoir in southeast Colorado. Over the course of an entire May-Sep. growing season, evaporation has varied from as low as 40 inches to more than 60" in the drought year of 1954.

A BRIGHT SAVINGS PLAN

Earth Day has come and gone. Now people are urging us to follow through on practices started on that day (or at least contemplated on Earth Day). Some of the major habit changes billed as practically painless and helpful to the environment were recyclying, reusing paper and plastic bags and buying organic foods. Installing shower flow reducers and decreasing the water volume in the toilet with a plastic bottle were others. One area that did not seem to get much press was changing our incandescent lamps to fluorescent. Electricity is a form of energy that is very inefficeint. Any savings brought about by decreasing electricity use has environmental impact. The coal burned by power plants exhausts pollution into the air. Roughly 1/3 of the energy burned by the coal is converted into electricity. In other words, it takes three units of fuel at the power plant to provide the consumer with one unit of electricity.

The lighting industry has come far in a few years. Many companies have moved into the business of providing energy efficient lamps & luminaires (the lighting trade word for light fixtures) at an ever decreasing cost. Although not found yet in most hardware stores, many of these lamps can be found in specialty lighting stores. There are fluorescent types which screw into the existing incandescent sockets. The cost for the fluorescent may be as much as $15 to $20, but it will pay for itself within 5 months and save the earth's atmosphere from 1500 lbs. of carbon dioxide, 12 lbs. of acid rain (sulfur dioxide) and 400 lbs. of coal.** How can these lamps accomplish this? A fluorescent lamp of this type uses only 18 watts of energy while providing the same lighting as a 75 watt incandescent unit. The lifetime of the fluorescents is close to 9000 hours as compared to the 1000 hours of most incandescents. While some people would prefer to maintain incandescent lighting in table lamps, the fluorescents are perfect for any bare lamp such as may be found in garages or basements. Also, flood lamps have fluorescent counterparts which can pay for themselves within 3 months. Moving away from residential a bit, the lighting business has developed and is marketing a fully electronic ballast for overhead fluorescent luminaires. This ballast can decrease atmospheric pollution by 6691 lbs. of carbon dioxide, 53 lbs of sulfur dioxide and 1781 lbs. of coal.** It also pays for itself within a year.

As a consumer, it would be nice to have a rough estimate of what kind of money one is really saving by buying these energy efficient lamps. Below is an example that can be easily calculated:

Replacing a 75 Watt incandescent with an 18 Watt fluorescent
(75-18) x (hours light is on during the year) x
(cost of electricity $/kwh) / 1000 watts/kw
Let's say the light is on 8 hours a day, 7 days per week
(75-18 w) x (8 x 365 hr/yr) x ($.07/kwh) / 1000 = $11.65
One also has to figure in the avoided cost of the incandescent bulbs you would have bought in the course of the year. At $1 for each bulb which lasted 1000 hrs, you would have had to buy 3 bulbs during the year, or $3 is saved. Now, if you take into account that the fluorescent will last you 3 years, the total savings of the energy efficient bulb is (3 x 11.65) + (3 X 3) or $43.95!

As seen by the example, one can save a significant amount of money using the new fluorescent bulbs. Not only do you, as the consumer, get a good deal money-wise, you also have the satisfaction that your lighting is actually helping to relieve the atmosphere of some of its possible pollutants. Buying new energy efficient luminaires is one more way in which you can follow through on the spirit of Earth Day.

**This information recieved from Conserve-A-Watt Lighting, Denver.

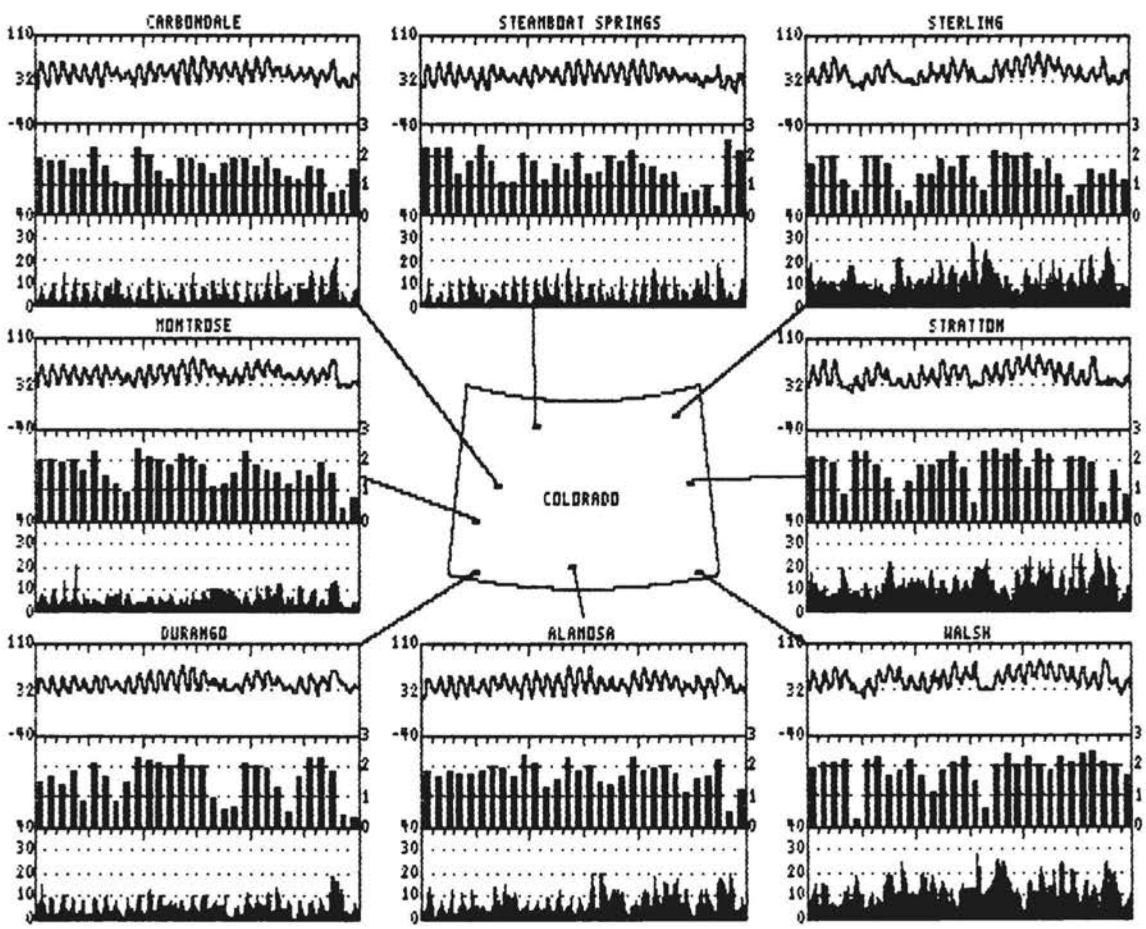
This article was written by Mary Sutter of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder, CO 80309-0428. Information on acquiring our weather data can by obtained by writing Mary Sutter at this address.

WTHRNET WEATHER DATA APRIL 1990

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)	44.0	44.2	46.0	49.3	42.6	46.2	47.7	51.5
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	72.3 16/14	72.7 14/15	74.7 16/15	75.9 15/16	69.3 15/13	79.2 22/16	80.4 22/14	81.1 22/13
minimum:	19.0 4/ 6	26.4 3/ 5	21.4 1/ 6	28.2 29/ 6	15.4 30/ 3	20.3 6/ 6	18.7 5/ 5	22.1 6/ 6
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	87 / 25	80 / 27	89 / 30	76 / 29	95 / 29	73 / 28	81 / 31	78 / 33
11 AM	39 / 26	48 / 30	42 / 29	45 / 32	44 / 29	43 / 30	48 / 34	39 / 32
2 PM	29 / 21	43 / 28	31 / 24	37 / 29	36 / 24	34 / 26	38 / 31	29 / 28
5 PM	35 / 23	47 / 28	31 / 23	36 / 27	40 / 25	36 / 24	39 / 28	31 / 28
11 PM	63 / 26	70 / 29	64 / 29	58 / 29	72 / 29	57 / 27	67 / 32	59 / 31
monthly average wind direction (degrees clockwise from north)								
day	208	195	251	217	226	143	141	150
night	168	90	180	160	142	209	198	207
monthly average wind speed (miles per hour)	5.74	4.05	4.12	4.40	4.28	9.95	10.56	10.21
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	221	348	364	257	364	28	19	46
3 to 12	426	356	329	451	309	494	461	429
12 to 24	73	16	27	12	47	188	234	236
> 24	0	0	0	0	0	10	6	9
monthly average daily total insolation (Btu/ft²·day)	1748	1571	1587	1662	1631	1513	1745	1903
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	136	96	106	110	109	143	174	211
40-60%	87	71	97	92	82	79	70	72
20-40%	76	73	112	88	83	73	61	47
0-20%	41	94	40	52	58	80	50	37

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

MAY 1990

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 13 Number 8

May in Review:

An early May snowstorm buried parts of southeastern Colorado. Frequent minor storm systems brought as many as 14 days of precipitation to northern Colorado, but clouds and sunshine were about average for this time of year. Precipitation totals ended up near or above average except in west central and northwest counties where totals were less than 50% of average. Temperatures were mostly below average east of the mountains and near average on the Western Slope.

Colorado's July Climate:

Every month I try to say something useful or profound about the kind of weather to expect for the coming month based on many years of historic observations. You may not have noticed it, but sometimes my descriptions are better than others. While what I try to tell you is generally true, it may not be true in a particular year. If it seems like my accuracy runs in cycles, you're right -- specifically, I am influenced by the annual cycle. It just so happens that in summer, weather patterns are most consistent, day to day changes are minimal, the effect of elevation is most consistent, and my "climate forecasts" (or climate descriptions from my point of view) are most accurate. The only problem is precipitation. Individual thunderstorm cells or clusters produce most of July's precipitation. They behave like clockwork, powered by the energy of the sun. But God only knows where they will hit. It is incredibly rare to make it through the month of July anywhere in Colorado without hearing rumbles of thunder, and it is almost a certainty that precipitation will fall. Yet it is the path of a single thunderstorm and the rainfall of a single hour that may determine if the month is much wetter or much drier than average.

So what can we say about July. It is summer at its consistent best. Temperatures behave quite predictably. At elevations below 7,000 feet, daytime temperatures climb into the 80's and 90's and lows fall into the 50's and 60's. Temperatures reliably decrease with elevation at a rate of about 5 degrees Fahrenheit per thousand feet. This makes the high country a welcome retreat when occasional heatwaves drive temperatures into the 90's and 100's down below. One episode of much cooler weather can also be expected sometime during the month.

Most days will have sunny mornings, clouds appearing over the mountains mid to late morning, afternoon thunder, maybe a rainbow, clearing later with a gorgeous sunset followed by a cool and calm night. Early July will have more sunshine, briefer storms (except out near Kansas) and hotter afternoons. Later in the month, humidity will increase (especially in eastern and southern Colorado) clouds will form earlier and lost longer. If you want to make sure you witness some lively thunderstorms, head to the Pikes Peak area. By the end of the month, there is a good chance that you will hear stories about somebody having a flood. Almost every year 4" or more of rain falls in an evening somewhere in the state. We keep our fingers crossed that no one will be hurt and the tragedy of the 1976 Big Thompson flood will be averted, but it remains a possibility.

Hydrologic Cycle -- Part II. The Lord Giveth and the Lord Taketh Away.

Last month we talked a little about evaporation. It is the component of the hydrologic cycle that is most forgotten about. In dry areas like Colorado where we need to make the most of our water supplies, it is extremely important to know as much as possible about evaporation. In the following paragraphs I want to point out a few characteristics of evaporation that should influence how we use and manage our water supplies.

(continued on page -9-)

MAY 1990 DAILY WEATHER

Date	Event
1-4	A strong upper level low pressure area spun over Arizona on the 1st as a cold high pressure area moved eastward across the plains. Cold temperatures covered the whole state, and snow fell heavily in parts of southern Colorado. Del Norte reported 7" of wet snow, 12" fell at Rio Grande Reservoir, 13" at Telluride and Westcliffe picked up 18". Mountain snows with low elevation rains continued on the 2nd over southern Colorado and tapered off in the southwest as the low moved northeastward. But over southeast Colorado rain and snow increased and continued into the 3rd. Parts of the southeast plains were shocked by 10-20" of wet snow by midday on the 3rd. Examples include 6" at Burlington, 9" at Pueblo, 13" at Rocky Ford and 18" near Kim. Tree limbs cracked and utilities were disrupted by the storm. In some areas this was the heaviest May snowfall in history. Meanwhile, northern Colorado enjoyed fairly pleasant weather with temperatures near 60°F. Skies cleared and snowcovered areas awoke to very cold temperatures on the 4th. Rocky Ford's 21°F was their coldest May temperature since 1909 when it dipped to 18° on May 1. Later on the 4th blustery northerly winds developed accompanied by a few mountain snow showers.
5-9	Clear and warmer statewide 5-6th. Increased clouds on the 7th as much cooler air moved back into northern Colorado, but highs reached the 70s and 80s over southern Colorado. The contrast helped trigger a few thunderstorms in northeast Colorado. The gradient continued on the 8th (Denver had a high of 50°F while Pueblo reached 83°F) and more widespread storms developed mostly in eastern Colorado. A few inches of snow fell in the northern and central mountains. Thunderstorms gave way to cold rains early on the 9th in northeastern Colorado followed by a brief period of snow as unseasonably cold air surged into Colorado. Akron reported 2" of snow. The cold air also chilled the Western Slope, and some fruit orchard areas experienced a damaging freeze. The low temperature at Cedaredge dipped to 26°. The 3° reading at Climax was the coldest in the State for May. It was cold again on the 10th and many areas east of the mountains had their last freeze of the spring.
10-20	An active jet stream produced a series of minor storm systems and predominantly west to southwest winds aloft. Disturbances crossed the State on the 11th, 13th, 16th, 18th and 20th. Precipitation was fairly light with each system, and hardly any precipitation accompanied the storms on the 18th and 20th. Cold rains and mountain snows were heaviest 15-16th. For example, from the 12th to the 16th Marvine Ranch received 1.35" of moisture. Eagle received 0.75" on the 15th. Winter Park reported 6" of snow on the 16th. Some areas had precipitation on as many as 7 days during this period. Also, scattered thunderstorms were common east of the mountains. Holyoke reported 0.78" of rain late on the 15th and a tornado was spotted near Paoli. The northern and central mountains benefited the most from this weather pattern. Temperatures remained cool suppressing mountain snowmelt, and cold rains and wet snows added slightly to the snowpack.
21-27	The first real episodes of summerlike weather got the spring snowmelt rolling 21-24th and raised temperatures at low elevations into the 80s. Cortez reached 82° on the 22nd and Greeley hit 87° on the 23rd. Campo and Springfield shared honors for the State's hot spot with 97° readings on the 23rd. Cooler air slipped into Colorado on the 24th and triggered some severe weather in northeast Colorado late. Southeast Wyoming was hard hit with several tornadoes that evening. The mountains and Western Slope remained dry 25-27th, but increasing moisture and a weak upper air disturbance tripped off major thunderstorm activity east of the mountains especially on the 26th. Akron had a heavy storm late on the 25th. Colorado Springs was zapped with 1.63" of rain on the 26th. There were also several reports of localized hail.
28-31	An unusually strong Pacific storm system for this time of year moved across California and headed to Colorado. Some rains began in southwest Colorado late on the 28th. Strong thunderstorms erupted that evening along the Front Range. More than 2" of rainfall was reported along the foothills from Lyons to north of Fort Collins. Storms and cooler temperatures became widespread on the 29th. Precipitation was light west of the mountains, but many parts of eastern Colorado had moderate to heavy storms. A small tornado was even reported in Denver. The storm system drifted eastward but still helped trigger another round of thunderstorms along the Front Range late on the 30th. The month ended with cool temperatures, high humidity, and a few local showers.

May 1990 Extremes

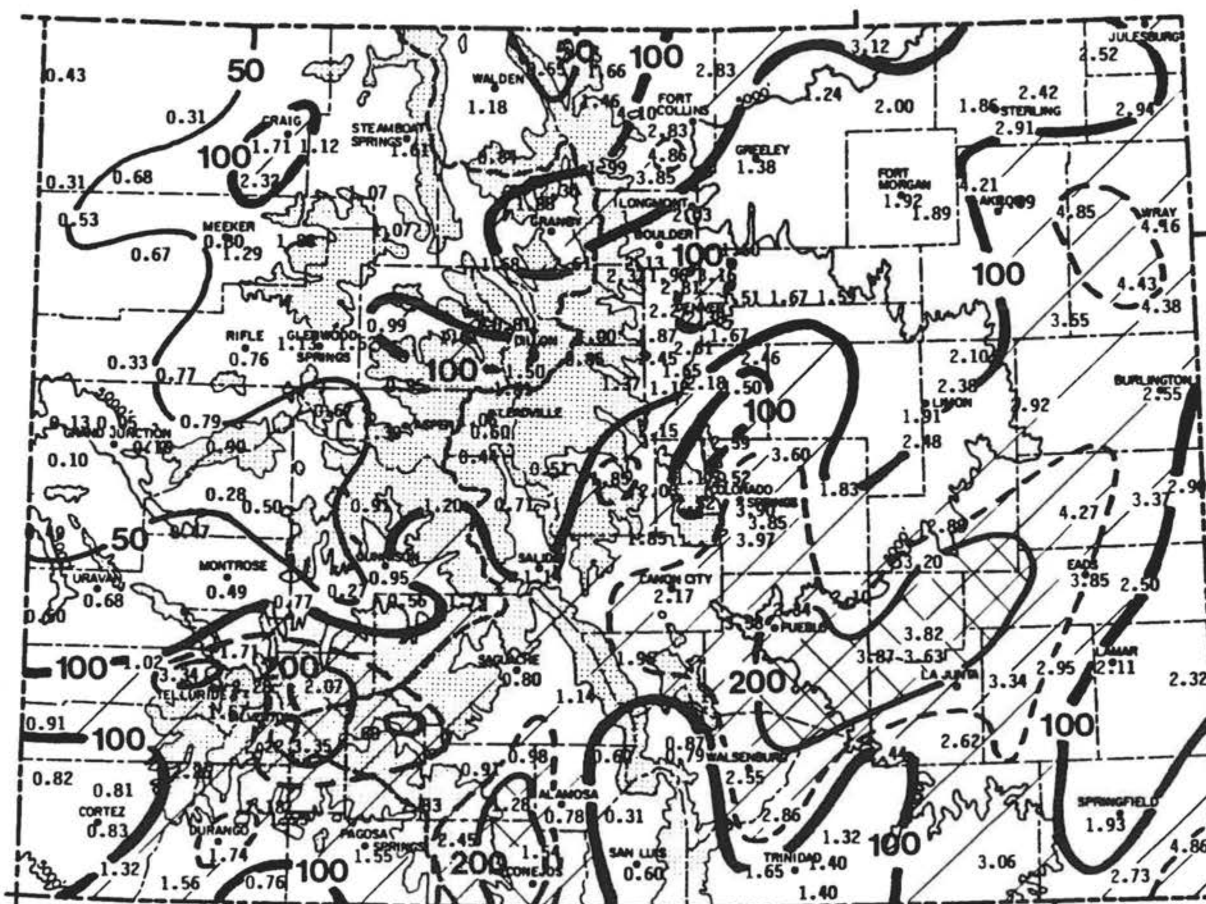
Highest Temperature	97°F	May 23	Campo 7S, Springfield 7WSW
Lowest Temperature	3°F	May 9	Climax
Greatest Total Precipitation	4.86"		Stonington, Waterdale
Least Total Precipitation	0.05"		Grand Junction WSO AP
Greatest Total Snowfall*	29"		Westcliffe

* For existing weather stations with complete daily records. Higher values are likely for unmonitored locations.

MAY 1990 PRECIPITATION

Not much moisture fell across southern Colorado after May 3. However, the early May storm that dropped 1-2" of moisture (much in the form of snow) was enough to keep May totals near or above average. Fowler totaled 3.87" for the month, more than 300% of average. Meanwhile, northeastern Colorado escaped the early storm and missed much of their normal May rains. Fortunately, a big storm dropped 1-3" of rain during the last few days of the month and brought their totals back up to near average. Western Colorado did not fare as well. Mountain precipitation was excellent in the San Juans, but totals deteriorated to the north. Western Valleys were especially dry during this critical time of year quickly raising concerns over forest and rangeland fire potential later this summer. From Dinosaur National Monument south to Grand Junction and Paonia, May precipitation was less than 50% of average. The Grand Junction airport received a meager 0.05", the lowest in the State.

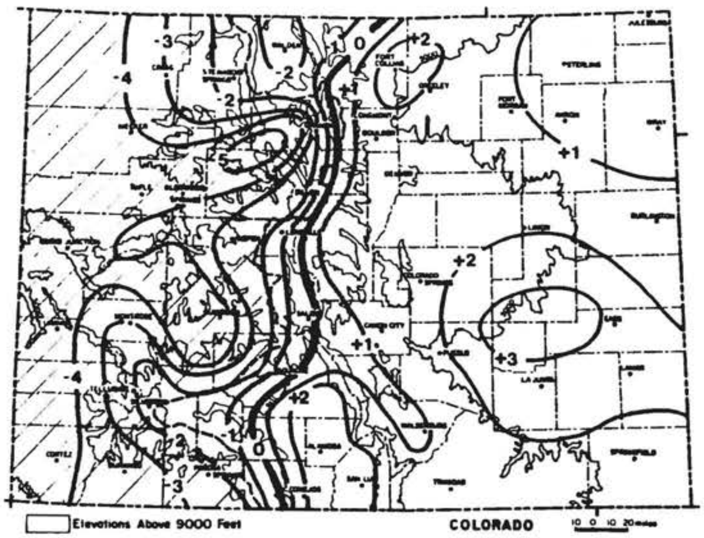
Greatest		Least	
Stonington	4.86"	Grand Juction WSO	0.05"
Waterdale	4.86"	Colorado Natl. Mon.	0.10"
Yuma	4.85"	Grand Junction 6ESE	0.11"
Idalia 5NNE	4.43"	Fruita	0.13"
Bonny Lake	4.38"	Palisade	0.16"
Kit Carson 6S	4.27"	Blue Mesa Dam	0.27"



Precipitation amounts (inches) for May 1990 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

Precipitation since October 1989 is near or above average over most of the eastern 2/3 of Colorado. This is a marked improvement over our situation at this same time last year. The Arkansas Valley below Canon City has enjoyed a particularly good year so far with more than 150% of average moisture in some areas. (Pueblo totalled 70" of snowfall for the winter, their snowiest on record.) But spring precipitation has not been sufficient on Colorado's Western Slope to compensate for previous deficits, and most of Western Colorado remains dry. Paradox, for example, has received only 48% of their average precipitation so far. Grand Junction stands at 57%. While these values are much better than at this point in 1977, this now represents the 2nd, 3rd or 4th consecutive year (depending on the particular location) with below average moisture. The Palmer Index values show the impact of these longer term deficits in western Colorado.

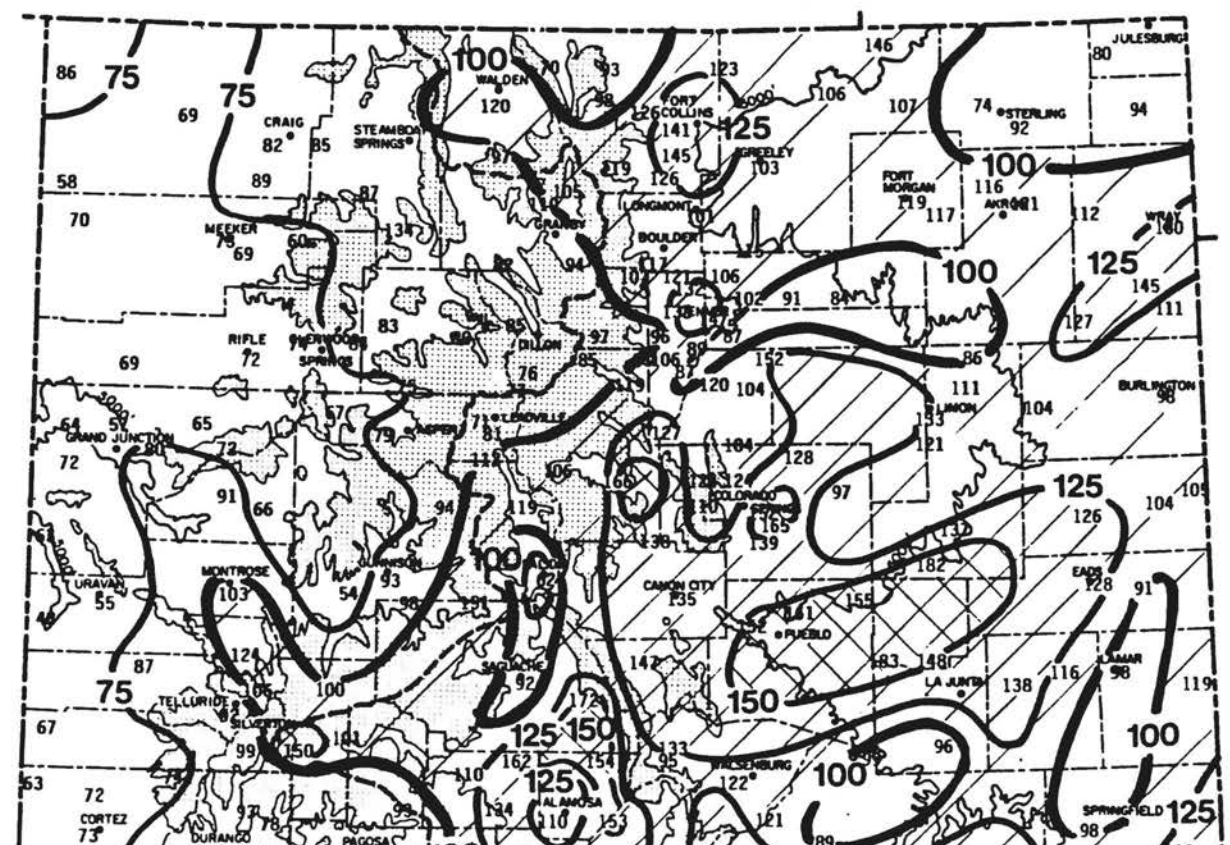


PALMER INDEX:

The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

Interpretation of Index

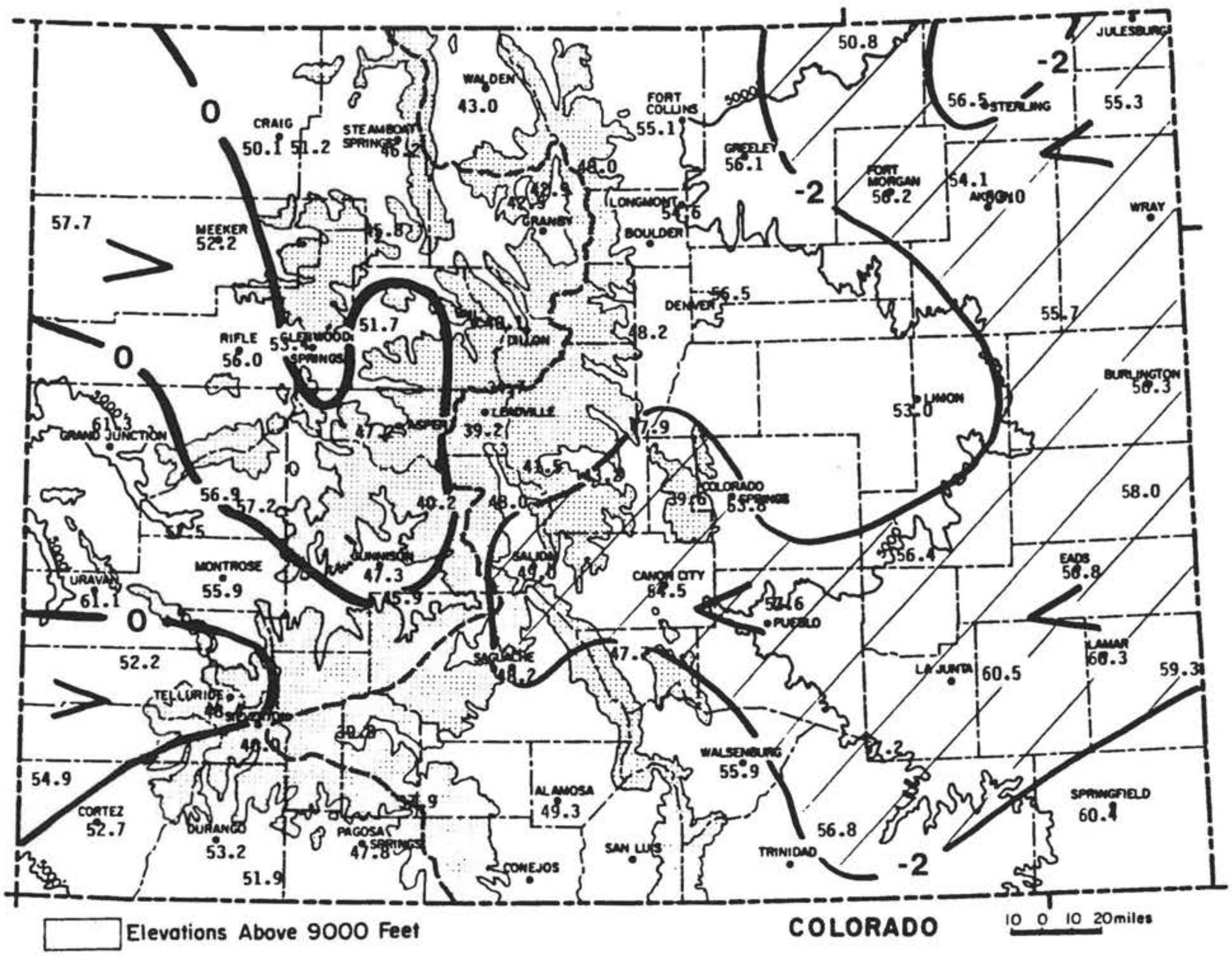
	extremely wet
+4	----------------
+3	ample moisture
+2	----------------
+1	
0	near normal
-1	
-2	----------------
	moderate drought
-3	----------------
	severe drought
-4	----------------
	extreme drought



Precipitation for October 1989 through May 1990
as a percent of the 1961-1980 average.

MAY 1990 TEMPERATURES AND DEGREE DAYS

Cool weather in May suppressed early snowmelt from the high mountains and temporarily ended our recent stretch of consecutive warm months. Some record cold was observed in early May in southeastern Colorado following their snowstorm. Also, a freeze on May 9th caused some damage to the Western Slope fruit industry. East of the mountains several areas had their last spring freeze on May 10, a few days later than average. Overall, May temperatures ended up 1 to 4 degrees below average most everywhere east of the Continental Divide. In western Colorado, temperatures were essentially average.



May 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

MAY 1990 SOIL TEMPERATURES

Soil temperatures have lagged behind average during much of the spring. During the last half of May they finally rose sharply to levels suitable for germinating seeds and initiating more rapid vegetative growth.

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.

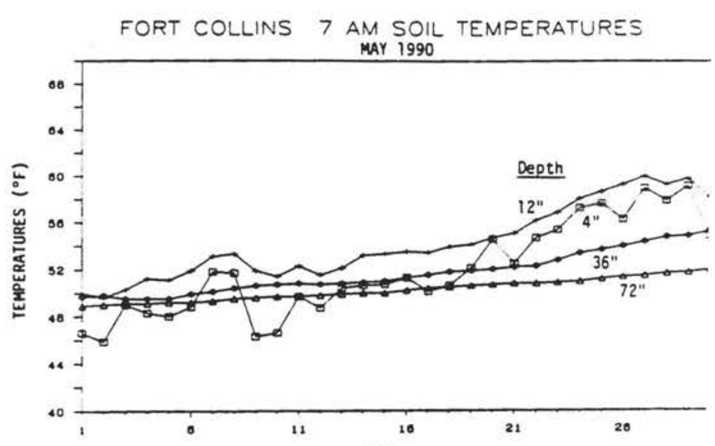


Table 1. Heating Degree Day Data through May 1990 (base temperature, 65°F).

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
	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132	1449	1401	1205	1043	833	689		9421
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729	1230	985	922	787	449	275		6000
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069	1574	1647	1254	906	672	540		8968
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684	1176	1030	887	638	309	188		5334
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138	1507	1499	1265	1188	920	793		10432
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762	1252	1078	991	815	555	364		6536
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749	1302	1048	994	917	552	319		6575
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869	1261	1169	1071	795	507	387		6841
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768	1156	1186	895	654	425	285		5928
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964	1298	1491	1160	873	630	524		8012
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676	1204	964	877	695	394	233		5510
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M	1130	1191	923	657	392	281		M
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974	1533	1580	1332	971	658	576		M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719	1254	1074	1026	760	427	275		M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869	1264	1273	1023	922	664	509		7685
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633	1153	980	874	681	420	266		5488
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075	1490	1359	1287	1068	796	674		9423
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581	1047	848	800	666	408	289		5103

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001	1400	1554	1089	880	640	480		8112
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974	1365	1365	1086	915	697	543		8163
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M	M	M	M	M	502	321		M
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812	1202	1184	991	857	660	518		7273
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684	1229	990	957	757	459	280		M
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584	1076	859	827	687	421	325		5289
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699	1163	966	928	805	526	345		6081
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850	1166	1222	959	776	490	377		6492
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892	1420	1319	1257	879	530	453		7621
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M	M	1161	865	626	355	237		M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658	1160	879	882	781	469	265		5671
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124	1495	1506	1271	1124	886	764		10116
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789	1133	1278	965	724	479	359		6374
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896	1348	1286	986	806	545	269		7007
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818	1221	1115	1030	932	662	513		7440
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711	1166	930	910	848	495	307		5997
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721	1285	1087	1010	776	M	274		M
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729	1103	1124	820	557	271	139		5099

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

MAY 1990 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	64.7	36.9	50.8	-4.2	84	24	433	1	240	3.12	0.75	131.6	12
STERLING	70.2	42.7	56.5	-1.5	91	30	275	18	328	1.86	-1.33	58.3	10
FORT MORGAN	69.4	43.1	56.2	-2.1	88	32	274	13	315	1.92	-0.54	78.0	9
AKRON FAA AP	67.1	41.1	54.1	-2.4	87	29	337	5	278	4.21	1.11	135.8	12
AKRON 4E	66.5	39.5	53.0	-3.4	87	27	372	6	265	4.09	0.89	127.8	13
HOLYOKE	67.0	43.5	55.3	-3.8	87	30	307	11	281	2.94	-0.10	96.7	11
JOES	69.5	41.9	55.7	-2.8	88	29	290	9	318	3.55	0.95	136.5	8
BURLINGTON	69.2	43.3	56.3	-3.1	89	31	280	19	321	2.55	-0.21	92.4	5
LIMON WSMO	66.6	39.4	53.0	-0.1	83	28	364	1	271	1.91	-0.27	87.6	8
CHEYENNE WELLS	72.4	43.7	58.0	-1.7	91	29	229	20	364	3.37	0.37	112.3	6
EADS	70.5	43.2	56.8	-4.4	92	30	269	23	327	3.85	1.26	148.6	4
ORDWAY 21N	71.8	41.1	56.4	-3.3	92	26	277	19	355	3.20	1.58	197.5	9
LAMAR	75.9	44.7	60.3	-2.8	95	30	188	50	410	2.11	-0.50	80.8	8
LAS ANIMAS	76.3	44.7	60.5	-2.8	95	27	188	55	416	3.34	1.39	171.3	11
HOLLY	74.4	44.2	59.3	-2.9	93	30	206	36	388	2.32	-0.32	87.9	7
SPRINGFIELD 7WSW	77.5	43.3	60.4	0.1	97	29	182	46	440	1.93	-0.76	71.7	5
TIMPAS 13SW	72.7	41.8	57.2	-3.6	93	27	235	18	346	1.44	-0.17	89.4	2

Foothills/Adjacent Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	68.7	41.4	55.1	-1.2	85	31	307	5	302	2.83	0.20	107.6	12
GREELEY UNC	70.6	41.7	56.1	-1.7	87	31	275	7	328	1.38	-1.27	52.1	8
ESTES PARK	61.8	34.2	48.0	-0.0	77	24	522	0	197	1.99	0.02	101.0	11
LONGMONT 2ESE	70.9	38.4	54.6	-2.5	89	27	319	6	330	2.03	-0.33	86.0	6
DENVER WSFO AP	70.7	42.4	56.5	-0.6	86	30	265	9	334	1.51	-0.68	68.9	12
EVERGREEN	63.9	32.5	48.2	-0.8	79	23	513	0	230	1.87	-0.71	72.5	6
CHEESMAN	66.1	29.6	47.9	-2.7	84	20	525	0	261	2.15	0.39	122.2	9
LAKE GEORGE 8SW	57.1	29.2	43.2	-3.0	72	21	668	0	143	1.85	0.66	155.5	9
ANTERO RESERVOIR	57.7	25.3	41.5	-1.5	71	14	720	0	150	0.51	-0.31	62.2	8
RUXTON PARK	53.7	25.5	39.6	-3.7	73	14	781	0	108	2.52	-0.01	99.6	12
COLORADO SPRINGS	66.8	40.8	53.8	-1.7	84	30	345	6	279	3.90	1.93	198.0	10
CANON CITY 2SE	68.5	40.5	54.5	-3.8	86	25	325	10	312	2.17	0.74	151.7	6
PUEBLO WSO AP	74.1	41.2	57.6	-3.6	92	27	233	13	384	2.34	1.25	214.7	7
WESTCLIFFE	63.4	31.9	47.7	-1.7	77	21	530	0	236	1.96	0.71	156.8	5
WALSENBURG	71.7	40.1	55.9	-1.6	88	24	289	13	361	2.55	1.14	180.9	7
TRINIDAD FAA AP	73.7	39.9	56.8	-2.2	89	24	266	18	387	1.32	-0.22	85.7	5

Mountains/Interior Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	59.7	26.2	43.0	-1.1	74	14	674	0	165	1.18	0.06	105.4	9
LEADVILLE 2SW	54.0	24.4	39.2	-0.3	66	17	793	0	96	0.60	-0.60	50.0	6
SALIDA	65.4	32.6	49.0	-3.3	80	20	489	0	265	1.14	0.02	101.8	7
BUENA VISTA	64.0	32.0	48.0	-1.9	79	22	518	0	240	0.71	-0.19	78.9	7
SAGUACHE	63.6	32.7	48.2	-2.1	77	27	514	0	226	0.80	0.11	115.9	4
HERMIT 7ESE	55.9	23.7	39.8	-1.7	70	17	773	0	125	1.60	0.59	158.4	3
ALAMOSA WSO AP	67.1	31.5	49.3	-1.2	78	22	480	0	281	0.78	0.09	113.0	6
STEAMBOAT SPRINGS	63.0	29.3	46.2	-1.3	76	16	576	0	212	1.61	-0.40	80.1	8
YAMPA	60.8	30.8	45.8	-1.1	72	21	589	0	180	1.07	-0.23	82.3	7
GRAND LAKE 1NW	59.7	26.1	42.9	0.6	72	16	676	0	167	2.30	0.40	121.1	11
GRAND LAKE 6SSW	59.4	25.6	42.5	-1.2	72	11	689	0	159	1.88	0.54	140.3	14
DILLON 1E	54.5	25.7	40.1	-2.2	69	17	764	0	104	0.81	-0.39	67.5	9
CLIMAX	47.3	22.1	34.7	-0.9	64	3	931	0	24	1.81	-0.04	97.8	9
ASPEN 1SW	60.5	33.8	47.2	0.2	73	23	543	0	175	1.30	-0.80	61.9	8
TAYLOR PARK	54.4	26.0	40.2	3.9	67	18	762	0	97	1.20	0.04	103.4	5
TELLURIDE	65.7	31.2	48.4	2.3	76	17	509	0	252	1.57	-0.06	96.3	5
PAGOSA SPRINGS	67.1	28.6	47.8	-1.3	80	22	524	0	274	1.55	0.49	146.2	9
SILVERTON	58.2	21.7	40.0	-0.9	70	14	767	0	145	2.22	0.84	160.9	6
WOLF CREEK PASS 1	51.2	24.6	37.9	-1.2	63	12	833	0	62	2.83	0.90	146.6	7

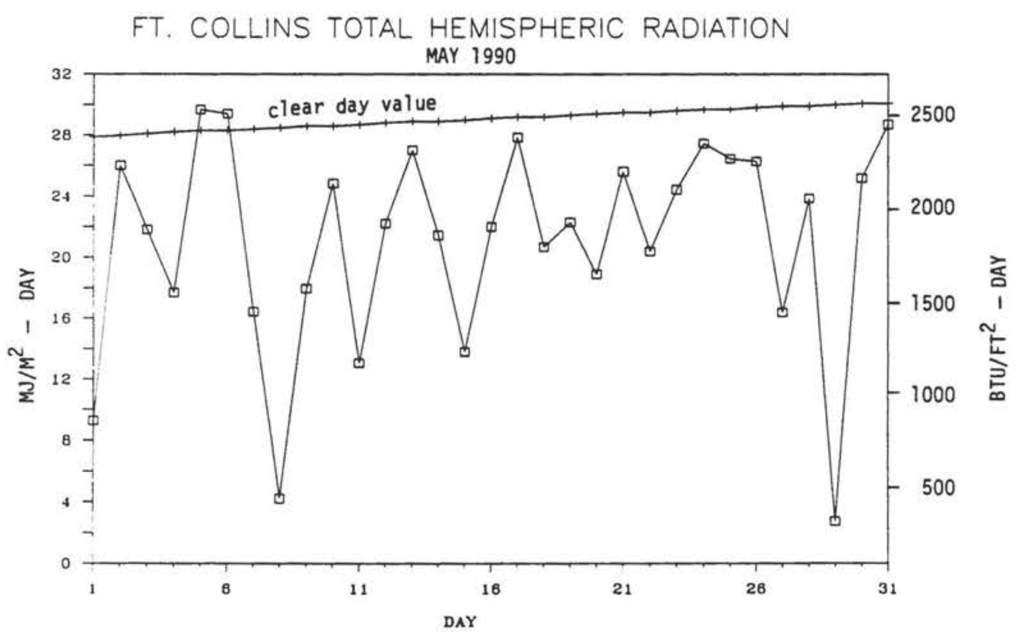
Western Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	65.6	34.6	50.1	-1.4	78	25	453	0	250	1.71	0.06	103.6	12
HAYDEN	67.6	34.8	51.2	-0.3	81	22	421	0	279	1.12	-0.16	87.5	9
MEEKER NO. 2	69.0	35.5	52.2	0.8	80	23	387	2	306	0.80	-0.57	58.4	7
RANGELY 1E	73.3	42.1	57.7	1.3	85	28	231	10	375	0.53	-0.38	58.2	5
EAGLE FAA AP	70.3	33.2	51.7	0.6	83	22	405	0	324	0.99	0.32	147.8	4
GLENWOOD SPRINGS	70.1	36.8	53.4	-1.1	84	29	353	1	320	1.13	-0.32	77.9	6
RIFLE	74.8	37.1	56.0	0.6	87	23	281	7	395	0.76	-0.20	79.2	3
GRAND JUNCTION WS	75.8	46.8	61.3	-0.7	90	33	139	34	427	0.05	-0.77	6.1	3
CEDAREDGE	73.5	40.3	56.9	0.4	86	26	261	16	383	0.28	-0.84	25.0	2
PAONIA 1SW	72.9	41.5	57.2	0.4	88	25	248	14	364	0.50	-0.79	38.8	8
DELTA	75.5	39.5	57.5	-2.0	89	33	237	13	406	0.47	-0.09	83.9	5
GUNNISON	65.7	28.8	47.3	0.2	77	22	540	0	258	0.95	0.33	153.2	4
COCHETOPA CREEK	64.5	27.2	45.9	-0.0	77	19	583	0	235	0.56	-0.12	82.4	5
MONTROSE NO. 2	69.9	41.9	55.9	-0.9	82	28	285	7	327	0.49	-0.27	64.5	6
URAVAN	77.7	44.5	61.1	-0.2	90	34	141	29	443	0.68	-0.33	67.3	6
NORWOOD	67.5	36.9	52.2	1.1	79	17	388	0	281	1.02	0.01	101.0	4
YELLOW JACKET 2W	71.0	38.8	54.9	1.2	83	25	305	0	332	0.82	-0.37	68.9	5
CORTEZ	70.6	34.8	52.7	-0.7	82	15	377	0	329	0.83	-0.09	90.2	5
DURANGO	71.8	34.6	53.2	-0.1	84	28	359	0	346	1.74	0.62	155.4	6
IGNACIO 1N	68.4	35.5	51.9	-0.5	81	30	399	0	293	0.76	-0.10	88.4	6

* 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 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	7	17	7	--	--
Denver	6	17	8	68%	65%
Fort Collins	4	18	9	--	--
Grand Junction	11	10	10	71%	71%
Pueblo	11	14	6	75%	73%

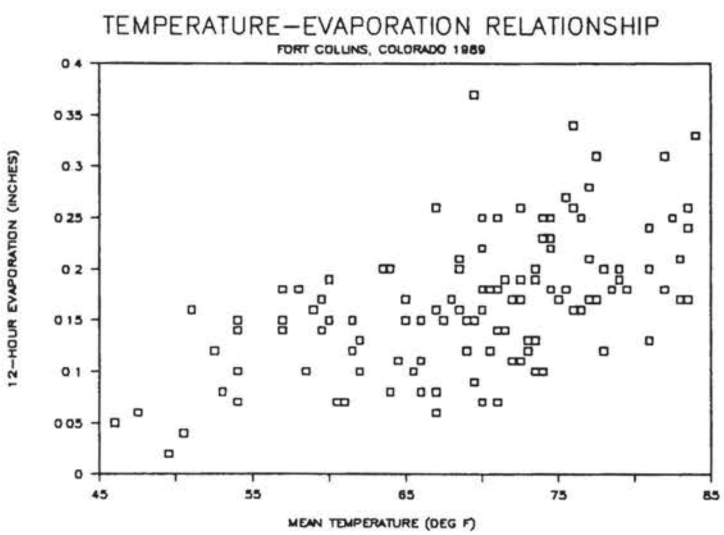


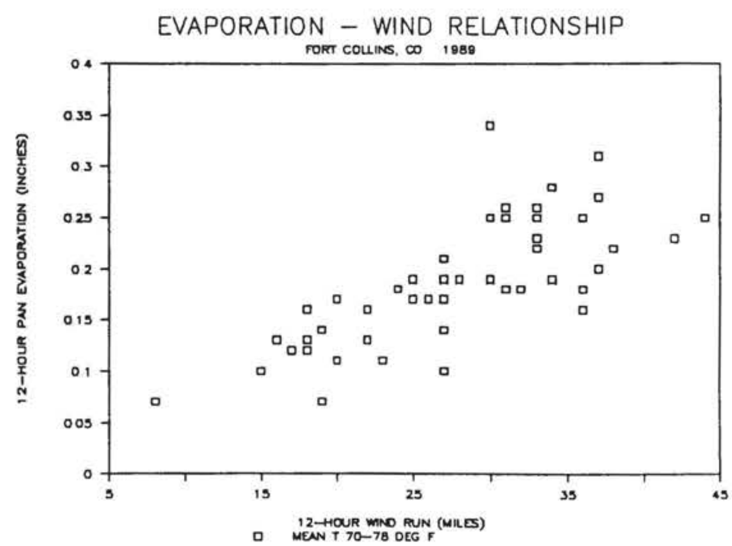
Hydrologic Cycle -- Part II. The Lord Giveth and the Lord Taketh Away continued:

The first point that I want to make is that evaporation varies greatly from one part of Colorado to another. The best maps that I am aware of come from the 1982 National Weather Service "Evaporation Atlas for the Contiguous 48 United States." If you do much work with water resources, you should get this report. It includes national maps of pan evaporation and free water surface evaporation. Free water surface evaporation is approximately the amount of water that would evaporate from a shallow lake. Deeper lakes normally are colder and experience lower rates of evaporation. Other ponds such as sewage lagoons or power plant cooling lakes may have higher evaporation rates depending on how they are operated. For the entire year, average free water surface evaporation ranges from more than 60" in southeastern Colorado to less than 35" in the mountains above about 9000 feet. Along the Front Range urban corridor, free water surface evaporation ranges from about 40" near Fort Collins to nearly 50" near Pueblo. Over most ot Colorado, evaporation exceeds precipitation. That is not the case everywhere. For comparison, equivalent evaporation in New York State is about 29" (with about 40" of precipitation), Alabama has about 40" of evaporation (about 53" of precipitation) and Iowa receives about 30" of precipitation but can evaporate about 39" from water surfaces. Death Valley, CA compares with about 100" of potential evaporation. One practical application of this information that has long been known is that reservoirs, when possible, should be built where evaporation rates are relatively low. In Colorado, that means that reservoirs in the mountains lose less water than in the lower valleys and on the plains. For example, Blue Mesa Reservoir near Gunnison loses less than 40". Evaporation rates are nearly double from Lake Mead near Las Vegas, NV.

A second key point is that evaporation rates are much greater during the day than at night. Pan evaporation measurements at Fort Collins have shown that evaporation rates between 7 AM and 7 PM are nearly 3 times greater than during the 7 PM to 7 AM nighttime period. The recommendations to water our yards and gardens at night are based on this knowledge. It makes good sense.

A third point that I would like to make is that wind is an important factor in determining evaporation losses. The dominant control on evaporation rates here in Colorado tends to be temperature, but in any given temperature range, wind speed makes a huge difference. The graphs below demonstrate this point. Over the May through September time period, these Fort Collins data from last year show that daytime (7 AM to 7 PM) evaporation increases with temperature at a rate of about .05" per 8 degrees F but with considerable variability. Focusing on just those days when the mean 7 AM - 7 PM temperature was between 70 and 78 degrees, you can see that wind speed (as indicated by the 12-hour values of total wind run) explained most of the variation. In fact, doubling the wind run from 20 to 40 miles typically doubles the pan evaporation from about .13" to about .25". The lesson that we learn here is that watering during windy periods or storing water in windy locations is going to result in greater evaporation losses. Also, if there is some way to increase friction near the surface such as fences, trees, tall grass, etc., ground level winds could be lowered and evaporation reduced. We could put huge barriers around all our lakes and reservoirs; better yet, put a roof over them; but that wouldn't make sailers and sail boarders very happy.





In summary, the hydrologic cycle is a marvelous way of circulating water across the globe. Precipitation and streamflow are obvious visible components of the cycle that we measure and experience. Evaporation is much harder to observe. We don't want to suppress it entirely -- that would mean killing all vegetation, covering all bodies of water and ultimately modifying other aspects of our climate. But by understanding our climate there are ways we can manage our water resources to reduce unnecessary evaporation.

Most people take for granted that there will be hot water for their morning shower or for washing dishes. The water heater is the trusty cylinder that sits down in the basement, patiently chugging out the needed hot water. There are two main ways to give the water the energy it must have to become warm; electricity and natural gas (or propane). Both give us hot water for a relatively low cost. However, both are also part of the energy use that America needs to reduce. Another way to heat the water we use is through the renewable source of the sun. Solar water heaters have advantages and disadvantages (as do most energy sources).

The pros and cons come out when a closer look is taken at the different kinds of solar water heaters that can be used. Two such heaters are the direct heater and the indirect heater. Both are active systems (meaning that there are pumps and other mechanical parts that move the fluids). The direct solar water heater is shown is Figure 1. The water that is used from the tank is directly passed through the flat plate collectors to be heated. If there is not enough sun to heat the water to the correct temperature, an electric resistance heating element within the storage tank will kick in to bring the water up to the desired temperature. Disadvantages to this kind of system can be thought of readily. Freezing of the water while it is in the collector or piping can cause major damage. Everywhere the water contacts must be made of copper since the water contains oxygen which would corrode steel or aluminum. Also, the system must be capable of withstanding the water pressure used by the city. In some cases the advantages may overcome these disadvantages. This system is less expensive to buy and maintain. There are less pumps than the indirect system, and so less chance of mechanical failures. Also, it is a more efficient system because the heat does not have to pass through a heat exchanger.

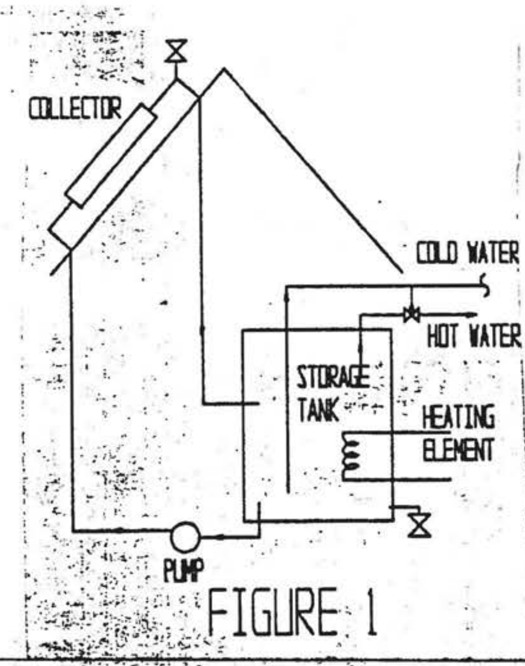


FIGURE 1

Figure 2 shows an example of one type of indirect system. The main difference between the two is the exchange of heat from the fluid that goes through the collector (some non-freezing fluid) and the water that is to be used in the home. It is a more expensive system. The indirect aspect of it does allow for colder weather and different materials for piping. In this system, the key new component is the heat exchanger. If sized improperly, it could cost you more than needed or not provide enough hot water.

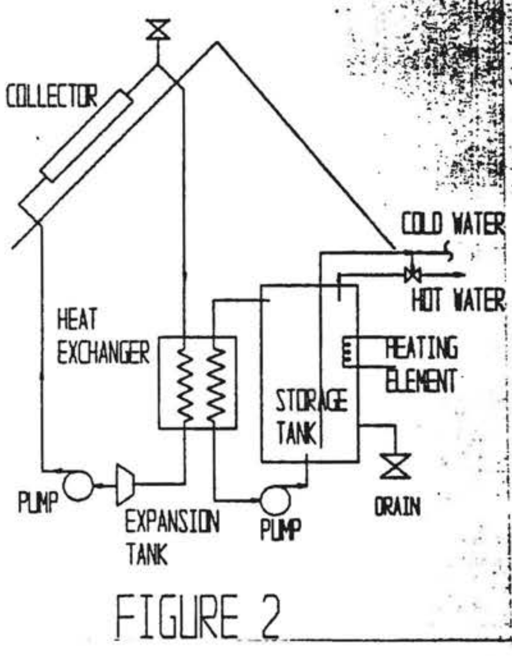


FIGURE 2

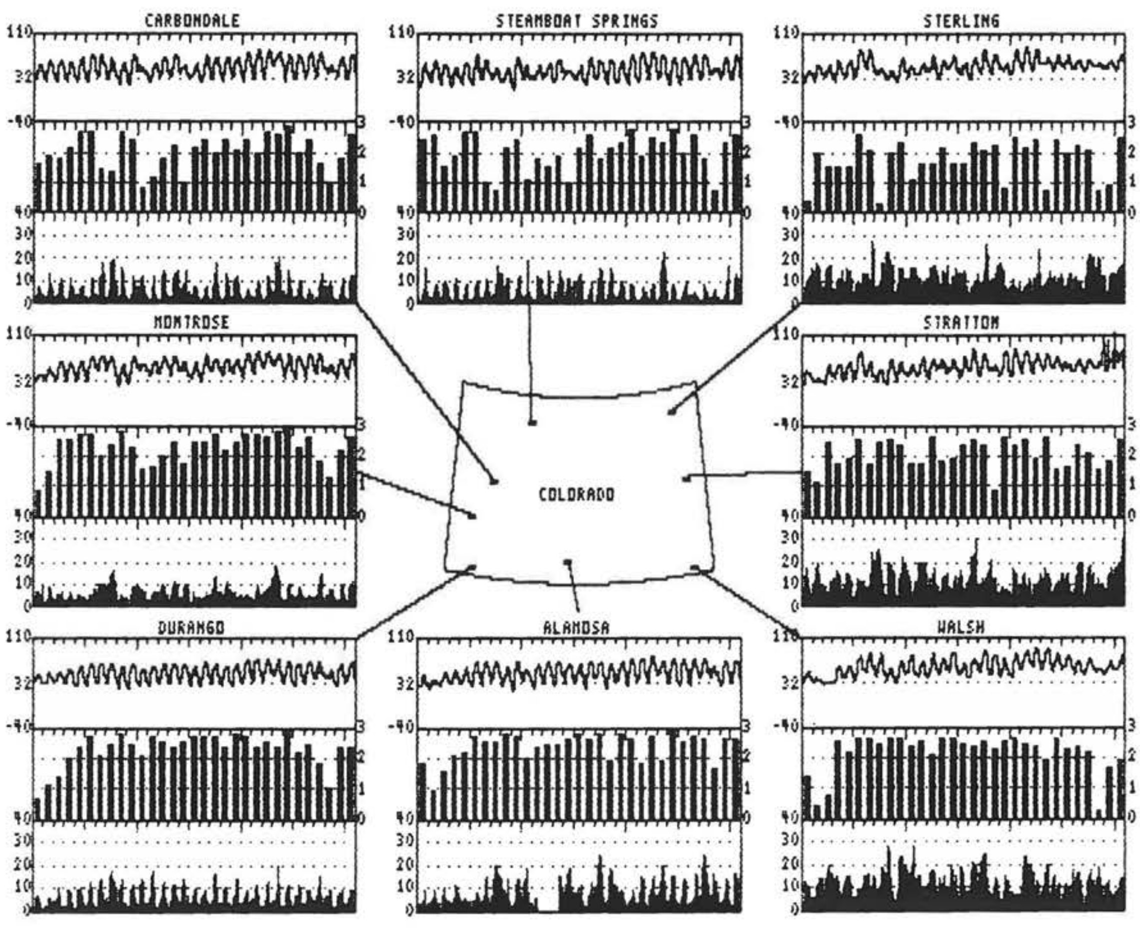
A solar hot water heater, whether direct or indirect, can be one way to conserve our finite fuel resources without giving up the accustomed habit of hot water on demand. In a future Colorado Climate we will discuss passive solar water heaters.

This paper was written by Mary Sutter of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder, CO 80309-0428. Information on acquiring our weather data can be obtained by writing Mary Sutter at this address.

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)								
	50.7	49.5	51.7	56.7	46.8	53.6	56.5	58.7
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	77.2 23/14	74.5 22/14	79.9 22/16	83.3 22/15	75.9 23/13	83.8 22/15	112.3 30/23	90.9 23/12
minimum:	21.9 10/ 5	25.5 9/ 6	23.4 10/ 5	25.0 9/ 5	16.2 10/ 5	28.9 1/ 5	28.6 3/ 5	31.6 3/ 4
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	70 / 23	68 / 24	81 / 28	53 / 23	95 / 28	73 / 34	82 / 40	70 / 37
11 AM	28 / 22	34 / 27	28 / 24	28 / 25	36 / 28	44 / 36	53 / 42	38 / 35
2 PM	22 / 21	26 / 24	23 / 22	22 / 24	32 / 25	37 / 33	43 / 40	30 / 32
5 PM	22 / 20	27 / 22	24 / 21	22 / 22	30 / 24	37 / 32	40 / 38	29 / 30
11 PM	41 / 20	50 / 23	49 / 26	34 / 21	68 / 30	62 / 36	69 / 42	56 / 35
monthly average wind direction (degrees clockwise from north)								
day	137	225	227	230	233	166	142	160
night	135	84	177	156	129	194	172	213
monthly average wind speed (miles per hour)								
	6.61	4.93	4.83	4.82	4.13	10.04	10.62	10.39
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	206	327	351	239	397	14	7	26
3 to 12	376	369	339	482	306	512	478	450
12 to 24	127	48	54	23	41	216	253	262
> 24	3	0	0	0	0	2	6	6
monthly average daily total insolation (Btu/ft²·day)								
	2369	2286	2033	2255	2030	1749	2049	2162
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	174	133	160	147	138	172	178	228
40-60%	67	67	77	95	88	84	102	82
20-40%	48	50	90	57	77	78	74	54
0-20%	22	56	31	25	46	89	40	42

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour. Stratton has had a temperature anomoly. It is highly unlikely that the highest temperature for the month (112) occured at 11 p.m. and should be regarded as incorrect. Because of this anomoly, we cannot determine for certain when the highest monthly temperature did occur.



COLORADO CLIMATE

JUNE 1990

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 13 Number 9

June in Review:

June 1990 began with a brief but wicked mountain snowstorm. Next came devastating tornadoes (Limon and elsewhere, June 6th) in keeping with June's severe weather reputation. Then, after a few normal June days in mid month, a major heatwave developed that dry-roasted the whole state and sent wildfire danger soaring. In total, it was one of the 10 hottest Junes in the past 100+ years, and precipitation was well below average over most of the State.

Colorado's August Climate:

Climatology rarely provides a perfect forecast but usually presents an appropriate perspective on what Mother Nature might produce. August, like July, has a well-deserved reputation for being consistent. Except for the hit-or-miss characteristics of thunderstorms that rumble over most of the State, other aspects of climate are well behaved. Temperatures change little from day to day and are controlled mostly by elevation -- the higher you go, the colder it gets. Extremes of temperature are unusual. It can get hot, but by August, the worst of the summer heatwaves are usually over. As the month progresses, daylength shortens noticeably. As it does, temperatures begin to cool gradually. By the end of the month, the mountain air can get surprisingly nippy. It won't be long until the high aspen trees begin to turn color. August winds are normally quite light. There are few cloudy days, but most days have afternoon cloud development.

The most active aspect of August climate is the thunderstorm development. August is typically not as stormy as July, and tornadoes and severe weather become ever less likely as the month progresses. However, there is enough moisture around to spawn plenty of moderate intensity storms. Early in the month, Monsoon moisture often covers the whole state and thunderstorms are heavy and widespread. Flash flooding is a real risk primarily along the Front Range and in and near the southern mountains. After about the second week of the month, northern Colorado begins to dry out, but storms continue to dampen southern portions. I hope to be in Pueblo for the State Fair and the big exhibit on Colorado water. That is almost sure to bring rain.

Expect August precipitation to total up to about 1" in northwestern Colorado. The region east of the mountains can expect 1.20" to 2.50" with greatest amounts normally falling on the Palmer Ridge and the Raton Plateau while the Platte Valley is normally the driest location. In the mountains, 2" to 3" of rainfall is normal with as much as 4" possible in some of the southern mountains. Daily temperatures average in the 80s and low 90s at lower elevations with lows mostly in the 50s. In the mountains, daytime temperatures reach into the 60s and 70s depending on the elevation with lows in the 30s and 40s. By month's end, subfreezing temperatures are quite likely in several areas.

The Pure-Bred Heatwave -- Late June 1990

The global warming cats are on the prowl again. The late June heatwave cooked Colorado and much of the Southwest, sent the mercury over 120°F for the first time in history in Phoenix, Arizona, accelerated the spread of numerous wildfires and generally increased the overall awareness in the West's drought situation. It was an interesting demonstration of what some people think we'll be seeing more of in the years to come. Here in Colorado, we've chuckled at some of our nation's heatwaves in recent years. Our cool nights, low humidities and afternoon cloud buildups often shield us from discomfort. But this time even we took our lumps. The entire State experienced abnormal heat. Countless individual daily record highs were broken. Several locations equalled or exceeded their hottest June temperature on record. At least 76 official weather stations

(continued on page -9-)

J U N E   1 9 9 0   D A I L Y   W E A T H E R

Date	Event
1-3	An unusually strong cold front for this time of year raced across Colorado on the 1st accompanied by a mountain blizzard, damaging winds and a few severe thunderstorms. Two hikers in Boulder County died as a result of the mountain blizzard. More than 0.50" of moisture fell on parts of extreme northwestern Colorado. Then temperatures plunged. Climax hit 10° early on the 2nd. Meeker was 23°. Cedaredge dipped to 28° and Grand Junction had 35°. Totally clear skies and the powerful June sun helped warm things up quickly. By the 3rd, Colorado was back to normal.
4-6	A quick blast of heat, the warmest so far this year, pushed many low elevation temperatures into the 90s on the 4th. Cooler air moved in overnight and a few evening thundershowers developed out on the plains. The 6th dawned unusually humid east of the mountains. Forecasters warned of the threat of severe weather. Sure enough, storms erupted east of Denver in the late afternoon. Then, near sunset, a major tornado happened to score a direct hit on Limon. Other tornadoes were spotted and also did damage that evening. Extensive property damage occurred in Limon, but timely warnings were heeded and there were no serious injuries or loss of life. Surprisingly little rainfall was noted from these storms by the official cooperative weather station network. The exception was Rush where 2.00" of rain and hail was measured.
7-9	The air was less humid on the 7th but a few more evening thunderstorms occurred. Fort Morgan picked up 0.72" from a storm. The 8th was dry statewide. Temperatures continued quite hot for early June. More moisture moved in on the 9th, and some lively eastern plains storms rumbled late into the night. Lamar recorded 0.85" of rain and John Martin Reservoir got 1.35".
10-18	The entire period was characterized by southwesterly winds aloft over Colorado as a big trough lingered over the Pacific Northwest. The 10-12th saw cool and moist air push into western Colorado while eastern section remained dry. Widespread and much-needed rains fell across the Western Slope. Uravan received 0.80", Rangely got nearly 1" and Craig was doused with 1.31". The remainder of the period was much drier although a few thundershowers were noted over northeastern Colorado but produced little rain. Cooler temperatures and even some fog and drizzle were observed on the 16th. The sunshine returned on the 17th followed by a blast of heat on the 18th -- a gentle preview of things to come. Grand Junction hit 97° on the 18th. Las Animas reached 100°F.
19-22	The heat was quickly interrupted on the 19th by a cold front and upper air disturbance. Several severe thunderstorm cells formed over southeastern Colorado. Lamar got 0.69" of rain and hail. Near Campo, 0.96" was reported. Then a cool surface high pressure area slipped down from the northwest giving all of Colorado pleasant, sunny days 20-22nd with cool nights. Greeley dipped to 46° on the 22nd. Mountain areas saw lows in the 20s.
23-30	The heatwave of 1990 arrived as a broad upper-level high pressure ridge formed directly over Colorado. There was enough moisture to generate a few thunderstorms from the mountains eastward, but significant precipitation was limited to a few points east of the mountains. Holly, for example, reported 0.86" from a storm on the 26th. Front Range areas were surprised by some morning thunder that day. The storms did spew out plenty of lightning, however, and ignited several forest fires. But the real story was the heat. This was one of the worst heatwaves to hit Colorado in several years and brought back memories of the many records that were set back in 1954. Several locations including Las Animas, Pueblo and Grand Junction rose to at least 100° on each of the last 7 days of the month. Other locations, like Fort Collins and Paonia, reached 100° for the first time in many years. Warm nighttime temperatures added to the discomfort. Springfield 7WSW claimed the State's hottest temperature for the month 111°F on the 28th. Several other communities were almost as hot. The heatwave continued as the month ended.

June 1990 Extremes

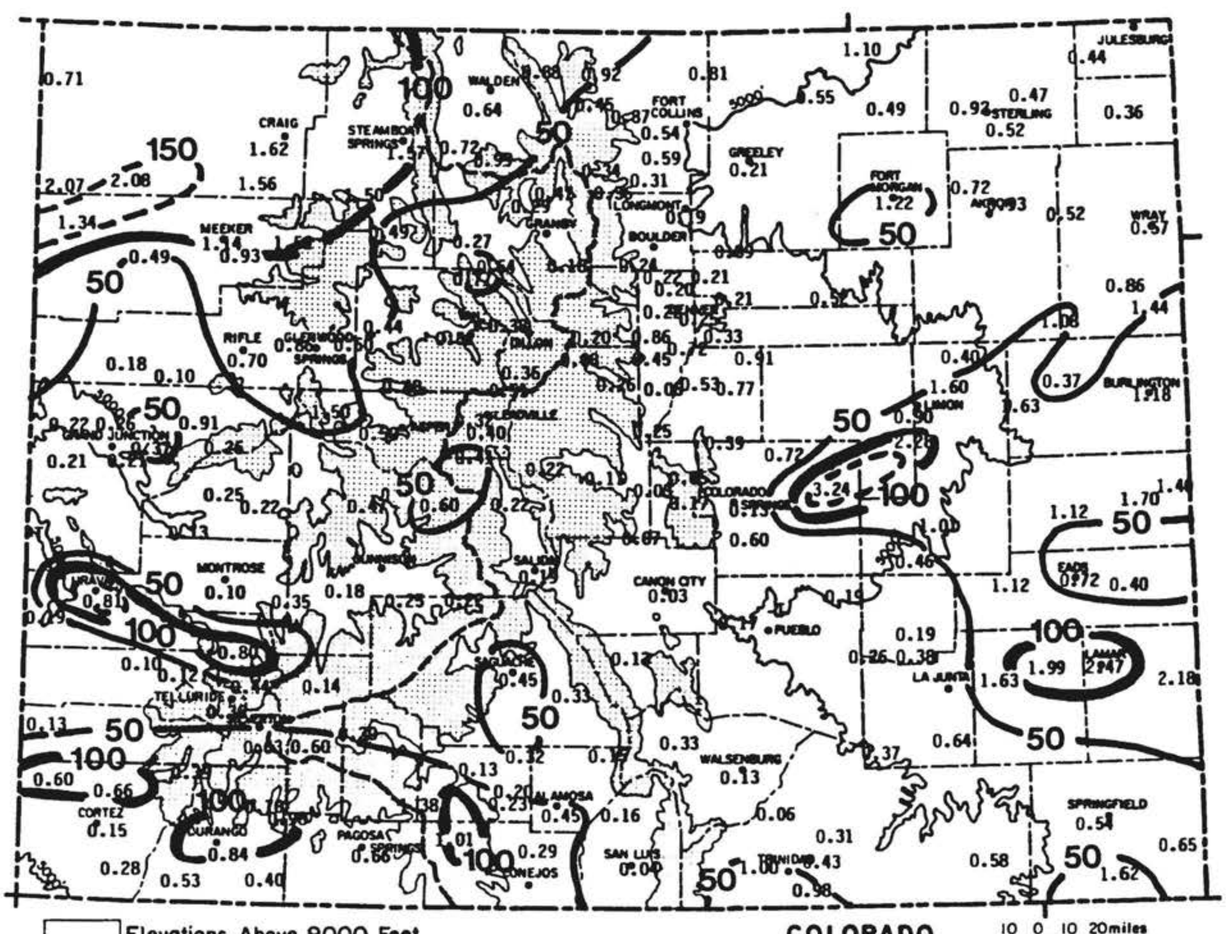
Highest Temperature	111°F	June 28	Springfield 7WSW
Lowest Temperature	10°F	June 2	Climax
Greatest Total Precipitation	3.24"		Rush 4N
Least Total Precipitation	Trace		Pueblo WSO, Gateway 1SW
Greatest Total Snowfall*	2"		Meeker

* For existing weather stations with complete daily records.
Higher values are likely for unmonitored locations.

JUNE 1990 PRECIPITATION

June was an extremely dry month over most of Colorado. Solar radiation was well above average, and thunderstorms were few in number. The majority of the State received less than half the average June precipitation. More than 1/3 of the official weather stations totalled less than 25% of average. There were some exceptions, however. Extreme northwestern Colorado was quite wet with some local areas near Rangely reporting nearly double the June average. There were a few other very localized areas where rainfall exceeded average. These were mostly in southwestern Colorado where June tends to normally be very dry. The only officially reported wet spots east of the mountains were southwest of Limon and in the vicinity of Lamar.

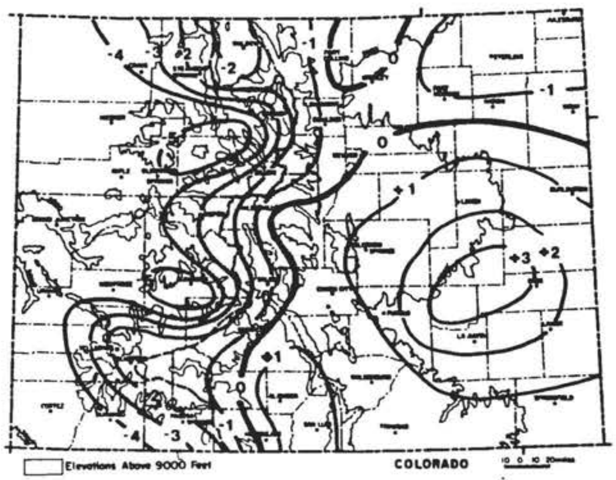
Greatest		Least	
Rush 4N	3.24"	Pueblo WSO AP	Trace
Lamar	2.47"	Gateway 1SW	Trace
Limon Hass Ranch	2.28"	Canon City	0.03"
Holly	2.18"	Florissant Fossil Bds	0.03"
Masadona 3E	2.08"	San Luis 2SE	0.04"
Dinosaur Natl. Park	2.07"	Manitou Springs	0.05"



Precipitation amounts (inches) for June 1990 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

We are already 75% of the way through the 1990 water year. Despite a dry June, most of eastern Colorado remains near or above the average for the October 1989 through June 1990 combined period. The exception is northeastern Colorado where a few stations have received less than 70% of average so far. Meanwhile, most of the western 1/2 of the State remains quite dry. Several areas, especially in extreme western counties, are still less than 70% of average. The mountain areas are not as dry and are currently standing at from 70% to close to 100% of average in a few spots. The long-term effects of several dry years continue to be felt, though. As the Palmer Index suggests, much of western Colorado will have a lot of catching up to do before drought conditions will be totally alleviated.

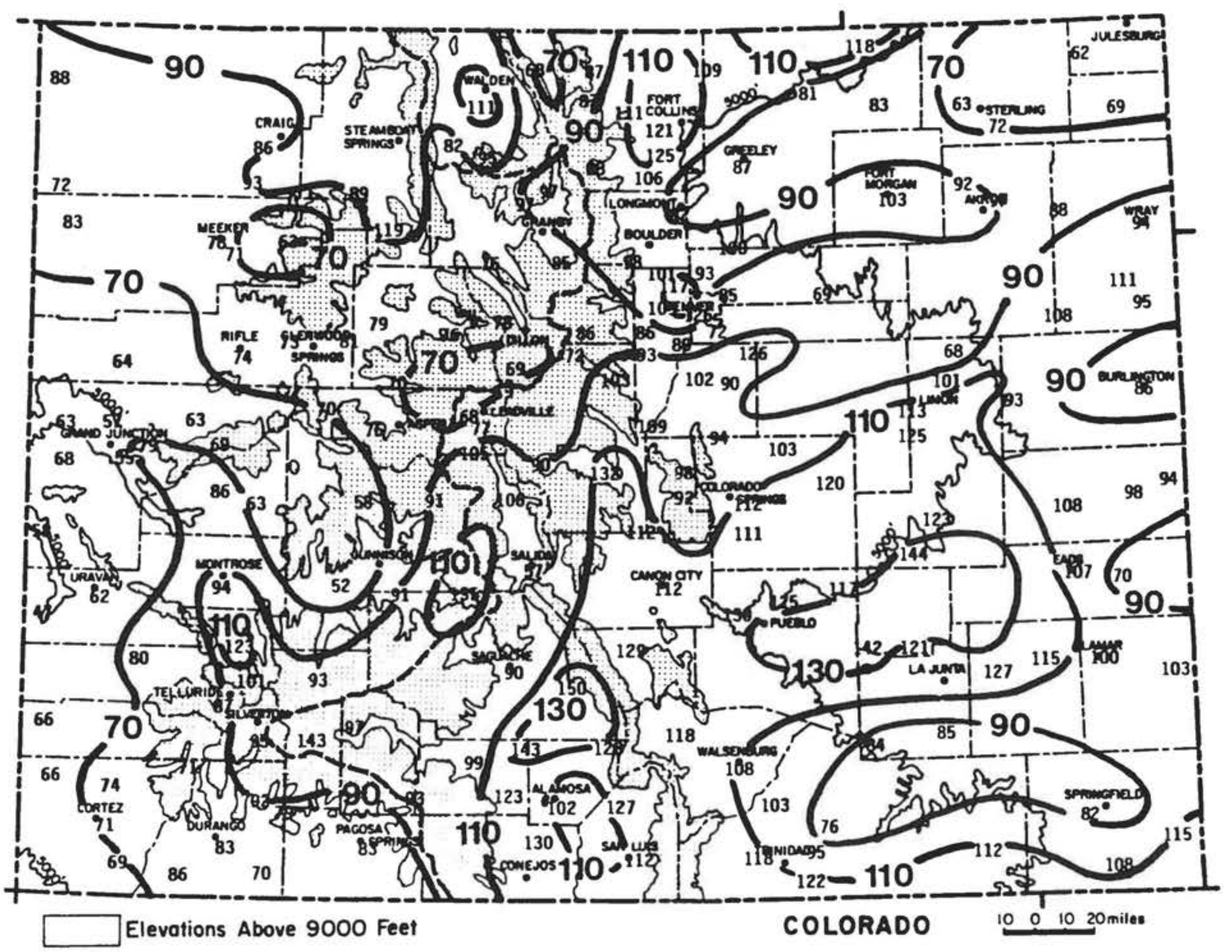


PALMER INDEX:

The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

Interpretation of Index

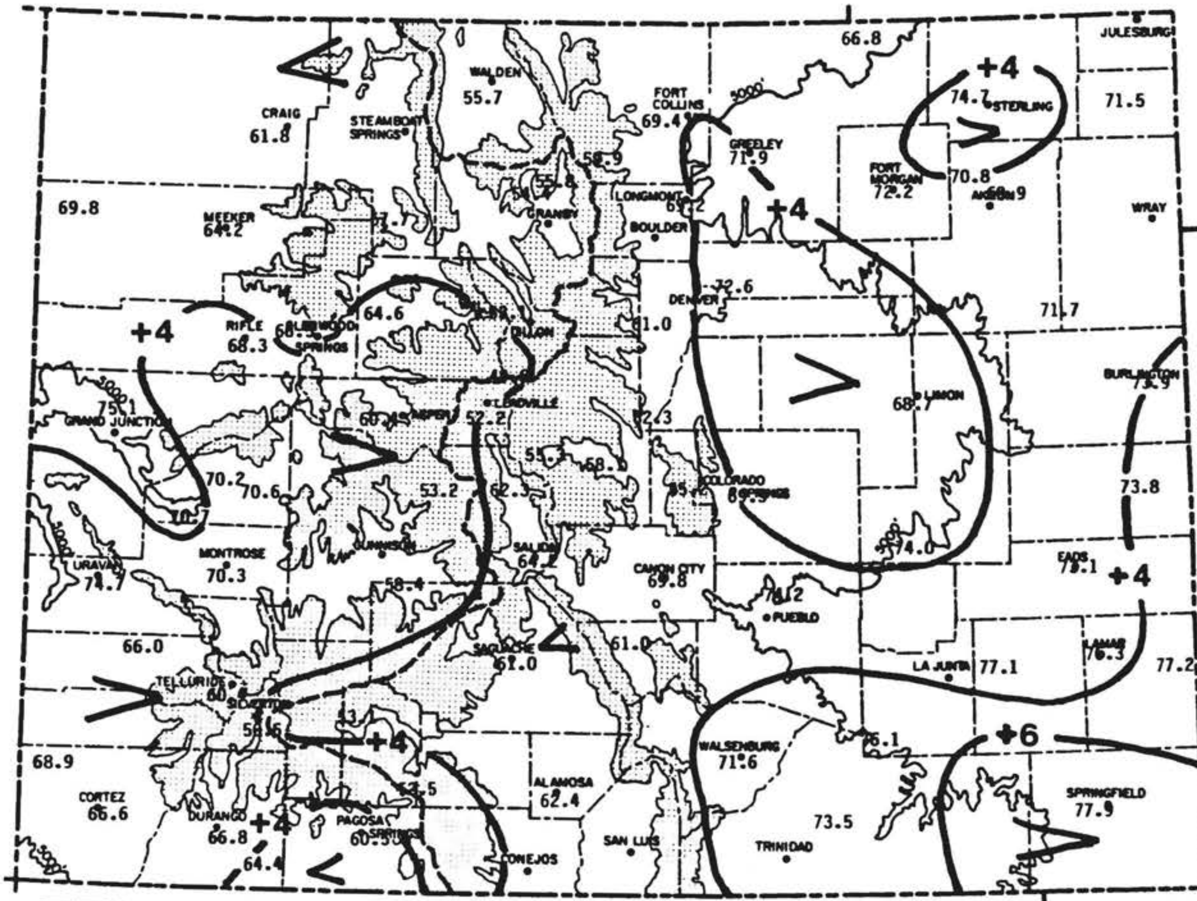
	extremely wet
+4	----------------
+3	ample moisture
+2	----------------
+1	
0	near normal
-1	
-2	----------------
	moderate drought
-3	----------------
	severe drought
-4	----------------
	extreme drought



Precipitation for October 1989 through June 1990
as a percent of the 1961-1980 average.

JUNE 1990 TEMPERATURES AND DEGREE DAYS

June ranks as one of the 10 hottest Junes in the past 103 years. The entire State was warmer than average. At Fort Collins it was the 4th hottest since 1887, and at Durango it was 2nd only to 1918 as the hottest June this century. Most locations ended up between 2 and 5 degrees F warmer than average for the month but isolated areas both east and west of the mountains were even warmer. Telluride was about 6 degrees warmer than average as was Denver. Springfield 7WSW which claimed the hottest daily maximum temperature for the month with 111°, also had the biggest departure from average -- more than 7 degrees.



June 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

JUNE 1990 SOIL TEMPERATURES

Soil temperatures rose steadily in response to the strong sunshine and unusually warm air temperatures.

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
JUNE 1990

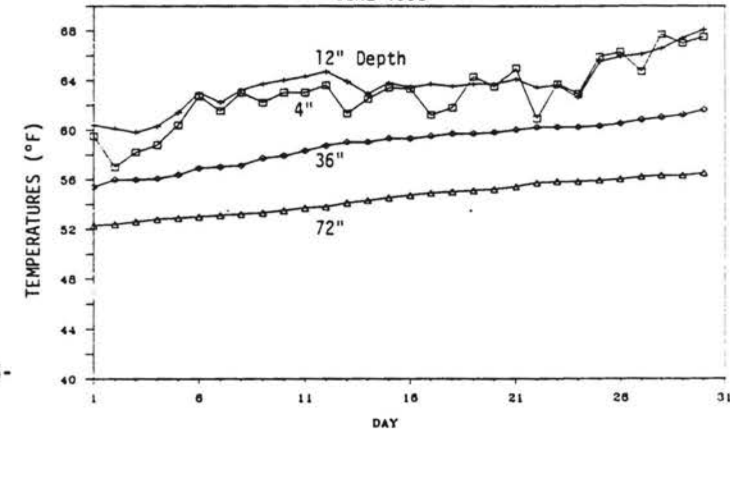


Table 1. Heating Degree Day Data through June 1990 (base temperature, 65°F).

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
	88-89	28	50	337	575	1048	1457	1544	1210	854	600	358	180	8241
	89-90	17	82	271	698	1001	1400	1554	1089	880	640	480	105	8217
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	88-89	34	79	394	550	1070	1375	1435	1171	899	692	476	269	8444
	89-90	68	176	303	671	974	1365	1365	1086	915	697	543	171	8334
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	88-89	1	4	125	311	692	993	880	1139	615	427	209	89	5485
	89-90	1	M	M	M	M	M	M	M	M	502	321	21	M
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	88-89	37	41	350	530	937	1342	1260	1153	784	645	360	207	7646
	89-90	39	112	270	628	812	1202	1184	991	857	660	518	106	7379
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	88-89	4	5	101	352	692	925	908	1135	697	375	M	M	M
	89-90	M	4	M	415	684	1229	990	957	757	459	280	3	M
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	88-89	0	9	112	287	650	937	866	1078	554	382	226	90	5191
	89-90	0	0	131	379	584	1076	859	827	687	421	325	22	5311
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	88-89	7	10	154	366	767	1099	988	1205	655	475	247	134	6107
	89-90	0	4	172	473	699	1163	966	928	805	526	345	24	6105
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	88-89	0	1	188	349	855	1148	1326	1008	718	450	282	112	6437
	89-90	0	16	142	494	850	1166	1222	959	776	490	377	59	6551
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	88-89	1	14	285	442	967	1417	1540	1443	894	531	365	169	8068
	89-90	4	46	235	586	892	1420	1319	1257	879	530	453	144	7765
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	88-89	M	M	M	M	M	M	1327	964	613	345	211	53	M
	89-90	M	M	M	330	M	M	1161	865	626	355	237	22	M
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	88-89	7	0	129	333	723	1043	969	1190	665	432	213	76	5780
	89-90	0	0	153	424	658	1160	879	882	781	469	265	7	5678
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	88-89	E 230	283	565	728	1178	1536	1546	1307	1088	875	679	490	10505
	89-90	226	357	502	861	1124	1495	1506	1271	1124	886	764	349	10465
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	88-89	1	5	191	365	869	1182	1296	933	666	388	237	76	6209
	89-90	2	19	106	520	789	1133	1278	965	724	479	359	44	6418
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	88-89	3	11	301	486	942	1448	1617	1227	829	536	344	181	7925
	89-90	1	60	217	593	896	1348	1286	986	806	545	269	68	7075
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	88-89	60	50	355	517	882	1203	1159	1227	794	636	439	261	7583
	89-90	49	118	325	657	818	1221	1115	1030	932	662	513	140	7580
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	88-89	3	2	163	362	751	1147	1011	1207	732	433	216	92	6119
	89-90	0	3	169	458	711	1166	930	910	848	495	307	19	6016
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	88-89	6	3	124	383	757	1222	1121	1230	726	446	183	77	6278
	89-90	0	2	156	416	721	1285	1087	1010	776	M	274	10	M
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	88-89	0	0	106	183	726	1078	1379	1037	534	260	113	8	5424
	89-90	0	0	40	316	729	1103	1124	820	557	271	139	20	5119

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

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
	88-89	191	208	461	667	1087	1540	1663	1368	1086	805	584	391	10051
	89-90	168	306	427	768	1132	1449	1401	1205	1043	833	689	266	9687
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	88-89	5	1	116	340	742	1166	1040	1230	711	444	184	71	6050
	89-90	1	2	166	454	729	1230	985	922	787	449	275	9	6009
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	88-89	E 75	E 125	394	631	1126	1698	2096	1578	1096	640	487	241	10187
	89-90	61	155	341	749	1069	1574	1647	1254	906	672	540	188	9156
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	88-89	0	0	32	252	609	958	919	1109	535	303	114	31	4862
	89-90	0	0	99	323	684	1176	1030	887	638	309	188	2	5336
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	88-89	318	306	601	730	1226	1539	1512	1310	1112	914	695	509	10772
	89-90	285	412	545	880	1138	1507	1499	1265	1188	920	793	377	10809
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	88-89	9	7	167	428	839	1138	1060	1211	751	516	275	143	6544
	89-90	1	6	204	508	762	1252	1078	991	815	555	364	33	6569
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	88-89	10	8	203	445	812	1276	1151	1307	841	542	256	110	6961
	89-90	2	8	200	484	749	1302	1048	994	917	552	319	25	6600
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	88-89	M	M	M	M	M	M	M	M	M	M	M	165	M
	89-90	0	41	198	543	869	1261	1169	1071	795	507	387	91	6932
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	88-89	0	1	169	292	794	1138	1340	972	605	348	180	64	5903
	89-90	0	10	110	439	768	1156	1186	895	654	425	285	27	5955
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	88-89	30	61	325	506	999	1354	1509	1095	860	574	447	230	7990
	89-90	24	118	284	646	964	1298	1491	1160	873	630	524	164	8176
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	88-89	1	0	84	308	689	1062	980	1141	573	378	134	35	5385
	89-90	0	0	94	373	676	1204	964	877	695	394	233	2	5512
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	88-89	0	0	198	327	826	1203	1445	1049	674	381	224	74	6401
	89-90	0	2	103	473	M	1130	1191	923	657	392	281	37	M
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	88-89	27	45	336	537	1053	1501	1640	1355	964	581	401	273	8713
	89-90	18	117	315	M	974	1533	1580	1332	971	658	576	M	M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	88-89	1	1	116	363	703	1089	1066	1189	730	416	152	59	5885
	89-90	M	3	144	428	719	1254	1074	1026	760	427	275	8	M
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	131	147	397	570	1036	1305	1363	1071	858	633	463	263	8237
	89-90	72	175	270	644	869	1264	1273	1023	922	664	509	145	7830
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	88-89	8	5	100	266	686	975	925	1026	538	378	159	79	5145
	89-90	0	1	111	369	633	1153	980	874	681	420	266	8	5496
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	88-89	144	189	507	668	1139	1495	1487	1369	1023	772	612	371	9776
	89-90	132	279	461	802	1075	1490	1359	1287	1068	796	674	273	9696
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	88-89	2	3	119	266	654	936	876	1031	492	376	164	82	5001
	89-90	0	2	117	345	581	1047	848	800	666	408	289	10	5113

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

JUNE 1990 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	81.9	51.7	66.8	2.4	100	39	67	127	500	1.10	-1.40	44.0	8
STERLING	90.8	58.7	74.7	6.5	110	44	8	306	660	0.92	-1.81	33.7	6
FORT MORGAN	87.6	56.9	72.2	3.8	105	46	10	235	613	1.22	-0.80	60.4	6
AKRON FAA AP	86.5	55.2	70.8	3.9	103	41	31	216	585	0.72	-1.92	27.3	4
AKRON 4E	86.0	53.8	69.9	3.3	105	40	30	186	570	0.93	-1.78	34.3	3
HOLYOKE	85.2	57.8	71.5	2.4	102	45	16	219	607	0.36	-3.00	10.7	2
JOES	87.7	55.7	71.7	2.7	103	44	13	219	597	1.08	-1.12	49.1	5
BURLINGTON	89.4	58.5	73.9	4.2	107	47	3	278	651	1.18	-1.14	50.9	4
LIMON WSMO	85.0	52.4	68.7	4.7	100	41	33	151	551	0.90	-0.90	50.0	6
CHEYENNE WELLS	90.0	57.5	73.8	4.3	107	43	7	279	651	1.70	-0.45	79.1	5
EADS	89.3	57.0	73.1	2.1	103	40	16	268	637	0.72	-1.32	35.3	2
ORDWAY 21N	92.6	55.3	74.0	4.3	108	41	4	281	632	0.46	-1.07	30.1	4
LAMAR	94.1	58.5	76.3	3.1	106	44	1	347	673	2.47	0.15	106.5	6
LAS ANIMAS	95.1	59.1	77.1	3.7	108	48	2	372	679	1.63	-0.11	93.7	5
HOLLY	94.1	60.3	77.2	4.6	108	45	5	377	692	2.18	-0.89	71.0	7
SPRINGFIELD 7WSW	96.7	59.1	77.9	7.8	111	42	2	397	690	0.54	-1.57	25.6	3
TIMPAS 13SW	94.5	57.6	76.1	5.8	107	45	0	341	661	0.37	-1.11	25.0	1

Foothills/Adjacent Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	84.9	54.0	69.4	4.0	100	44	19	159	561	0.54	-1.30	29.3	3
GREELEY UNC	87.8	56.1	71.9	4.0	103	45	9	226	603	0.21	-1.60	11.6	4
ESTES PARK	78.1	41.8	59.9	3.3	90	33	159	14	427	0.34	-1.42	19.3	4
LONGMONT 2ESE	88.2	50.2	69.2	3.2	104	39	25	154	543	0.19	-1.81	9.5	1
BOULDER	86.4	53.5	69.9	2.8	100	40	21	179	569	0.39	-1.87	17.3	4
DENVER WSFO AP	89.0	56.2	72.6	6.2	102	46	7	244	620	0.21	-1.66	11.2	2
EVERGREEN	80.2	41.8	61.0	3.3	91	34	140	26	446	0.86	-1.25	40.8	7
CHEESMAN	84.0	40.7	62.3	2.5	95	32	106	35	491	0.25	-1.36	15.5	4
LAKE GEORGE 8SW	75.1	41.2	58.1	3.0	87	26	205	7	383	0.11	-1.17	8.6	2
ANTERO RESERVOIR	74.8	35.8	55.3	3.7	85	25	282	0	381	0.22	-0.70	23.9	5
RUXTON PARK	72.9	37.5	55.2	3.8	86	28	290	2	349	0.17	-2.19	7.2	4
COLORADO SPRINGS	85.8	53.2	69.5	4.3	99	40	24	168	568	0.13	-2.19	5.6	3
CANON CITY 2SE	87.1	52.6	69.8	2.1	100	40	22	175	569	0.03	-1.27	2.3	1
PUEBLO WSO AP	94.0	54.5	74.2	3.4	108	45	2	286	617	0.00	-1.32	0.0	0
WESTCLIFFE	81.3	40.8	61.0	3.1	91	23	125	14	466	0.13	-0.95	12.0	2
WALSENBURG	89.7	53.5	71.6	5.0	100	43	10	218	603	0.13	-1.09	10.7	2
TRINIDAD FAA AP	92.7	54.3	73.5	5.0	102	37	8	272	624	0.31	-1.22	20.3	3

Mountains/Interior Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	75.2	36.2	55.7	2.5	91	27	273	3	380	0.64	-0.38	62.7	3
LEADVILLE 2SW	70.9	33.5	52.2	3.7	82	22	377	0	321	0.40	-0.60	40.0	4
SALIDA	84.2	44.3	64.2	3.8	95	33	69	55	494	0.19	-0.72	20.9	3
BUENA VISTA	81.6	43.0	62.3	3.6	92	34	106	31	470	0.22	-0.59	27.2	5
SAGUACHE	79.6	42.5	61.0	2.7	90	27	139	28	455	0.45	-0.12	78.9	3
HERMIT 7ESE	74.4	31.8	53.1	3.7	85	15	351	0	376	0.30	-0.42	41.7	2
ALAMOSA WSO AP	82.8	42.1	62.4	3.3	93	24	105	35	478	0.45	-0.27	62.5	3
YAMPA	75.4	40.0	57.7	2.8	86	26	228	15	393	0.49	-1.04	32.0	3
GRAND LAKE 1NW	76.5	35.2	55.8	5.4	86	27	266	0	403	0.47	-1.16	28.8	4
GRAND LAKE 6SSW	74.8	34.0	54.4	2.5	86	21	313	0	378	0.29	-1.01	22.3	3
DILLON 1E	71.5	34.6	53.1	2.5	82	24	349	0	330	0.38	-0.78	32.8	5
CLIMAX	64.1	35.1	49.6	4.5	76	10	455	0	221	0.51	-0.97	34.5	3
ASPEN 1SW	76.6	44.2	60.4	5.4	88	22	171	37	417	0.50	-0.91	35.5	6
TAYLOR PARK	71.6	34.8	53.2	6.2	83	20	347	0	329	0.60	-0.46	56.6	2
TELLURIDE	80.9	39.9	60.4	6.3	90	20	145	14	459	0.36	-0.86	29.5	4
PAGOSA SPRINGS	83.6	37.4	60.5	3.4	97	24	164	36	476	0.66	-0.11	85.7	3
SILVERTON	72.9	28.4	50.6	2.6	83	15	423	0	350	0.63	-0.62	50.4	3
WOLF CREEK PASS 1	68.0	37.0	52.5	5.1	80	17	365	0	278	1.38	-0.26	84.1	4

Western Valleys

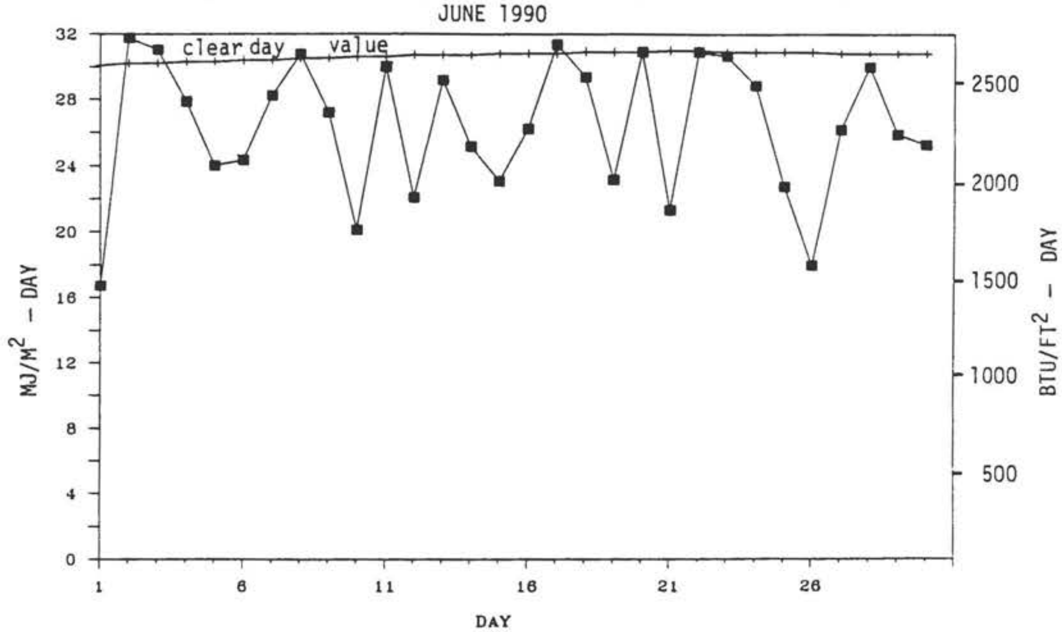
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	78.9	44.7	61.8	2.4	95	31	144	57	421	1.62	0.27	120.0	7
HAYDEN	81.9	43.0	62.4	2.5	95	29	119	51	459	1.52	0.30	124.6	8
MEEKER NO. 2	83.5	45.0	64.2	3.3	96	23	91	77	488	1.14	0.29	134.1	4
RANGELY 1E	87.6	52.1	69.8	3.8	100	32	42	193	561	1.34	0.61	183.6	4
EAGLE FAA AP	86.9	42.4	64.6	5.1	100	28	68	63	506	0.44	-0.41	51.8	3
GLENWOOD SPRINGS	86.8	46.2	66.5	3.4	98	29	53	107	511	0.86	-0.45	65.6	4
RIFLE	89.5	47.1	68.3	4.7	102	29	37	143	530	0.70	-0.13	84.3	4
GRAND JUNCTION WS	92.1	58.2	75.1	3.1	105	35	20	331	662	0.26	-0.24	52.0	3
CEDAREDGE	90.0	50.5	70.2	4.8	102	28	32	195	558	0.25	-0.48	34.2	2
PAONIA 1SW	88.7	52.5	70.6	5.1	101	32	26	201	579	0.22	-0.58	27.5	4
DELTA	93.7	47.7	70.7	2.8	105	30	22	199	549	0.13	-0.42	23.6	2
GUNNISON	81.1	36.3	58.7	3.6	90	22	188	8	464	0.04	-0.50	7.4	1
COCHETOPA CREEK	80.4	36.5	58.4	4.2	92	18	200	11	450	0.25	-0.47	34.7	3
MONTROSE NO. 2	86.5	54.1	70.3	4.4	96	30	27	195	581	0.10	-0.51	16.4	3
URAVAN	93.9	55.5	74.7	4.5	107	35	21	319	625	0.81	0.39	192.9	4
NORWOOD	83.3	48.8	66.0	6.0	94	25	67	106	508	0.10	-0.76	11.6	1
YELLOW JACKET 2W	86.7	51.2	68.9	5.7	98	27	33	157	551	0.60	0.11	122.4	2
CORTEZ	86.9	46.3	66.6	4.0	98	28	59	113	533	0.15	-0.26	36.6	1
DURANGO	88.7	44.9	66.8	5.4	98	29	44	106	529	0.84	0.27	147.4	3
IGNACIO 1N	85.0	43.8	64.4	3.2	95	28	78	67	508	0.40	-0.13	75.5	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.

JUNE 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days: clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	17	10	3	--	--
Denver	17	10	3	81%	71%
Fort Collins	11	17	2	--	--
Grand Junction	20	8	2	89%	79%
Pueblo	21	8	1	83%	79%

FT. COLLINS TOTAL HEMISPHERIC RADIATION
JUNE 1990



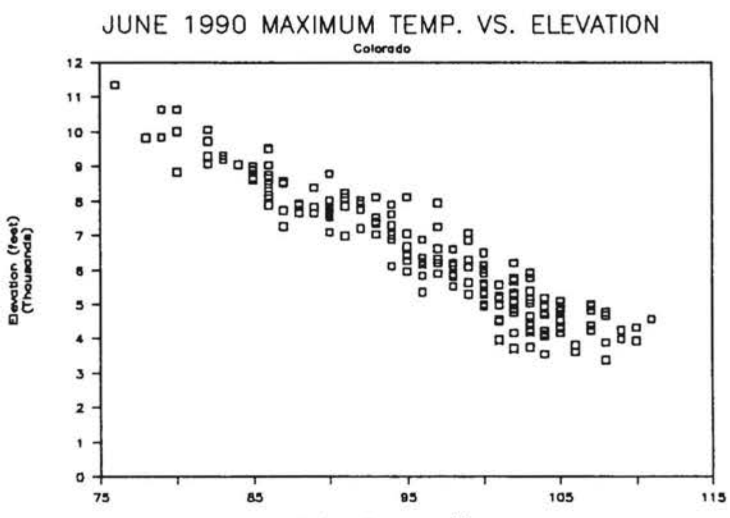
The Pure-Bred Heatwave -- Late June 1990 continued:

hit the 100° mark. The Eagle airport hit 100° for the first time in their 49-year weather reporting history. Nighttime temperatures, cool in comparison to many parts of the country, were nevertheless very warm for here. Several locations had at least one night when the temperature never dropped below 70°. Here in Fort Collins, we set 4 new daily records and reached 100° for the first time in 17 years. It was the most uncomfortable that I have been in the 13 years I have lived here. Even though I don't remember it directly, it brought back memories of 1954. That summer, Sedgwick (northeast Colorado) reported a temperature of 114° on July 11 which tied Las Animas for the highest verifiable temperature ever reported in Colorado. Dozens of Colorado stations still show June 23, 1954 as their hottest June day on record.

As a little boy in Illinois that summer (1954), I apparently nearly died of some heat-related disease. Many people did die. Polio claimed its final victims -- some in my home town. That summer helped push the development of domestic air conditioning -- something that many of us are now addicted to even though it has greatly increased our nation's fossil fuel consumption.

Ooops. I'm getting off the subject. I really want to tell you about the 1990 heatwave in Colorado. Our State high temperature record is still intact, but we did surpass 110° for only the 2nd time since 1954. Springfield, down in southeastern Colorado, took the honors on June 28th when they reached 111°. They are not usually the hottest in the State, but this was their year. They also exceeded 100° on 8 additional days. Temperatures in excess of 110° anywhere in Colorado have been observed at official weather stations in only 15 years since 1888. Seven of those 15 years were during the decade of the 1930s. The 1950s contributed another 3 years to the total. 1902 and 1903 are also on the list as is 1981. If these sound strangely like years of drought in Colorado, you're right. The vast majority of the years when Colorado experienced a temperature of more than 110° were during or near the end of major droughts (based on values of the Palmer Drought Index which have been calculated back to 1895). Hot temperature extremes and drought seem to go hand in hand.

One nice thing about heatwaves in a state like Colorado is that you can always escape the heat by heading for the mountains. The figure below shows a graph of the highest temperature reported in June of 1990 plotted as a function of elevation for each of the National Weather Service cooperative weather stations. In a relative sense, everywhere in Colorado had a severe heatwave, but as you go up, the temperatures go down. Our lowest elevation station is Holly at 3390'. They had a maximum temperature for the month of 108°. Our highest elevation station is Climax at 11,350'. They only hit 76°. (By the way, an average late June day at Climax would see a high near 65°.) There is quite a predictable change of temperature with elevation. Averaged over the entire State, these maximum temperatures decrease at a rate of nearly 5 degrees F per thousand feet. However, there is a wide spread. For example, the stations which reached a maximum of 100° ranged in elevation from 4980' (Flagler) up to 6500' (Eagle). At the approximate elevation of 8000 feet, observed maximum temperatures ranged from 86° at Yampa up to 95° at Crestone.



Here are a few examples of noteworthy June 1990 maximum temperatures. Hopefully it will be a long time until we see this kind of temperature again.

Sterling	110°F (27th)	Cedaredge	102°F (29th)	Walden	91°F (30th)
Ordway 2ENE	110°F (28th)	Durango	98°F (24th)	Vail	91°F (29th)
Pueblo WSO AP	108°F (29th)	Mesa Verde	99°F (24th)	Telluride	90°F (24th)
Uravan	107°F (30th)	Pagosa Sprgs	97°F (29th)	Leadville	82°F (29th)
Grand Junction	105°F (27th)	Alamosa	93°F (29th)	Wolf Crk Pass	80°F (27th)

JCEM BULLETIN BOARD

The advent of computers and modems have spawned a new interpretation for the word bulletin board. While a bulletin board is still a place to put messages and read information, the media that convey those messages differs. Electronic storing of data allows greater accumulation and easier dissemination. The Joint Center for Energy Management has joined in this updated version of the bulletin board by making our weather data available to the public by telephone. There is no charge for use of this bulletin board except the cost of the phone call. Regular long distance charges are in effect for the time one spends on the line to the bulletin board.

Our IBM-PC based board uses a 2400 baud modem but has the ability to communicate with a 1200 or 300 baud rate modem and would automatically scale down to the incoming callers modem rate. The phone number is **(303) 492-3525** and will be open for calls 24 hours a day starting July 1. The initial call from anyone will ask for basic information such as name, city and computer abilities. The board will recognize anyone who has registered on our board and will skip a section on tips for using the board in future calls. We are currently offering our formatted data from all of our stations for 1989 and 1990 up to the current month. There will be a month lag in data, i.e. June data will be placed onto the board during the first week of July. While our technical staff has done error checking on this information, no claims are made by JCEM that it is error free data. Your feedback is welcome via a message to the sysop (systems operator). Erika is the current sysop and can provide the caller with more data if desired. We do have weather data from August 1987; however, not for all eight stations. We also have raw data which are available along with a text file to help you understand the format.

An initial caller should plan to spend 10-15 minutes on the board just exploring the different menus and abilities of our board. If you are already familiar with bulletin boards, ours is similar to most other bulletin boards and should be quite simple to follow. Below is an example of the main menu:

```
+++MAIN MENU+++          W T H R N E T   B U L L E T I N B O A R D

   =MESSAGES=                  =EXIT=
Enter a message   [E]        Goodbye         [G]
Remove a message  [K]        Quit            [Q]
Personal mail     [P]
Read messages     [R]         =UTILITIES=
                             Help      [H or ?]
   =SYSTEM=                  Expert on/off [X]
Bulletins         [B]
Comment           [C]         =OTHER MENUS=
Operator page     [O]        Files           [F]
                             Utilities       [U]
```

By typing the letter in the [ ] box, the caller will advance to the section stated. WTHRNET files are found in the [F]iles menu. Here a separate menu will be pulled up to the screen. There is an example of how to upload the desired files, however, you must know how your particular telecommunications software works to upload/download information. For example, we use PC-VT here at JCEM. To download we must hit Ctl-F3 to begin the process. Nowhere does our board tell you how to do this since it is a function that varies among users. It will take 10-15 minutes at 1200 baud to upload one formatted file for one month at one site to your computer.

Our bulletin board is meant to be a service to the public. We want to provide you with quality data and would hope that any questions or comments you have regarding the board or data would be passed on to us via a message on the board or a letter to Mary Sutter at the address below. Welcome to our new JCEM WTHRNET bulletin board!

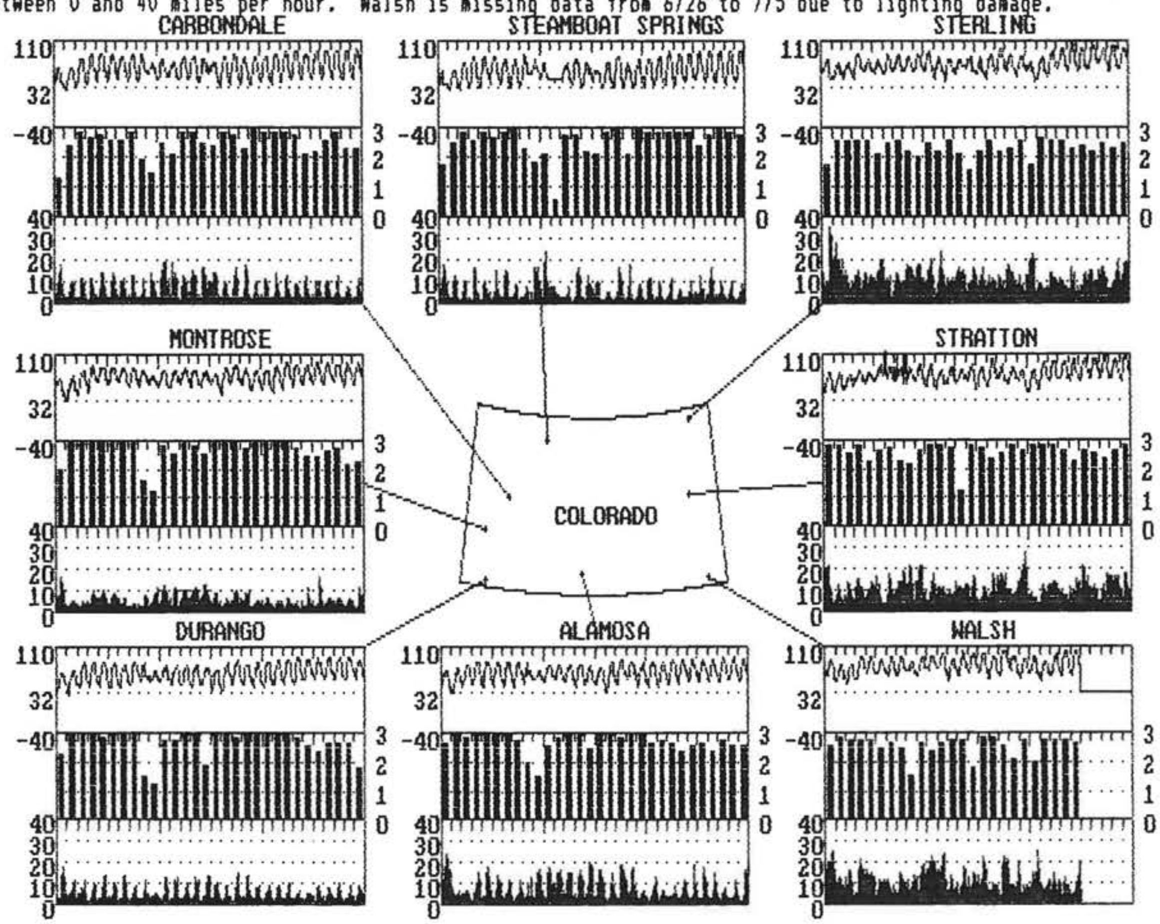
This article was written by Mary Sutter of the Joint Center for Energy Management, Campus Box 428, Boulder, CO 80309-0428.

WTHRNET WEATHER DATA JUNE 1990

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)								
	63.4	62.7	64.5	70.3	58.0	71.1	73.3	67.6
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	89.2 29/16	90.3 29/14	95.4 30/15	94.5 26/15	93.9 30/14	106.2 27/15	111.2 7/ 4	102.0 18/15
minimum:	29.7 2/ 5	27.5 2/ 5	25.0 2/ 5	28.4 2/ 5	28.8 2/ 3	41.5 21/23	44.2 21/ 5	32.0 26/ 1
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	71 / 35	53 / 27	75 / 33	37 / 25	97 / 36	56 / 39	62 / 46	45 / 27
11 AM	28 / 36	21 / 29	17 / 27	17 / 29	32 / 38	25 / 37	31 / 43	15 / 21
2 PM	20 / 31	16 / 26	14 / 26	14 / 27	24 / 30	17 / 32	22 / 39	11 / 18
5 PM	20 / 31	17 / 25	16 / 26	15 / 27	25 / 30	17 / 31	21 / 37	11 / 18
11 PM	43 / 34	36 / 26	34 / 27	24 / 24	72 / 40	36 / 34	53 / 48	28 / 23
monthly average wind direction (degrees clockwise from north)								
day	141	214	255	226	243	175	143	119
night	211	77	178	99	125	196	206	163
monthly average wind speed (miles per hour)								
	6.58	4.65	4.96	4.79	3.71	9.81	9.94	8.49
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	200	317	363	205	437	21	11	134
3 to 12	392	369	311	500	237	492	510	389
12 to 24	127	34	46	15	46	202	195	194
> 24	1	0	0	0	0	5	4	3
monthly average daily total insolation (Btu/ft²·day)								
	2653	2626	2493	2632	2547	2314	2562	2103
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	201	154	213	183	194	251	269	250
40-60%	46	50	63	56	44	78	60	40
20-40%	26	33	38	28	27	52	30	35
0-20%	11	23	13	10	25	55	23	12

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour. Walsh is missing data from 6/26 to 7/5 due to lighting damage.



COLORADO CLIMATE

JULY 1990

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 13 Number 10

July in Review:

Following a very hot and dry June, July 1990 was relatively cool and wet. Temperatures were near average on the Western Slope but were as much as 4 degrees Fahrenheit cooler than average east of the mountains. More than 85% of the 200+ weather stations used in this report received above average rainfall for the month. Many local areas scattered throughout Colorado received more than 200% of average, but the heaviest rains fell in southeastern Colorado. Several damaging hailstorms were reported including the storm of July 11 that moved through central Denver. Damage claims of more than $400 million have been reported from that single storm.

Colorado's September Climate:

September is reliably a beautiful month here in Colorado. There will still be some hot days, especially early in the month. But soon the effect of shortening daylength (the time between sunrise and sunset decreases by more than an hour in September) and reduced solar energy (the solar energy on a clear day on level ground decreases by more than 20% during the month) can't help but take over. The common afternoon thundershowers of summer dissipate, temperatures begin to drop, and we are left with prevailing clear, deep blue skies, more frequent and stronger cold fronts, increased chances for frost, and even the possibility of snow. Last year, residents of the Front Range were greeted by snow on Sept. 12 -- one of the earlier snows on record.

Expect daily high temperatures in September to still reach into the 70s and 80s at elevations below about 7,000 feet with lows in the 40s and 50s. A few days will be much cooler. By the end of the month, there is a good chance that temperatures will approach the freezing point on one or more nights. Higher in the mountains the cool autumn air sets in earlier, but daytime temperatures remain pleasant. Subfreezing nocturnal temperatures are almost a certainty above 7,500 feet, and low temperatures in the teens are not unheard of by late September. Huge day to night temperature fluctuations of more than 50 degrees are common in some mountain valleys adding vigor to the autumn.

September precipitation averages between 1.00" and 1.50" and tends to be more uniformly distributed across the state than at any other time of year. But the story is more complicated. Hidden in these numbers are a wide variety of very wet and very dry months and a great diversity of storm types -- thunderstorms, snowstorms, upslopes, cold fronts and even hurricane remnants. Unlike summer, when scattered thunderstorms are the primary rainmaker, September precipitation becomes increasingly controlled by large but infrequent low pressure areas that develop near or migrate toward Colorado. These don't occur every year, but when they do the results can be surprising. Since the atmosphere in September is still relatively warm, it can hold large amounts of water vapor. As a result, very heavy rains can fall that may be sufficient to cause flooding. Don't start yelling "flood" just because you read this. 60% of all Septembers experience less precipitation than average. But it is important to know that heavy rains are possible. During the past century, heavy September rains have occurred on the average of about once or twice per decade. Our last real soaking was back in 1982.

Hot, Dry June -- Cool, Wet July! Was That Normal?

In case you were out of town for the summer, our weather did an incredible "about face" starting on the 4th of July. We experienced a June which for the State as a whole was in the hottest 5% of all years during the past 100 years while June precipitation was in the driest 10-15%. Suddenly, the weather pattern changed. From the 4th of July on into August, cool and fairly humid air became the dominant airmass (especially east of the mountains). Clouds and thunderstorms became a daily occurrence. Instead of concerns about heat and drought, we started to hear more complaints about corn that wouldn't mature, tomatoes that wouldn't ripen, hay that wouldn't dry and the inevitable "it's going to be an early winter".

(continued on page -9-)

JULY 1990 DAILY WEATHER

Date	Event
1-2	The June heatwave continued for 2 more days with temperatures near or above the 100° mark in many parts of Colorado. At least 5 locations in northeast and southeast Colorado hit 108°, the hottest in the state for the month. But the high pressure ridge responsible for the heat finally began shifting eastward allowing more humidity to move northward into western Colorado. Silverton was surprised by a 1.68" downpour on the 2nd--very unusual for early July.
3-10	Southwesterly winds aloft brought subtropical moisture up into Colorado. From the 3rd to the 6th, cooler surface air slid into Colorado from the north. This combination triggered numerous thundershowers, some of which dropped heavy rainfall. Holyoke received 1.58" of rain late on the 3rd. Durango was soaked by 2.12" 5-6th. Hot temperatures returned briefly on the 7th east of the mountains, but clouds and showers covered western Colorado. Cool, damp weather covered much of the State 8-9th. Fort Morgan was doused by 2.87" of rain late on the 8th with another 1.05" on the 9th. Warmer, drier air gradually returned 9-10th but southeastern Colorado continued to have widespread and locally heavy storms on the 10th. At John Martin Reservoir 4.13" was measured on the 10th.
11-15	Winds aloft shifted to the northwest above Colorado. This pattern kept temperatures seasonally hot over western Colorado but quite cool from the mountains eastward. Temperatures dropped into the 30s each night in the mountains. Although this air was drier, there was still sufficient residual moisture to fuel some thundershowers near the mountains. An upper air disturbance helped trigger a strong thunderstorm on the 11th that moved from Estes Park directly over downtown Denver. An intense hail swath pelted the city. The combination of tree, roof, window and vehicle damage to insured property may have exceeded $400 million making this the most costly hailstorm in U.S. history and one of the 10 most expensive U.S. natural disasters of any kind (based on insured losses).
16-18	Summerlike temperatures returned to the whole state with low elevation temperatures reaching into the 90s. The typical summer pattern of clear mornings with afternoon buildups and local mountain thundershowers was observed.
19-24	A surprisingly strong surge (for this time of year) of cool Canadian surface air wedged southward across Colorado while moist subtropical air remained in place over the Rockies. The result was widespread clouds and storms; some of which were quite heavy especially near the Front Range. Numerous areas east of the Continental Divide received more than 1" of rain 19-21st. Boulder reported 2.12" on the 20th. Ordway received 2.60" on the 21st. Temperatures east of the mountains were remarkably cool, and fog covered some areas. The temperature peaked out at only 53° at Allenspark on the 21st. Conditions moderated 22-24th but scattered thundershowers persisted.
25-31	Subtropical moisture subsided and the Canadian air masses moderated and moved eastward 25-26th. Only scattered thundershowers were reported, most of these east of the mountains. Then another cool air mass dropped down across the plains triggering moderate storms on the 27-29th several of which contained damaging hail. Akron picked up more than 1" of rain late on the 28th. As the cool air pushed farther south, 2.41" of rain fell south of Trinidad on the 30th. Local fog was again reported along the Front Range.

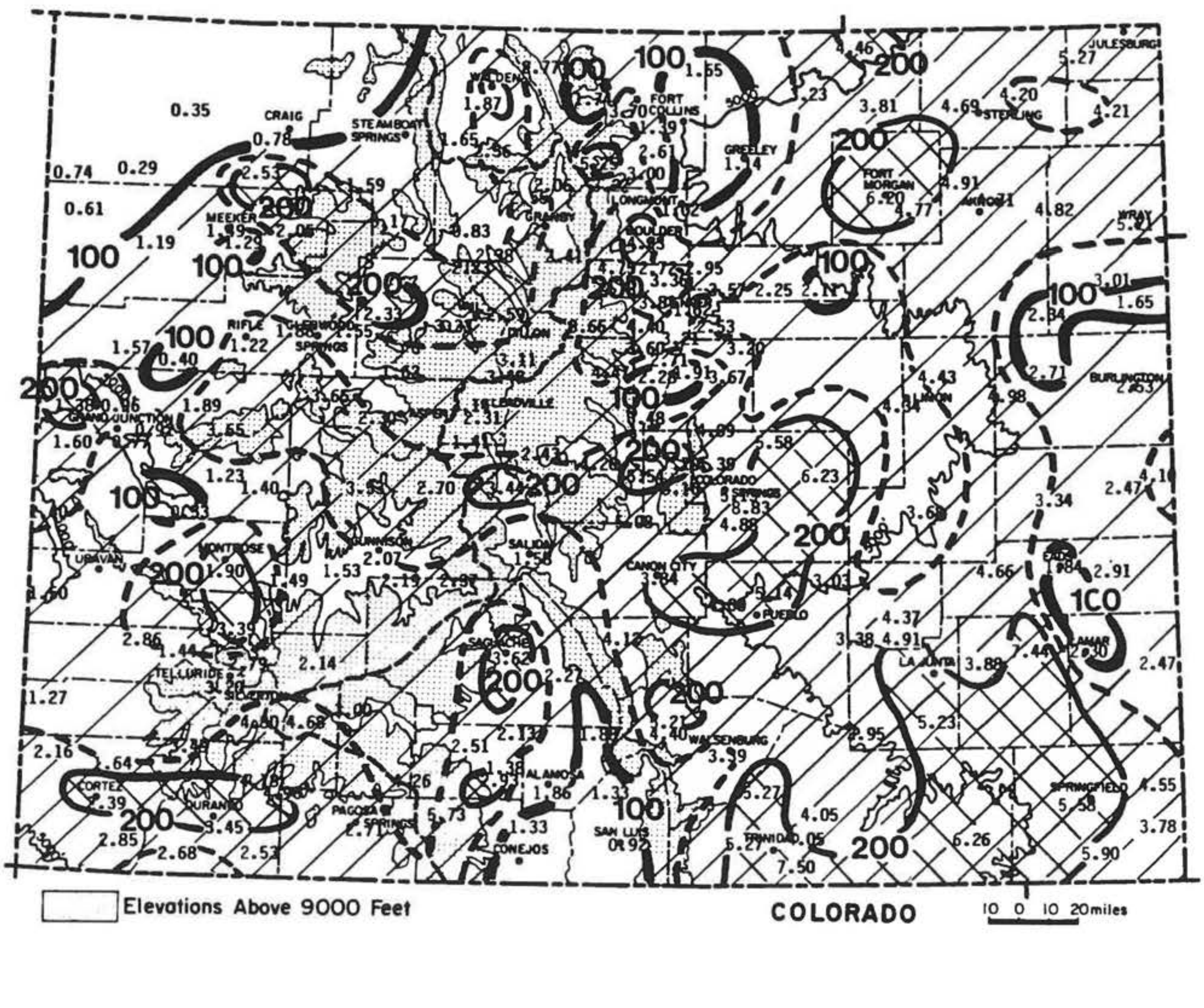
July 1990 Extremes

Highest Temperature	108°F	July 1	Sterling, Las Animas, and several other locations
Lowest Temperature	23°F	July 29	Florissant Fossil Beds National Monument
Greatest Total Precipitation	8.83"		Fountain
Least Total Precipitation	0.29"		Masadona 3E
Most Days with Measurable Precipitation	25		Florissant Fossil Beds National Monument

JULY 1990 PRECIPITATION

When averaged over the entire State, more precipitation typically falls on Colorado in July than in any other month of the year. This year lived up to expectations. Thunderstorms rumbled somewhere in Colorado on almost every day of the month. Most locations received measurable rainfall on 9 to 22 days. Precipitation was heaviest and most widespread on the 4-10th and again on the 19-30th. Numerous storms dropped an inch or more of rainfall in short periods of time. As a result, the majority of the State ended up wetter than average for the month. Sixty-two official weather stations recorded at least 4" of rainfall in July. Numerous areas received more than double the July average with the wettest areas concentrated over southeastern Colorado. But there were still a few dry spots. Rainfall in extreme northwestern Colorado was only about 50% of average. The area from Longmont to Greeley and Fort Collins was a little drier than average. The only other dry spots were local areas that happened to be skipped by some of the heavier storms.

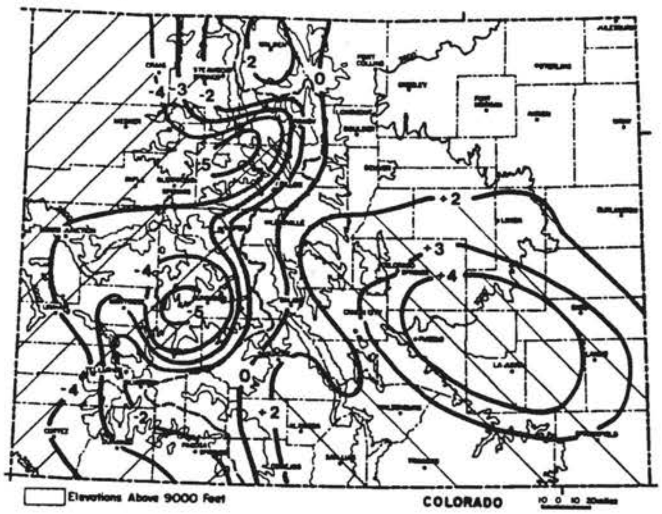
Greatest		Least	
Fountain	8.83"	Masadona 3E	0.29"
Ruxton Park	8.16"	Maybell	0.35"
Manitou Springs	7.70"	Parachute	0.40"
Wootton Ranch	7.50"	Delta	0.53"
John Martin Dam	7.44"	Rangely 1E	0.61"



Precipitation amounts (inches) for July 1990 and contours of precipitation as a percent of the 1961-1980 average.

1990 WATER YEAR PRECIPITATION

Wet weather in July helped improve accumulated precipitation totals for the 1990 water year. Areas west of the Continental Divide still show deficits of from 10% to 40% from average but have improved greatly from mid-winter values. Meanwhile, many areas of eastern Colorado are now experiencing a wet year. Several portions of southeastern Colorado have received from 130% to 170% of average. The Palmer Drought Severity Index improved in all areas of Colorado from their July 1 values with the exception of the Yampa-White Valleys in northwestern Colorado. Despite improvements, the index still shows the Western Slope to be in severe to extreme drought -- the accumulated effect of several years of deficit precipitation.

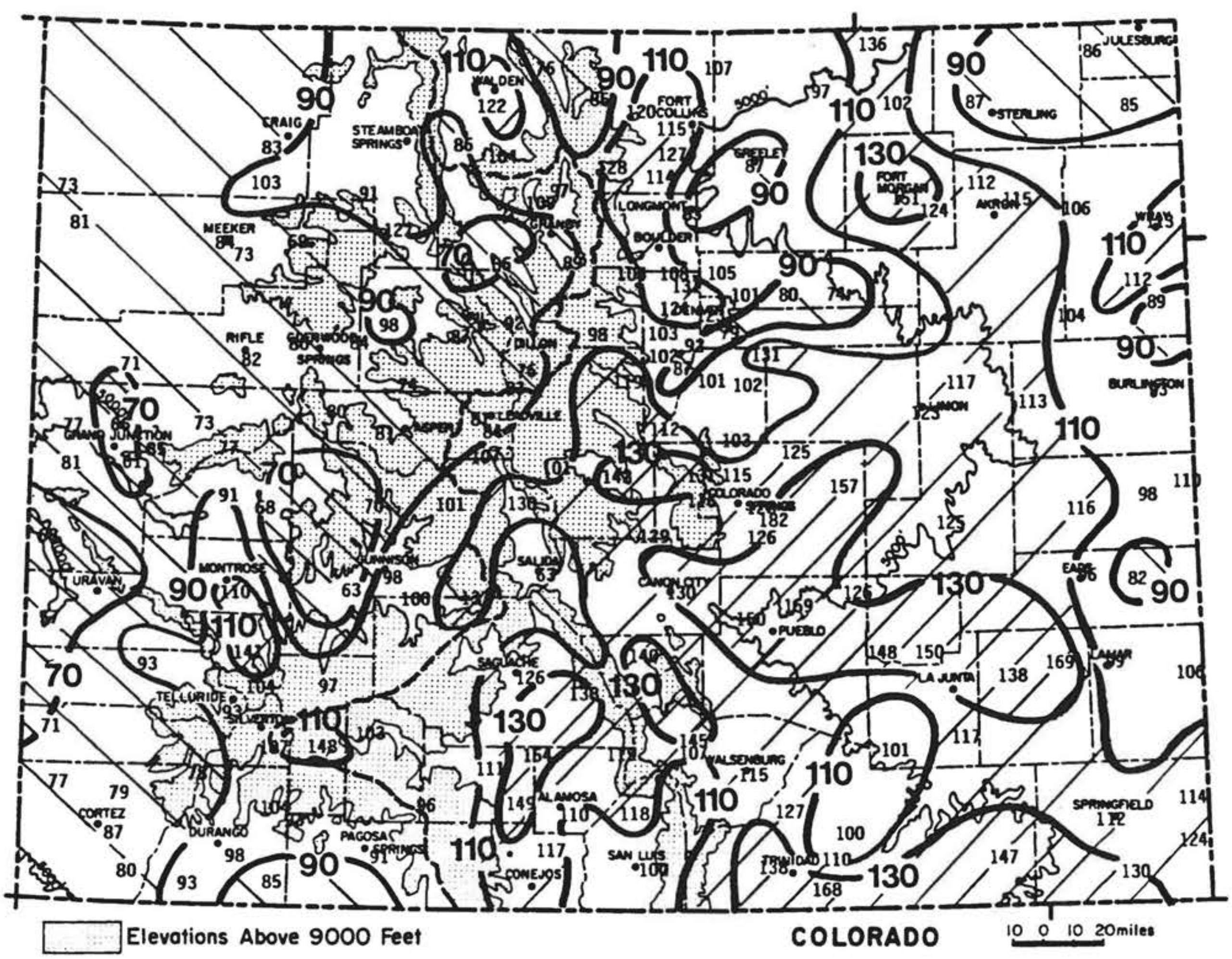


PALMER INDEX:

The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

Interpretation of Index

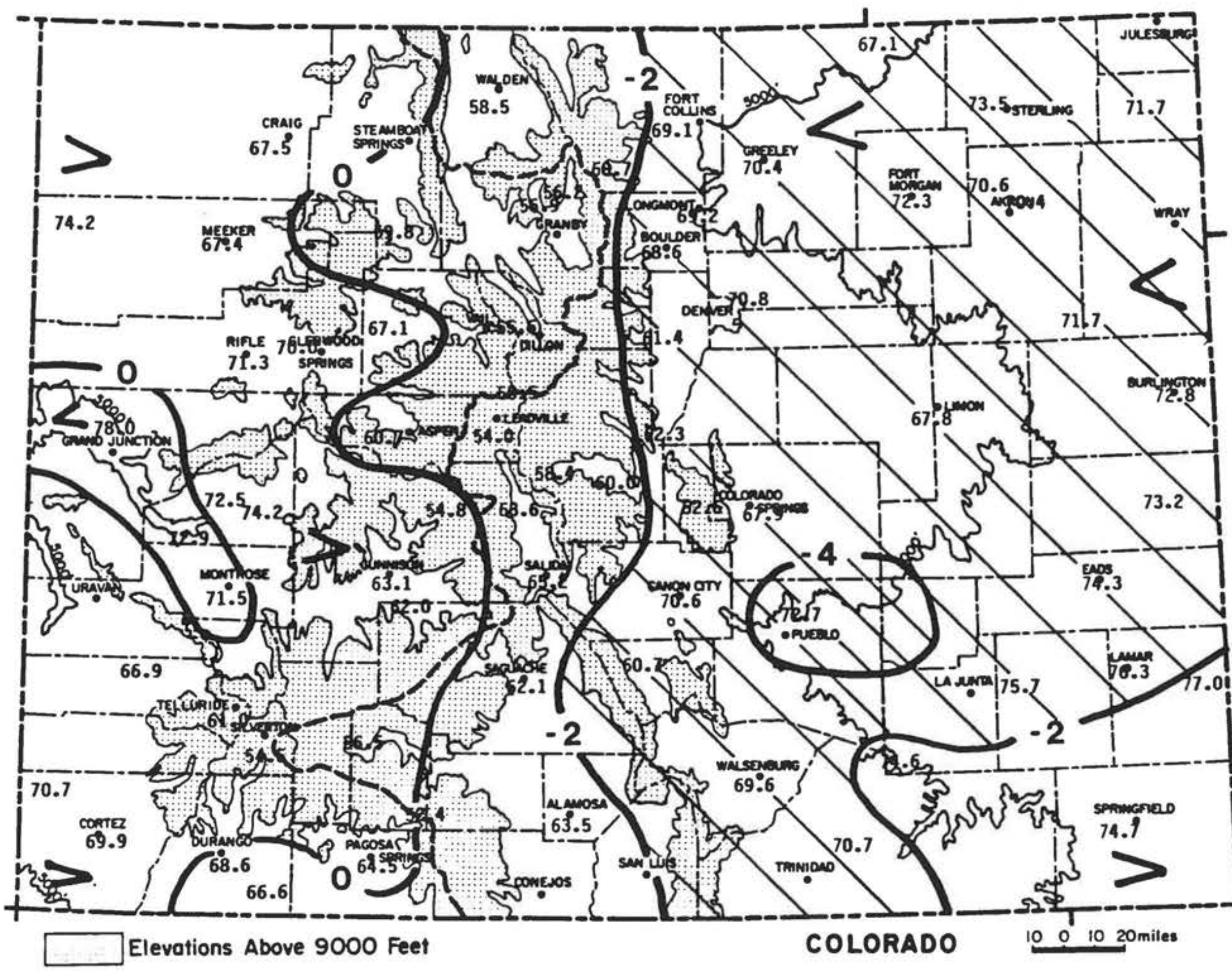
	extremely wet
+4	----------------
+3	ample moisture
+2	----------------
+1	
0	near normal
-1	
-2	----------------
	moderate drought
-3	----------------
	severe drought
-4	----------------
	extreme drought



Precipitation for October 1989 through July 1990 as a percent of the 1961-1980 average.

JULY 1990 TEMPERATURES AND DEGREE DAYS

For the month as a whole, July temperatures were near average in Western Colorado but considerably cooler than average east. At Pueblo, for example, this was the coolest July since 1950 and the 7th coolest July this century. Except for a few hot days early in the month, July temperatures were consistently pleasant. Las Animas, Colorado's traditional hot spot where July daily maximum temperatures average 96°F, enjoyed 10 days with maximum temperatures below 85°F. After the blistering heat of late June, these cooler temperatures were greatly appreciated by most Coloradans as well as summer visitors. However, it also meant a reduction in growing degree days which are crucial for the development of some of Colorado's crops such as corn and sorghum.



July 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

JULY 1990 SOIL TEMPERATURES

Deep soil temperatures continued to rise during July. However, near the surface, the soil cooled in response to cooler than average air temperatures and less sunshine than normal.

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 1990

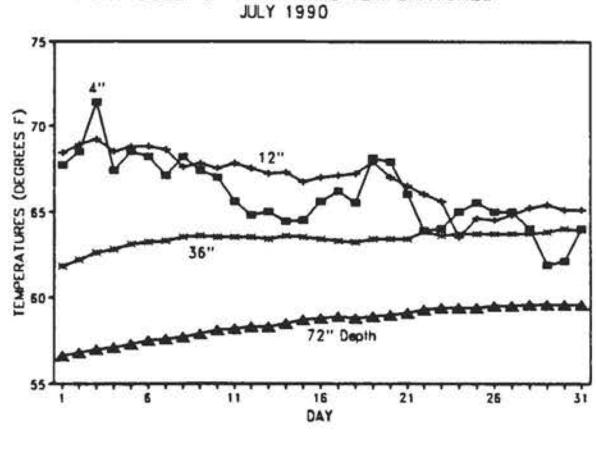


Table 1. Heating Degree Day Data through July 1990 (base temperature, 65°F).

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
	89-90	17	82	271	698	1001	1400	1554	1089	880	640	480	105	8217
	90-91	59												59
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	89-90	68	176	303	671	974	1365	1365	1086	915	697	543	171	8334
	90-91	134												134
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	89-90	1	M	M	M	M	M	M	M	M	502	321	21	M
	90-91	32												32
BUENA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
VISTA	89-90	39	112	270	628	812	1202	1184	991	857	660	518	106	7379
	90-91	66												66
BURLING-	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
TON	89-90	M	4	M	415	684	1229	990	957	757	459	280	3	M
	90-91	10												10
CANON	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
CITY	89-90	0	0	131	379	584	1076	859	827	687	421	325	22	5311
	90-91	14												14
COLORADO	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
SPRINGS	89-90	0	4	172	473	699	1163	966	928	805	526	345	24	6105
	90-91	28												28
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	89-90	0	16	142	494	850	1166	1222	959	776	490	377	59	6551
	90-91	1												1
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	89-90	4	46	235	586	892	1420	1319	1257	879	530	453	144	7765
	90-91	14												14
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	89-90	M	M	M	330	M	M	1161	865	626	355	237	22	M
	90-91	0												0
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	89-90	0	0	153	424	658	1160	879	882	781	469	265	7	5678
	90-91	12												12
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	89-90	226	357	502	861	1124	1495	1506	1271	1124	886	764	349	10465
	90-91	284												284
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	89-90	2	19	106	520	789	1133	1278	965	724	479	359	44	6418
	90-91	4												4
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	89-90	1	60	217	593	896	1348	1286	986	806	545	269	68	7075
	90-91	15												15
EVER-	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
GREEN	89-90	49	118	325	657	818	1221	1115	1030	932	662	513	140	7580
	90-91	120												120
FORT	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
COLLINS	89-90	0	3	169	458	711	1166	930	910	848	495	307	19	6016
	90-91	19												19
FORT	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
MORGAN	89-90	0	2	156	416	721	1285	1087	1010	776	M	274	10	M
	90-91	18												18
GRAND	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
JUNCTION	89-90	0	0	40	316	729	1103	1124	820	557	271	139	20	5119
	90-91	0												0

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

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

STATION		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANN
GRAND	AVE	214	264	468	775	1128	1473	1593	1369	1318	951	654	384	10591
LAKE	89-90	168	306	427	768	1132	1449	1401	1205	1043	833	689	266	9687
	90-91	264												264
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	89-90	1	2	166	454	729	1230	985	922	787	449	275	9	6009
	90-91	14												14
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	89-90	61	155	341	749	1069	1574	1647	1254	906	672	540	188	9156
	90-91	65												65
LAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
ANIMAS	89-90	0	0	99	323	684	1176	1030	887	638	309	188	2	5336
	90-91	4												4
LEAD-	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
VILLE	89-90	285	412	545	880	1138	1507	1499	1265	1188	920	793	377	10809
	90-91	331												331
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	89-90	1	6	204	508	762	1252	1078	991	815	555	364	33	6569
	90-91	36												36
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	89-90	2	8	200	484	749	1302	1048	994	917	552	319	25	6600
	90-91	24												24
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	89-90	0	41	198	543	869	1261	1169	1071	795	507	387	91	6932
	90-91	9												9
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	89-90	0	10	110	439	768	1156	1186	895	654	425	285	27	5955
	90-91	0												0
PAGOSA	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
SPRINGS	89-90	24	118	284	646	964	1298	1491	1160	873	630	524	164	8176
	90-91	44												44
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	89-90	0	0	94	373	676	1204	964	877	695	394	233	2	5512
	90-91	1												1
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	89-90	0	2	103	473	M	1130	1191	923	657	392	281	37	5189
	90-91	0												0
STEAMBOAT	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
SPRINGS	89-90	18	117	315	M	974	1533	1580	1332	971	658	576	M	M
	90-91	M												M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	89-90	M	3	144	428	719	1254	1074	1026	760	427	275	8	M
	90-91	17												17
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	72	175	270	644	869	1264	1273	1023	922	664	509	145	7830
	89-90	117												117
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	89-90	0	1	111	369	633	1153	980	874	681	420	266	8	5496
	90-91	4												4
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	89-90	132	279	461	802	1075	1490	1359	1287	1068	796	674	273	9696
	90-91	202												202
WALSEN-	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
BURG	89-90	0	2	117	345	581	1047	848	800	666	408	289	10	5113
	90-91	15												15

* = AVES ADJUSTED FOR STATION MOVES   M = MISSING   E = ESTIMATED

JULY 1990 CLIMATIC DATA

Eastern Plains

Name	Max	Min	Temperature Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
NEW RAYMER 21N	80.9	53.2	67.1	-4.0	101	42	62	134	516	4.46	2.30	206.5	14
STERLING	88.1	58.9	73.5	-1.2	108	46	17	289	660	4.69	2.12	182.5	9
FORT MORGAN	86.1	58.5	72.3	-2.9	105	47	18	252	637	6.20	4.50	364.7	13
AKRON FAA AP	83.9	57.2	70.6	-3.0	104	44	28	210	607	4.91	2.28	186.7	13
AKRON 4E	84.8	55.9	70.4	-3.0	106	42	33	205	590	4.71	2.14	183.3	11
HOLYOKE	83.9	59.5	71.7	-3.3	103	46	29	243	638	4.21	1.43	151.4	9
JOES	85.7	57.7	71.7	-3.3	105	44	15	229	632	2.34	-0.26	90.0	10
BURLINGTON	86.5	59.2	72.8	-3.0	104	46	10	260	654	2.53	0.56	128.4	11
LIMON WSMO	81.0	54.7	67.8	-2.9	99	45	36	130	542	4.34	1.44	149.7	14
CHEYENNE WELLS	88.0	58.4	73.2	-2.2	104	41	14	277	666	2.47	-0.00	100.0	10
EADS	88.1	60.4	74.3	-2.7	103	48	7	302	688	1.84	-0.99	65.0	9
ORDWAY 21N	89.3	57.4	73.3	-1.9	105	49	5	271	645	5.22	2.90	225.0	13
LAMAR	91.9	60.7	76.3	-2.6	105	48	5	362	710	2.30	-0.10	95.8	12
LAS ANIMAS	90.5	61.0	75.7	-3.6	108	50	4	343	702	3.88	1.63	172.4	13
HOLLY	91.3	62.8	77.0	-1.7	108	46	3	383	741	2.47	0.40	119.3	9
SPRINGFIELD 7WSW	90.6	58.8	74.7	-0.6	106	46	4	310	685	5.58	3.14	228.7	9
TIMPAS 13SW	89.6	59.5	74.6	-1.2	104	53	2	306	685	2.95	1.26	174.6	10

Foothills/Adjacent Plains

Name	Max	Min	Temperature Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	81.6	56.5	69.1	-2.4	99	49	19	152	577	1.39	-0.38	78.5	14
GREELEY UNC	83.9	56.8	70.4	-3.1	102	49	14	190	598	1.14	-0.07	94.2	14
ESTES PARK	74.6	46.8	60.7	-1.6	89	40	142	16	397	5.25	3.08	241.9	21
LONGMONT 2ESE	85.6	52.8	69.2	-3.2	103	44	24	163	558	1.02	-0.04	96.2	9
BOULDER	81.6	55.6	68.6	-4.9	99	47	32	152	561	4.23	2.34	223.8	16
DENVER WSFO AP	84.1	57.5	70.8	-2.5	102	49	12	196	608	3.57	1.67	187.9	16
EVERGREEN	75.6	47.1	61.4	-2.4	92	41	120	16	408	4.40	2.15	195.6	18
CHEESMAN	80.7	43.8	62.3	-3.2	96	35	105	30	465	3.48	0.65	123.0	19
LAKE GEORGE 8SW	73.9	46.0	60.0	-1.3	85	36	155	5	380	4.20	1.67	166.0	22
ANTERO RESERVOIR	74.5	42.2	58.4	0.6	87	33	203	4	389	2.43	0.54	128.6	15
RUXTON PARK	68.2	37.0	52.6	-3.7	86	30	375	0	290	8.16	3.92	192.5	21
COLORADO SPRINGS	80.2	55.7	67.9	-3.3	96	48	28	128	548	5.13	2.23	176.9	16
CANON CITY 2SE	84.1	57.0	70.6	-3.0	97	49	14	194	615	3.84	1.93	201.0	16
PUEBLO WSO AP	88.0	57.5	72.7	-4.5	104	50	1	250	645	5.14	3.20	264.9	15
WESTCLIFFE	76.4	45.0	60.7	-2.7	89	37	136	7	422	4.12	1.83	179.9	16
WALSENBURG	83.7	55.5	69.6	-2.6	97	47	15	164	596	3.39	0.99	141.2	13
TRINIDAD FAA AP	85.6	55.7	70.7	-3.3	98	49	4	189	613	4.05	1.88	186.6	11

Mountains/Interior Valleys

Name	Max	Min	Temperature Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	76.1	40.9	58.5	-0.4	91	33	202	6	405	1.87	0.94	201.1	12
LEADVILLE 2SW	70.1	37.9	54.0	-0.5	83	30	331	0	320	2.31	0.01	100.4	20
SALIDA	81.4	49.0	65.2	-0.5	92	40	40	54	506	1.58	-0.11	93.5	15
BUENA VISTA	79.6	47.6	63.6	-1.3	93	39	66	33	465	3.44	1.87	219.1	18
SAGUACHE	76.4	47.9	62.1	-1.9	85	41	93	12	423	3.62	2.01	224.8	16
HERMIT 7ESE	73.4	39.7	56.5	0.7	84	32	255	0	370	3.00	0.68	129.3	9
ALAMOSA WSO AP	79.5	47.6	63.5	-1.6	89	40	59	22	476	1.86	0.52	138.8	13
STEAMBOAT SPRINGS	79.3	42.4	60.8	-0.8	89	36	129	8	470	2.68	1.40	209.4	8
YAMPA	73.7	45.9	59.8	-1.5	84	38	157	6	381	3.17	1.28	167.7	12
GRAND LAKE 1NW	74.1	38.3	56.2	-0.1	88	27	264	0	380	2.06	0.02	101.0	18
GRAND LAKE 6SSW	73.3	40.6	56.9	-1.2	86	35	242	0	369	2.55	1.20	188.9	20
DILLON 1E	71.6	39.5	55.6	-1.3	84	34	284	0	342	2.59	1.04	167.1	15
CLIMAX	63.3	37.7	50.5	-1.2	78	31	441	0	213	3.48	1.40	167.3	18
ASPEN 1SW	74.8	46.6	60.7	-1.3	86	40	134	9	398	2.30	0.60	135.3	16
TAYLOR PARK	68.8	40.8	54.8	1.4	79	35	307	0	299	2.70	1.16	175.3	15
TELLURIDE	77.6	44.3	61.0	1.0	84	37	117	0	433	3.20	0.78	132.2	19
PAGOSA SPRINGS	82.2	46.7	64.5	0.4	94	40	44	35	500	2.71	0.97	155.7	16
SILVERTON	72.0	37.0	54.5	0.6	81	27	318	0	350	4.80	2.07	175.8	20
WOLF CREEK PASS 1	65.7	39.2	52.4	-0.7	76	33	381	0	251	4.26	1.03	131.9	21

Western Valleys

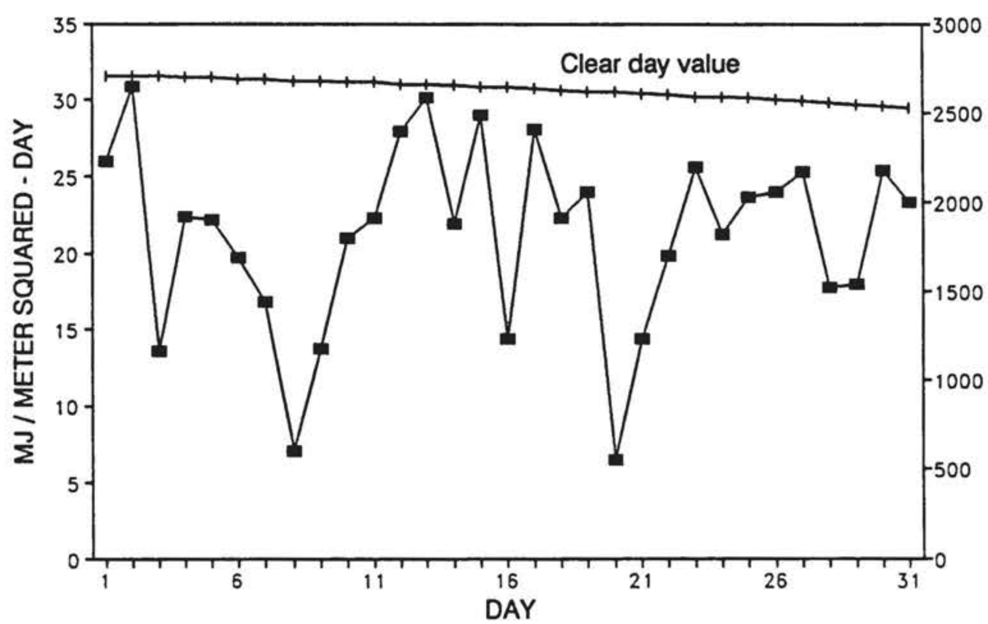
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	83.2	51.8	67.5	0.8	95	42	14	99	549	0.78	-0.52	60.0	8
MEEKER NO. 2	84.4	50.5	67.4	0.2	96	42	9	94	556	1.49	0.38	134.2	9
RANGELY 1E	89.8	58.6	74.2	0.9	100	52	0	296	692	0.61	-0.33	64.9	6
EAGLE FAA AP	84.8	49.3	67.1	0.6	96	41	15	86	550	2.33	1.30	226.2	10
GLENWOOD SPRINGS	87.2	52.9	70.0	0.1	99	46	0	166	600	1.88	0.61	148.0	10
RIFLE	89.3	53.2	71.3	1.0	100	46	0	203	614	1.22	0.53	176.8	6
GRAND JUNCTION WS	91.9	64.1	78.0	-1.1	102	58	0	412	778	0.96	0.40	171.4	9
CEDAREDGE	90.2	54.8	72.5	0.6	100	48	0	242	637	1.23	0.39	146.4	6
PAONIA 1SW	90.4	58.1	74.2	1.8	100	54	0	293	686	1.40	0.27	123.9	13
DELTA	92.4	53.5	72.9	-0.8	106	45	0	254	626	0.53	-0.13	80.3	10
GUNNISON	80.8	45.4	63.1	1.9	91	41	65	16	478	2.07	0.76	158.0	11
COCHETOPA CREEK	78.9	45.2	62.0	0.9	91	38	101	17	455	2.19	0.62	139.5	12
MONTROSE NO. 2	86.2	56.8	71.5	-0.8	97	53	0	210	651	1.90	1.02	215.9	10
NORWOOD	82.1	51.7	66.9	0.6	92	47	3	71	532	2.86	1.10	162.5	11
URAVAN	94.3	62.0	78.1	0.9	107	57	0	414	748	1.98	0.82	170.7	12
YELLOW JACKET 2W	86.3	55.0	70.7	0.1	97	51	0	182	622	2.16	0.86	166.2	7
CORTEZ	86.5	53.3	69.9	1.1	99	44	1	160	607	2.39	1.36	232.0	8
DURANGO	85.4	51.8	68.6	-0.2	98	45	4	124	568	3.45	1.94	228.5	15
IGNACIO 1N	81.9	51.3	66.6	-1.6	93	42	10	65	530	2.53	1.18	187.4	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.

JULY 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	4	18	9	--	--
Denver	6	14	11	62%	71%
Fort Collins	4	17	10	--	--
Grand Junction	18	6	7	77%	78%
Pueblo	11	13	7	71%	79%

FT. COLLINS TOTAL HEMISPHERIC RADIATION
JULY 1990



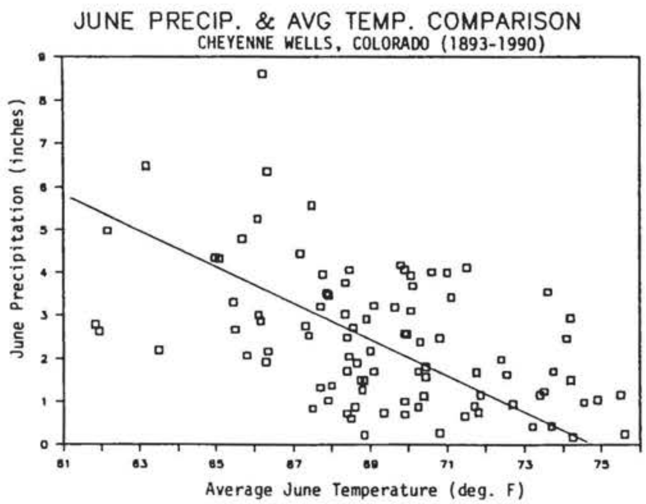
Hot, Dry June -- Cool, Wet July! Was That Normal?

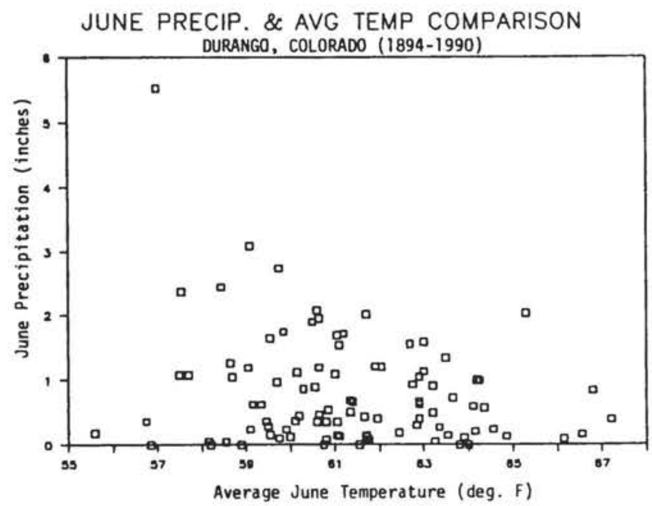
To satisfy our own curiosity, we dug out the records for the past 100 years for several locations in Colorado and looked to see how often weather patterns similar to the summer of 1990 had occurred in the past. We were curious to know if there was any way we could have anticipated this unusual weather. We performed various comparisons and correlations using June and July temperatures and precipitation. We even included El Nino information. Here is what we learned.

First of all, although it was an unusual summer it was not unprecedented. We ranked all June's and July's from hottest to coldest and also from driest to wettest and combined those rankings. We then produced "scatterplots" of June versus July combined temperature and precipitation rankings. We found that for any given location across the State, about 10 years in the past 100 could be characterized as crudely similar to 1990. However, we could find only 3 other years which showed these same general characteristics both east and west of the mountains. These years were 1918, 1950 and 1968. Of these, only 1918 exhibited comparably extreme June temperatures.

While these first results were underwhelming, one thing was interesting. We noted there was a much greater chance of having extreme July's following extreme June's for any combination of temperature and precipitation east of the mountains than in or west of the mountains. For example, there were a number of years east of the mountains when very hot and dry July's followed hot and dry June's. Examples included 1901, 1931, 1933, 1934, 1936, 1952, 1953, 1954, 1963, and 1977, all during notable drought periods. None of those years showed similar behavior in southwestern Colorado. There were also examples of cool and wet June's being following by both cool/wet and hot/dry July's in eastern Colorado. In western Colorado it was more common to have extreme months followed by more normal conditions and vice versa. No relationships appeared strong enough to suggest that a statistical forecast for July could be made based solely upon June observations.

These results encouraged us to take a giant step backwards. Instead of comparing one month to the next, we simply compared temperatures to precipitation within a single month. At last, some relationships began to appear. As you can see from the graph below for Cheyenne Wells, there is a tendency for hot June's to be dry while cooler June's are more likely to be wet. We found the same to be true for other summer months at locations east of the mountains. But at Durango (see graph below) and other western Colorado locations, monthly temperatures and coincident precipitation were essentially unrelated, especially later in the summer.





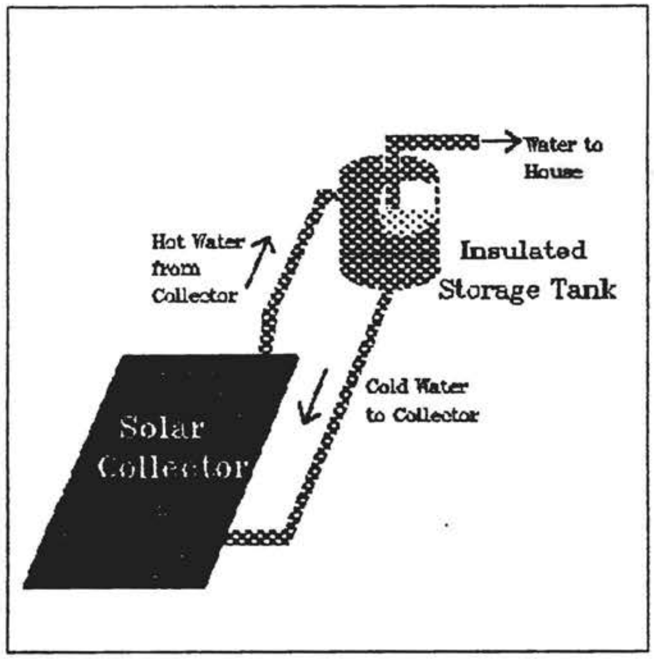
We then took one final leap and attempted to incorporate information about the atmospheric/oceanic circulation in the tropical Pacific known as the El Nino Southern Oscillation. What we found was an indication that El Nino's (abnormally warm water temperatures west of South America) do appear to have a slight influence on summer weather in Colorado. They relate best to conditions early in the summer out on the eastern plains. Associations with temperatures and precipitation from the Front Range westward are much weaker. During El Nino years, June's tend to be cooler and wetter than non-El Nino years. La Nina's (abnormally cool ocean temperatures) appear to be associated with hotter and drier June's. Had we tried to make a forecast this year based on Pacific conditions during the late spring, we would have predicted a hot and dry June but would have had to toss a coin for July.

It appears we can draw a few conclusions. Some are painfully obvious. First, no two years are ever the same. Second, what happens east of the mountains is usually different from what happens on the Western Slope and may appear unrelated. Simple relationships between weather conditions from one month to the next offer little forecasting skill, but temperatures and precipitation within a given month are correlated east of the mountains. The El Nino circulation appears to have some effect on June temperature and precipitation patterns in Colorado but the effect disappears in July.

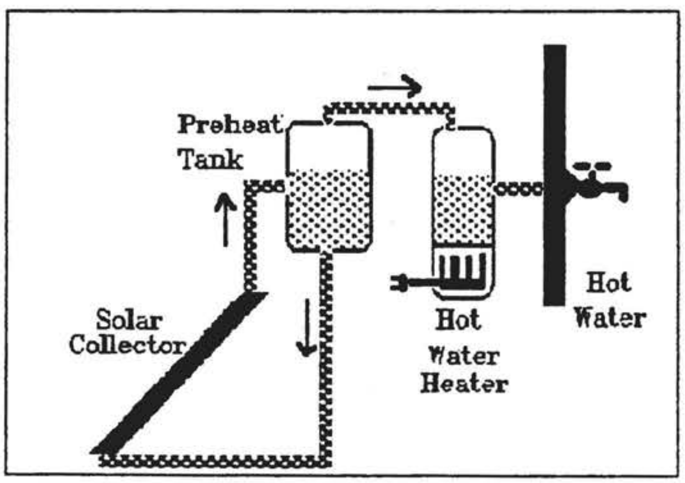
SOLAR WATER HEATERS II

If your Grandma is like my Grandma, she takes her bath on Saturdays. Even if it is a leap year, she will only step in to the tub on Saturdays. After strenuous research, I have found the reason for this ancient ritual, hot water heating. When my Grandmother was a girl it took all day to heat enough water for the family baths. A simmering cast iron cauldron was her faithful hot water heater until science and technology advanced far enough to place a hot water heating tank right on the stove. While Grandma thought she was firing up the stove, she was actually using a passive water heater. A passive system is one that does not have mechanical parts to move the fluids.

If your Grandma lived in southern California or Arizona, she probably used a Climax solar water heater. Climax was one of the first passive solar water heaters. An example of a passive solar water heater is shown to the right. The storage tank is strategically located at least 1 foot above the solar collector so no pumps are needed. Cold water moves down the pipe into the collector by the force of gravity. As it is warmed in the collector it begins to rise. It will rise to the top of the collector then into the storage tank which displaces cold water and moves it into the collector. As long as there is solar radiation on the collector this process will continue.



In a climate as cold as Colorado's, a passive solar water heater is best suited to preheat water. As shown in the figure on the left, the water is heated in the same way as above, but the heated water is then sent to the standard hot water heater. If the incoming city water is at 40 F and it is needed at 140 F, the hot water heater needs to raise the temperature of the water 100 degrees. If a solar water heater is added to preheat the water, it would raise the water to about 100 degrees F. That means your hot water heater only has to heat the water 40 degrees instead of 100 which saves you money and saves all of us a little of the Environment



If your Grandma is like my Grandma, she is pretty concerned about the environment. A passive solar water heater helps preserve the environment and saves you money with very little maintenance.

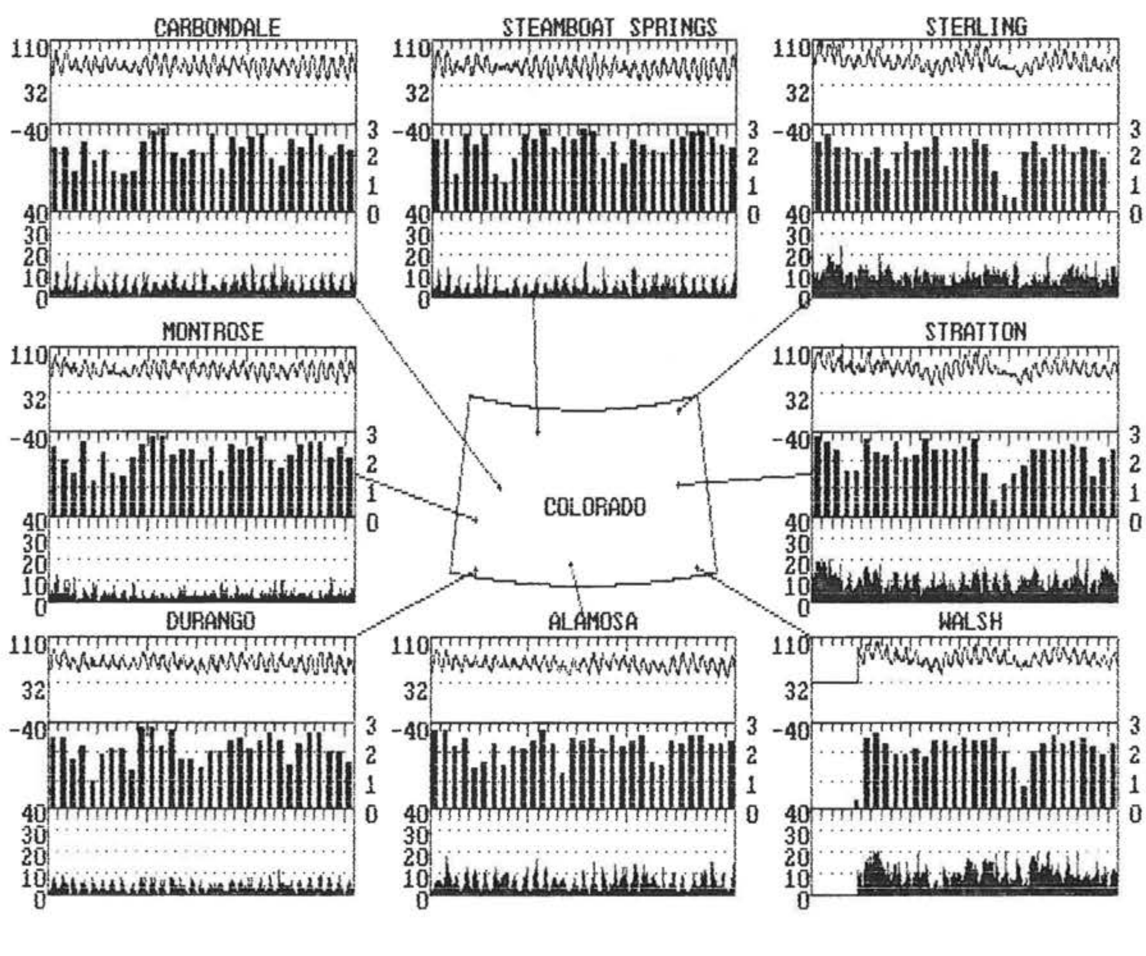
This paper was written by Erika Komito of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder, CO. 80309-0428. Information on acquiring our weather data can be obtained by writing Mary Sutter at this address.

WTHRNET WEATHER DATA JULY 1990

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)								
	61.9	63.3	65.1	68.7	62.6	70.9	72.0	66.4
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	86.5 1/16	87.1 1/15	93.4 2/16	93.6 1/15	92.1 1/14	106.9 1/16		98.1 7/15
minimum:	40.1 31/ 5	43.0 30/ 5	39.9 22/ 5	45.9 30/ 5	37.9 28/ 5	43.9 22/ 5	44.4 13/ 5	
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	95 / 47	85 / 46	93 / 47	83 / 49	98 / 46	64 / 45	74 / 51	76 / 42
11 AM	56 / 53	49 / 51	48 / 53	49 / 56	50 / 53	33 / 42	42 / 50	46 / 44
2 PM	42 / 48	43 / 48	36 / 49	42 / 54	43 / 51	26 / 38	33 / 46	39 / 44
5 PM	44 / 46	42 / 46	40 / 47	44 / 53	43 / 50	24 / 36	32 / 45	42 / 46
11 PM	72 / 48	74 / 48	69 / 49	64 / 51	79 / 50	49 / 42	58 / 51	66 / 46
monthly average wind direction (degrees clockwise from north)								
day	184	184	208	204	227	132	126	125
night	174	85	171	90	122	182	188	166
monthly average wind speed (miles per hour)								
	4.97	3.18	3.48	2.94	2.94	7.93	8.90	7.52
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	223	402	440	430	472	47	17	146
3 to 12	492	342	299	312	260	601	548	453
12 to 24	29	0	5	2	12	96	179	145
> 24	0	0	0	0	0	0	0	0
monthly average daily total insolation (Btu/ft²·day)								
	2209	2100	2098	2203	2290	1965	2150	1812
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	228	161	173	166	195	204	202	202
40-60%	68	72	102	88	65	77	103	81
20-40%	60	68	67	52	59	81	64	41
0-20%	45	65	40	47	35	49	41	42

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour. Walsh is missing data from 6/26 to 7/5 due to lightning damage.



COLORADO CLIMATE
AUGUST 1990

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 13 Number 11

August in Review:

The relatively cool and wet weather of July continued through the first half of August. Then hot and dry weather returned to Colorado. Statewide temperatures ended up slightly warmer than average in western and extreme southeastern Colorado but a bit cooler than average elsewhere. Precipitation was varied as it often is in the summer. Several areas ended up quite wet such as parts of southwestern, central and northeastern Colorado. Northwest and southeast Colorado were quite dry.

Colorado's October Climate:

Well, this is it. Another winter lies before us. In September we can still get away with pretending it's summer, but not in October. Don't panic, October weather can be downright delightful. There is usually a lot of sunshine. Winds are light most of the time. Temperatures, except high in the mountains, are still pleasant during the daytime most of the time. But there are a few other little details that may not be so pleasant. For example, trees loose their leaves. Daylength gets progressively shorter. Trout fishing gets trickier. Grass stops growing. Frosts kill most other vegetation. Pumpkins become popular. Cold fronts become stronger and more frequent. A few ski areas begin making snow. The first major snowstorm normally strikes. Halloween trick-or-treaters may get snowed on. A few hunters get stranded or lost in the mountains. The first downslope windstorm occasionally buffets the Front Range. Average temperatures typically plummet at least 10 degrees F from October 1 to the 31st. We often get a siege of cloudy, damp weather for a few days in a row that makes you think you're in Cleveland. The remains of a hurricane sometimes heads north and spreads clouds and rain into southwestern Colorado. So, even though most days are nice, don't be surprised by some inevitably adverse weather.

October precipitation patterns begin to show some of the traits of winter. Precipitation tends to be more plentiful west of the mountains than on the east side. This is because upper level winds begin to strengthen from the west bringing more Pacific moisture to Colorado. Monthly totals average only 0.50 - 0.80" on the eastern plains. Front Range and Western Slope areas average close to 1" of moisture for the month. Totals increase to as much as 2.50" in the northern and central mountains, but portions of the San Juan Mountains average as much as 4". Near the Utah border, October is the wettest month of the year on average. But most Octobers are not average. About 60% of all years are drier than average, but when it rains it pours. Durango's 11.79" rainfall total for October 1972 is a good example. The expected number of precipitation days ranges from about 3 in southeastern Colorado, 4 in the northeast, 5 along the Front Range, 5 to 6 on the Western Slope up to 10 in the high mountains. Temperatures in October begin with highs in the 70s at lower elevations, but 50s and 60s are most common by month's end. Freezes are likely at any time, but by Halloween lows are often in the 20s. In the mountains, expect temperatures to be at least 10 degrees cooler.

"Colorado Water -- Liquid Gold":

"Colorado Water -- Liquid Gold" was the title of an impressive exhibit at the 1990 Colorado State Fair. An entire pavilion was set aside to help Coloradans and out-of-state visitors visualize and appreciate where our water supplies come from and where it goes. Beginning with famous quotations such as these words from Daniel Webster in 1852, "To what use could we ever hope to put these great deserts and endless mountain ranges;" this exhibit showed how far Colorado has come during the past century and a half making the most of our limited water supplies. During 11 days of the State Fair, thousands of visitors wandered through the exhibit, hopefully taking with them a bit more understanding about Colorado water than they started with.

(continued on page -9-)

AUGUST 1990 DAILY WEATHER

Date	Event
1-3	It was seasonally warm on the 1st with scattered thundershowers most numerous over the mountains. Then a weak disturbance aloft crossed the state on the 2nd and triggered a line of thunderstorms on the eastern plains late. Stonington reported 1.50" of rain. A chilly morning in the mountains on the 3rd. Fraser dipped to 27°F. It was dry on the Western Slope on the 3rd, but scattered light thundershowers were visible over most of the rest of Colorado.
4-6	A cool Canadian airmass pushed down across the Great Plains 4th-6th and helped produce cool but very damp upslope flow across eastern Colorado. Meanwhile, western Colorado experienced seasonal temperatures with just a few light mountain showers. Moderate to heavy thunderstorms were widespread over the plains on the 4th and continued late into the night in some places. Springfield measured 1.09" of rain. Castle Rocky received 1.32". A vivid lightning display entertained residents of northern Front Range communities. Much of eastern Colorado awoke to cool, cloudy weather on the 5th with some patches of fog. An unusual storm organized over the Fort Morgan-Brush area on Sunday morning (5th). Summer morning heavy rains are always unusual in Colorado, but this was a doozy. Brush received 3.44", most of it between 7 am and 1 pm. The high temperature in Akron that day only reached 58°. There was more morning fog and low clouds east of the mountains on the 6th, but skies cleared and temperatures were remarkably pleasant. Las Animas, for example, only reached 74° on the 6th.
7-11	A high pressure ridge aloft brought the brief return of hot summer weather. Except for a few very light thundershowers over the mountains 7-8th, most of the State was sunny and dry. Lower elevation temperatures climbed into the 90s. Uravan hit 103° on the 8th. Then an increase in moisture east of the mountains 10-11th produced cooler temperatures but some locally heavy storms. Flagler reported 1.40" of rain late on the 10th. Pueblo and Sterling measured 1.12" and 1.90", respectively, on the 11th.
12-23	A moist, subtropical airmass fueled daily thunderstorm activity over the mountains and kept daytime maximum temperatures cooler than average. Several storms rolled out out of the mountains and struck portions of the eastern plains. During this period, several heavy rain episodes were reported. Cool, moist upslope flow contributed to the 1.78" of rain received near Timpas on the 12th. Antero Reservoir got 1.70" on the 13th -- one of their heaviest 1-day rains on record. Vallecito Reservoir received 1.61" on the 14th as much of the southern slopes of the San Juans got drenched. Climax got 0.88" and Roxborough State Park reported 1.82" on the 15th. Durango remained socked in with clouds and rain on the 16th and totalled 0.90" for the day. Longmont reported 1.65" late on the 16th. Akron received 1.80" on the 17th and Limon added 1.28". Storms were not as heavy on the 18-19th but were still numerous as a large low pressure trough moved into the western U.S. Unusually strong southerly winds aloft for this time of year ahead of the trough generated more heavy rains in the San Juans on the 20th. Alamosa got 0.84" on the 20th. Lemon Dam reported 1.80". Buena Vista recorded 1.18" on the 22nd and Walsenburg had 1.10" on the 23rd.
24-31	At last, drier air aloft moved over Colorado as south winds shifted to southwesterly aloft. Skies were persistently clear over Colorado 24-29th While temperatures dropped quickly at night, especially in the mountains, daytime temperatures soared to their highest levels since early July. Las Animas hit 106° on the 28th and Grand Junction rose to 98° on the 29th. Hohnholz Ranch (Laramie River) awoke to 25° on the 30th, the coldest in the State. But downslope winds helped raise temperatures that afternoon to record levels east of the mountains. Denver hit 98°F. Holly's 107° was the warmest in the State. Thundershowers then erupted late on the 30th and again on the 31st mostly in northern Colorado as a cool front nipped the region.

August 1990 Extremes

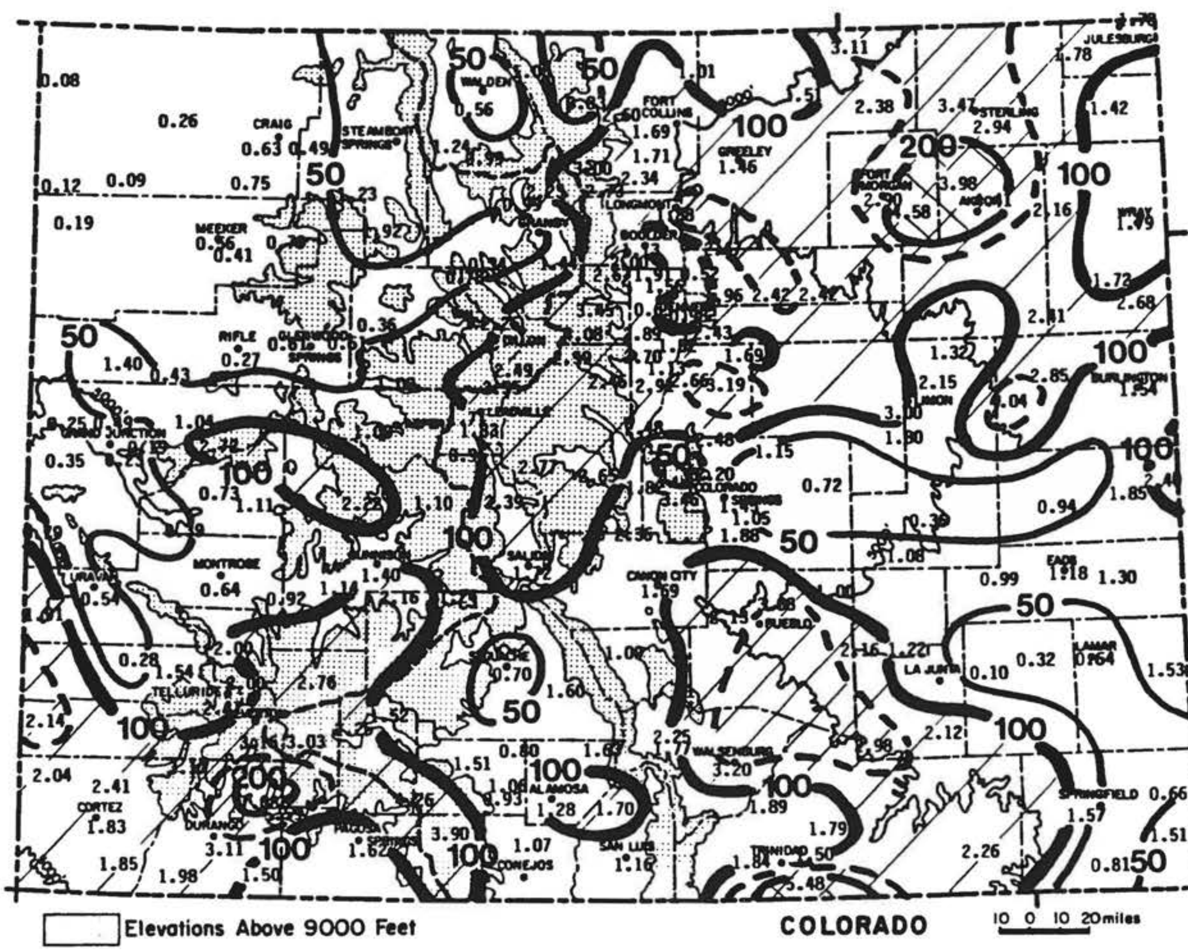
Highest Temperature	107°F	August 30	Holly
Lowest Temperature	25°F	August 30	Hohnholz Ranch
Greatest Total Precipitation	7.08"		Lemon Reservoir
Least Total Precipitation	0.08"		Brown's Park Refuge
Greatest Total Snowfall	2.00"	*	Leadville

* Two inch accumulation of hail on August 18.

AUGUST 1990 PRECIPITATION

August picked up where July left off with thundershower activity developing almost every day in and near the mountains for the first 24 days of the month. On several occasions, rainfall amounts were heavy. More than 30 stations had 1-day precipitation amounts in excess of 1.00". The wettest areas were found in the San Juan Mountains, in mountains and foothills from near Salida northward to Estes Park, and over parts of the northeastern plains. The 4.58" monthly total at Brush was well over double their average. Lemon Reservoir, near Durango, recorded 7.08". Yet there were several areas that missed out on much of the action. Very little moisture fell in northwestern Colorado. Rangely reported only 0.19". Portions of southeastern Colorado were also very dry. Las Animas measured just 0.10". On the whole, the month really was not as wet as most of us first thought. Of the 212 official stations reporting, 20% were very dry in August (less than 50% of average), 22% were dry (51-80%), 30% were near normal (81%-119%), 17% were wet (120%-150%) and 11% were very wet (more than 150% of average).

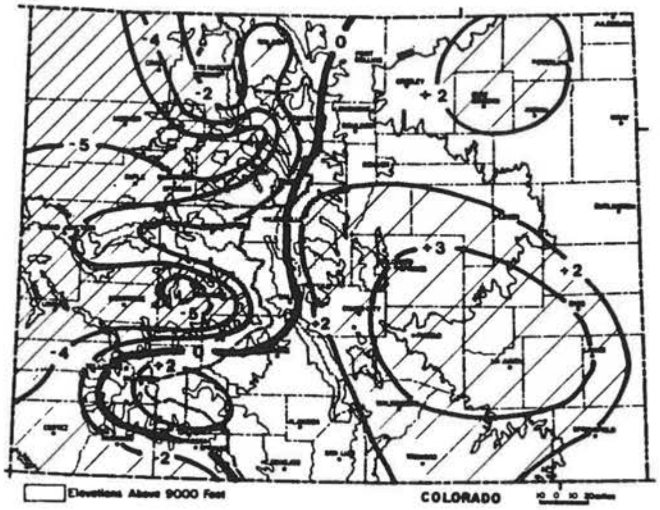
Greatest		Least	
Lemon Dam	7.08"	Browns Park Refuge	0.08"
Vallecito Dam	5.59"	Masadona 3E	0.09"
Wootton Ranch	5.48"	Las Animas	0.10"
Brush	4.58"	Dinosaur Natl. Mon.	0.12"
Akron 4E	4.41"	Rangely 1E, Palisade	0.19"



Precipitation amounts (inches) for August 1990 and contours of precipitation as a percent of the 1961-1980 average.

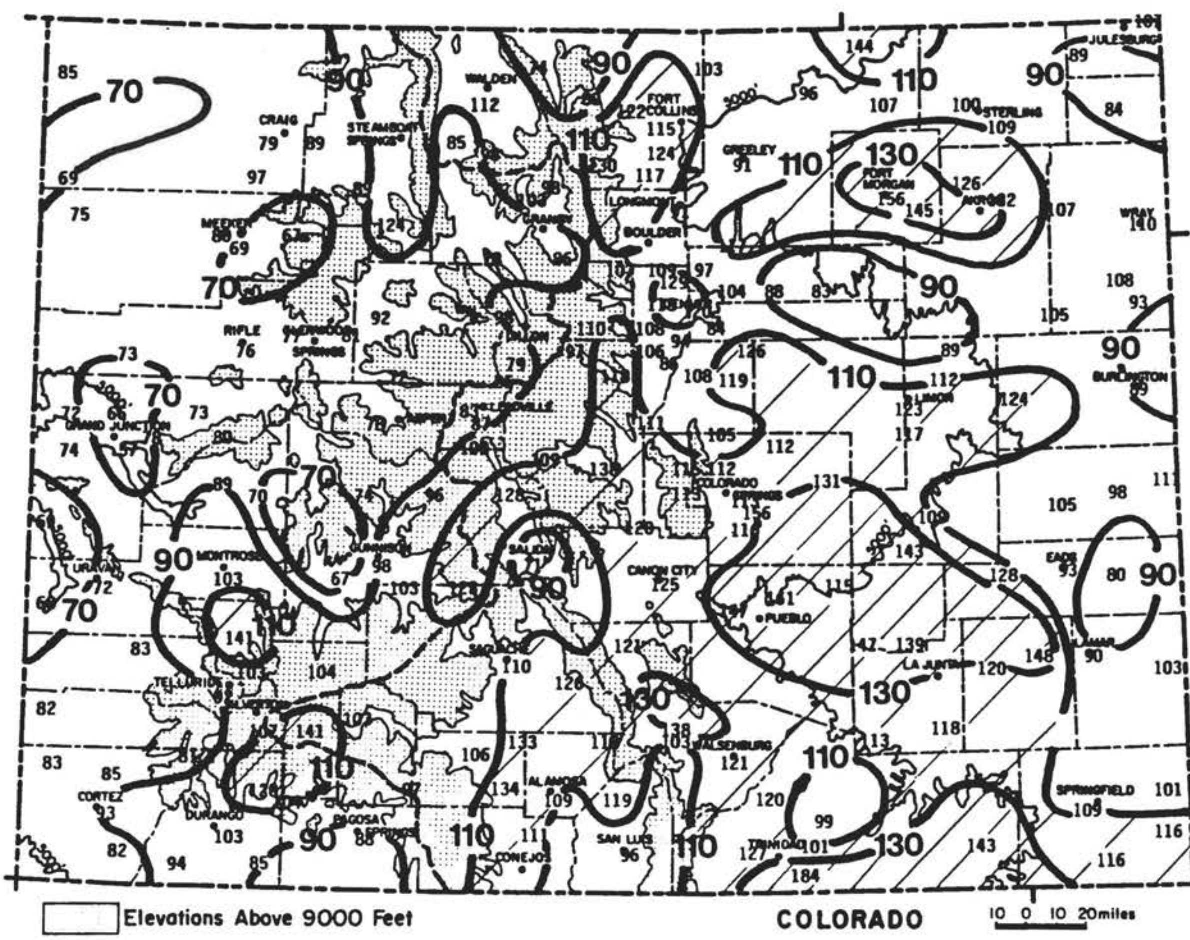
1990 WATER YEAR PRECIPITATION

Northwestern and extreme western Colorado have clearly emerged as the driest areas in Colorado this year. This is the 4th consecutive year with below average precipitation in Moffat county making this one of the most significant droughts of this century there. Other areas of western Colorado remain drier than average but have been greatly helped by abundant summer precipitation. Parts of the San Juans are now a little above average for the year after getting off to a very dry start. Despite considerable local variation, moisture conditions east of the mountains still look good with most areas at or above average for the year.



PALMER INDEX:
The Palmer Index is a relative indicator of soil moisture. It uses regional temperature and precipitation data as inputs to a soil moisture budget. It is best suited for unirrigated non-mountainous locations.

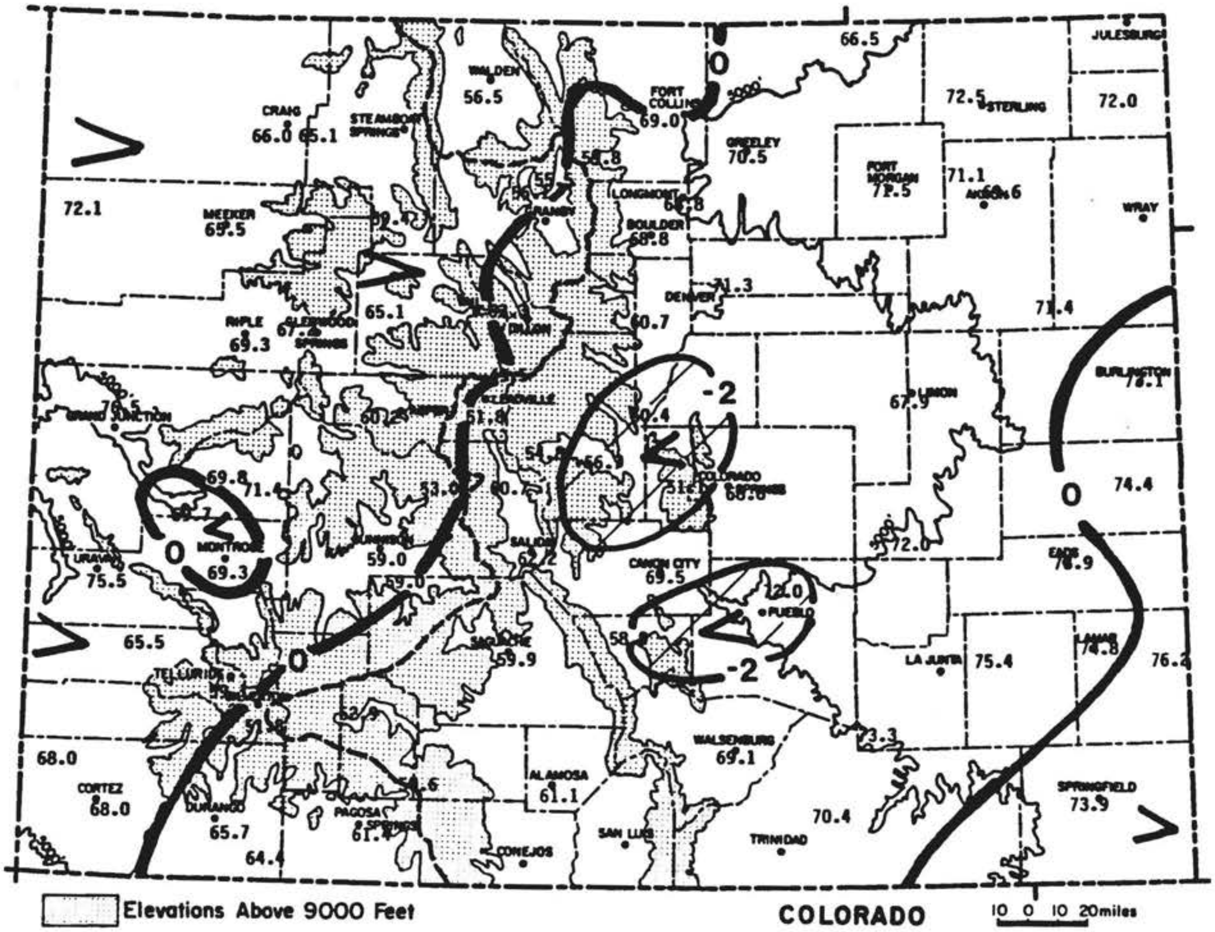
Interpretation of Index		
		extremely wet
	+4	----------------
	+3	ample moisture
	+2	----------------
	+1	
	0	near normal
	-1	
	-2	----------------
		moderate drought
	-3	----------------
		severe drought
	-4	----------------
		extreme drought



Precipitation for October 1989 through August 1990
as a percent of the 1961-1980 average.

AUGUST 1990 TEMPERATURES AND DEGREE DAYS

The eastern two-thirds of the Colorado experienced cooler than average temperatures most of the first 3 weeks of the month. Then, the month ended with the first sustained heatwave since before July 4th which brought monthly temperatures back to near normal. The month as a whole ended up a little warmer than average in extreme southeastern Colorado and over much of the Western Slope. Slightly cooler than average temperatures covered the rest of the region. The coolest area was the Pikes Peak region where temperatures were as much as 3 degrees F below average.



August 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

AUGUST 1990 SOIL TEMPERATURES

The soil temperature data collection system at Colorado State University had been failing during the summer. The display and recording device was removed and replaced near the end of August. Complete soil temperature data should be available again next 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.

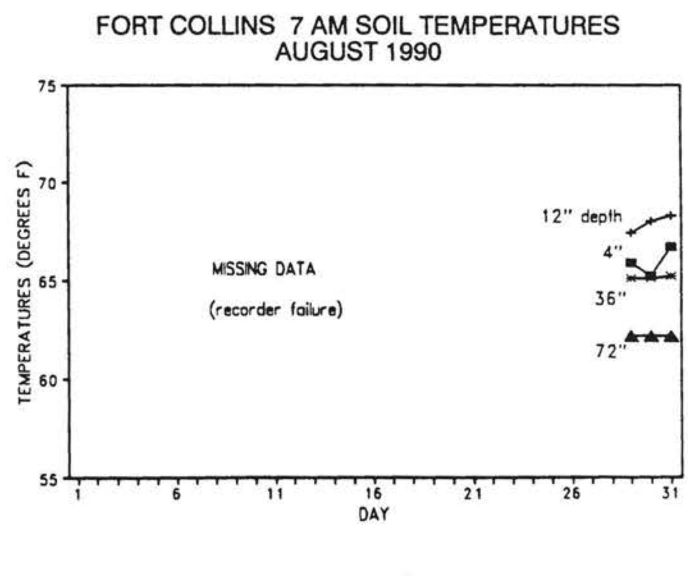


Table 1. Heating Degree Day Data through August 1990 (base temperature, 65°F).

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
	89-90	17	82	271	698	1001	1400	1554	1089	880	640	480	105	8217
	90-91	59	118											177
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	89-90	68	176	303	671	974	1365	1365	1086	915	697	543	171	8334
	90-91	134	146											280
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	89-90	1	M	M	M	M	M	M	M	M	502	321	21	M
	90-91	32	13											45
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	89-90	39	112	270	628	812	1202	1184	991	857	660	518	106	7379
	90-91	66	130											196
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	89-90	M	4	M	415	684	1229	990	957	757	459	280	3	M
	90-91	10	4											14
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	89-90	0	0	131	379	584	1076	859	827	687	421	325	22	5311
	90-91	14	12											26
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	89-90	0	4	172	473	699	1163	966	928	805	526	345	24	6105
	90-91	28	21											49
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	89-90	0	16	142	494	850	1166	1222	959	776	490	377	59	6551
	90-91	1	6											7
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	89-90	4	46	235	586	892	1420	1319	1257	879	530	453	144	7765
	90-91	14	18											32
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	89-90	M	M	M	330	M	M	1161	865	626	355	237	22	M
	90-91	0	2											2
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	89-90	0	0	153	424	658	1160	879	882	781	469	265	7	5678
	90-91	12	3											15
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	89-90	226	357	502	861	1124	1495	1506	1271	1124	886	764	349	10465
	90-91	284	355											639
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	89-90	2	19	106	520	789	1133	1278	965	724	479	359	44	6418
	90-91	4	28											32
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	89-90	1	60	217	593	896	1348	1286	986	806	545	269	68	7075
	90-91	15	23											38
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	89-90	49	118	325	657	818	1221	1115	1030	932	662	513	140	7580
	90-91	120	131											251
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	89-90	0	3	169	458	711	1166	930	910	848	495	307	19	6016
	90-91	19	6											25
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	89-90	0	2	156	416	721	1285	1087	1010	776	M	274	10	M
	90-91	18	7											25
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	89-90	0	0	40	316	729	1103	1124	820	557	271	139	20	5119
	90-91	0	0											0

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

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
	89-90	168	306	427	768	1132	1449	1401	1205	1043	833	689	266	9687
	90-91	264	268											532
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	89-90	1	2	166	454	729	1230	985	922	787	449	275	9	6009
	90-91	14	2											16
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	89-90	61	155	341	749	1069	1574	1647	1254	906	672	540	188	9156
	90-91	65	179											244
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	89-90	0	0	99	323	684	1176	1030	887	638	309	188	2	5336
	90-91	4	0											4
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	89-90	285	412	545	880	1138	1507	1499	1265	1188	920	793	377	10809
	90-91	331	402											733
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	89-90	1	6	204	508	762	1252	1078	991	815	555	364	33	6569
	90-91	36	11											47
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	89-90	2	8	200	484	749	1302	1048	994	917	552	319	25	6600
	90-91	24	11											35
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	89-90	0	41	198	543	869	1261	1169	1071	795	507	387	91	6932
	90-91	9	23											32
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	89-90	0	10	110	439	768	1156	1186	895	654	425	285	27	5955
	90-91	0	3											3
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	89-90	24	118	284	646	964	1298	1491	1160	873	630	524	164	8176
	90-91	44	108											152
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	89-90	0	0	94	373	676	1204	964	877	695	394	233	2	5512
	90-91	1	0											1
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	89-90	0	2	103	473	M	1130	1191	923	657	392	281	37	5189
	90-91	0	4											4
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	89-90	18	117	315	M	974	1533	1580	1332	971	658	576	M	M
	90-91	129	M											M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	89-90	M	3	144	428	719	1254	1074	1026	760	427	275	8	M
	90-91	17	7											24
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	72	175	270	644	869	1264	1273	1023	922	664	509	145	7830
	89-90	117	179											296
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	89-90	0	1	111	369	633	1153	980	874	681	420	266	8	5496
	90-91	4	6											10
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	89-90	132	279	461	802	1075	1490	1359	1287	1068	796	674	273	9696
	90-91	202	258											460
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	89-90	0	2	117	345	581	1047	848	800	666	408	289	10	5113
	90-91	15	8											23

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

AUGUST 1990 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	81.5	51.4	66.5	-2.1	99	46	29	83	515	3.11	1.65	213.0	9
STERLING	88.5	56.4	72.5	1.0	100	51	7	245	640	3.47	1.64	189.6	6
FORT MORGAN	86.5	56.4	71.5	-0.4	101	52	7	214	624	2.90	1.40	193.3	7
AKRON FAA AP	84.8	57.4	71.1	-0.0	99	50	12	208	624	3.98	2.20	223.6	10
AKRON 4E	84.4	54.8	69.6	-2.0	100	49	15	164	579	4.41	2.64	249.2	9
HOLYOKE	84.6	59.5	72.0	-0.4	102	52	8	236	653	1.42	-0.51	73.6	6
JOES	87.0	55.7	71.4	-1.1	103	50	9	213	610	2.41	0.21	109.5	6
BURLINGTON	87.5	58.7	73.1	0.4	102	52	4	265	663	1.54	-0.65	70.3	6
LIMON WSMO	82.6	53.3	67.9	-0.6	95	46	11	109	550	3.00	0.55	122.4	6
CHEYENNE WELLS	90.1	58.8	74.4	1.7	103	52	1	300	677	1.85	-0.07	96.4	9
EADS	88.9	58.9	73.9	-0.1	103	52	2	285	679	1.18	-0.55	68.2	3
ORDWAY 21N	89.5	54.5	72.0	-0.8	102	47	2	229	621	1.08	-1.02	51.4	4
LAMAR	91.6	58.0	74.8	-1.1	105	52	1	312	666	0.64	-1.30	33.0	4
LAS ANIMAS	92.6	58.2	75.4	-0.6	106	52	0	330	673	0.10	-1.33	7.0	1
HOLLY	92.6	59.8	76.2	1.0	107	53	0	355	700	1.53	-0.34	81.8	7
SPRINGFIELD 7WSW	89.6	58.1	73.9	1.1	101	49	3	285	669	1.57	-0.11	93.5	4
TIMPAS 13SW	88.0	58.5	73.3	-0.5	98	53	0	262	675	2.98	1.35	182.8	7

Foothills/Adjacent Plains

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
FORT COLLINS	83.8	54.2	69.0	0.3	96	49	6	140	580	1.69	0.32	123.4	10
GREELEY UNC	85.8	55.1	70.5	-0.4	96	51	2	182	610	1.46	0.31	127.0	6
ESTES PARK	75.6	44.0	59.8	-0.4	85	39	154	2	410	3.00	0.94	145.6	21
LONGMONT 2ESE	86.5	51.0	68.8	-0.9	100	42	11	136	570	1.88	0.71	160.7	4
BOULDER	82.8	54.7	68.8	-2.2	94	48	13	140	575	1.13	-0.13	89.7	10
DENVER WSFO AP	85.9	56.6	71.3	0.3	98	52	3	203	630	1.96	0.43	128.1	12
EVERGREEN	77.5	43.9	60.7	-0.8	91	39	131	5	433	2.89	0.89	144.5	16
CHEESMAN	80.3	40.5	60.4	-2.9	97	35	143	8	465	2.48	0.10	104.2	14
LAKE GEORGE 8SW	70.9	42.5	56.7	-2.1	82	35	250	0	330	2.65	0.46	121.0	15
ANTERO RESERVOIR	72.0	37.6	54.8	-0.7	80	30	309	0	348	2.77	0.69	133.2	14
RUXTON PARK	67.0	35.3	51.1	-3.2	81	31	421	0	269	3.46	-0.12	96.6	17
COLORADO SPRINGS	81.6	54.3	68.0	-0.6	94	49	21	121	550	1.45	-1.36	51.6	11
CANON CITY 2SE	83.7	55.2	69.5	-1.6	94	47	12	157	589	1.69	-0.02	98.8	10
PUEBLO WSO AP	89.3	54.7	72.0	-2.2	102	48	0	223	614	3.08	1.28	171.1	10
WESTCLIFFE	76.5	41.4	58.9	-2.1	84	35	184	4	420	1.09	-1.48	42.4	9
WALSENBURG	83.8	54.3	69.1	-0.3	94	49	8	142	578	3.20	1.17	157.6	8
TRINIDAD FAA AP	85.5	55.2	70.4	-1.1	94	48	6	180	605	1.79	-0.06	96.8	5

Mountains/Interior Valleys

Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
WALDEN	77.5	35.6	56.5	0.6	85	28	258	0	434	0.56	-0.64	46.7	8
LEADVILLE 2SW	68.9	34.7	51.8	-0.7	78	29	402	0	300	1.83	-0.17	91.5	15
SALIDA	79.8	44.5	62.2	-1.8	89	38	95	17	466	1.73	0.21	113.8	16
BUENA VISTA	77.5	43.8	60.7	-1.4	86	39	130	3	434	2.39	0.41	120.7	14
SAGUACHE	75.7	44.1	59.9	-1.4	83	39	150	1	406	0.70	-0.84	45.5	12
HERMIT 7ESE	70.4	35.4	52.9	-0.9	79	29	371	0	327	2.25	0.13	106.1	8
ALAMOSA WSO AP	78.7	43.6	61.1	-1.2	87	37	118	3	451	1.28	0.04	103.2	6
YAMPA	75.2	43.5	59.4	0.1	83	36	166	0	400	1.92	0.16	109.1	12
GRAND LAKE 1NW	74.6	36.5	55.5	1.5	84	30	286	0	387	2.23	0.14	106.7	18
GRAND LAKE 6SSW	74.4	37.9	56.1	-0.1	82	32	268	0	385	0.99	-0.60	62.3	17
DILLON 1E	70.7	35.8	53.3	-1.4	79	28	355	0	328	2.26	0.62	137.8	10
CLIMAX	62.4	36.6	49.5	0.2	72	31	473	0	198	2.55	0.24	110.4	13
ASPEN 1SW	74.9	45.5	60.2	0.7	84	38	146	4	393	1.00	-0.90	52.6	12
TAYLOR PARK	68.6	37.4	53.0	1.6	80	32	363	0	296	1.10	-0.75	59.5	5
TELLURIDE	76.1	42.0	59.1	1.2	87	36	179	3	411	2.41	-0.29	89.3	20
PAGOSA SPRINGS	80.7	42.0	61.4	-0.5	91	35	108	4	472	1.62	-0.87	65.1	17
SILVERTON	69.7	33.8	51.8	-0.7	80	28	403	0	314	3.16	0.18	106.0	17
WOLF CREEK PASS 1	64.3	37.0	50.6	-0.6	76	33	440	0	230	4.26	0.34	108.7	20

Western Valleys

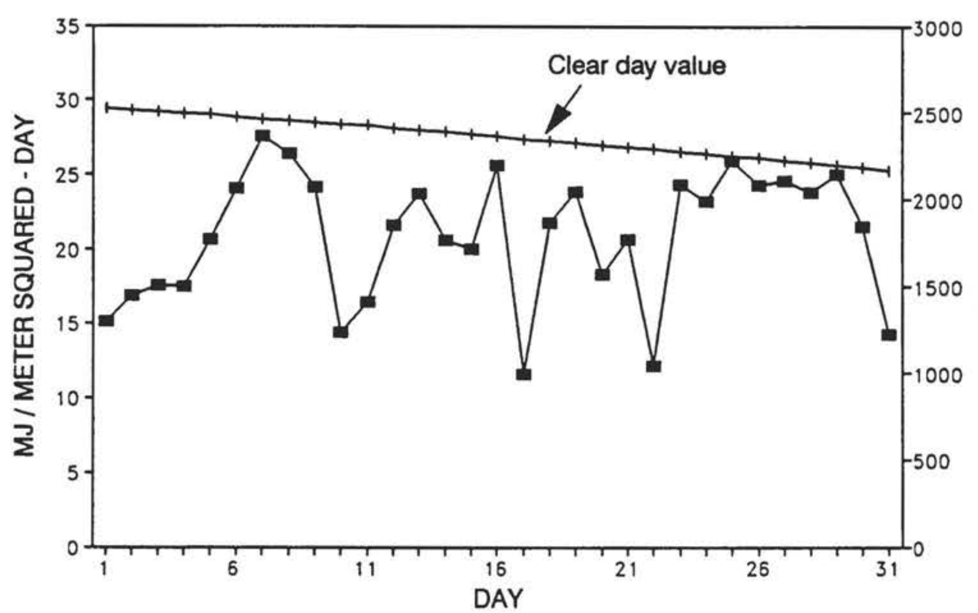
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	83.6	48.4	66.0	1.1	91	42	18	57	524	0.63	-0.97	39.4	6
HAYDEN	83.1	47.1	65.1	0.9	90	38	22	31	512	0.49	-1.00	32.9	6
MEEKER NO. 2	83.4	47.6	65.5	0.7	92	41	23	47	518	0.56	-0.60	48.3	5
RANGELY 1E	89.2	55.1	72.1	2.1	96	48	0	229	640	0.19	-0.62	23.5	3
EAGLE FAA AP	85.1	45.1	65.1	1.3	94	37	23	36	536	0.36	-0.52	40.9	11
GLENWOOD SPRINGS	85.3	49.1	67.2	-0.1	95	40	24	99	535	0.61	-0.72	45.9	7
RIFLE	87.5	51.1	69.3	1.3	98	44	4	145	566	0.27	-0.77	26.0	4
GRAND JUNCTION WS	90.5	62.6	76.5	0.5	98	57	0	368	752	0.49	-0.27	64.5	4
CEDAREDGE	87.5	52.2	69.8	0.4	95	48	0	155	583	0.73	-0.34	68.2	5
PAONIA 1SW	87.4	55.4	71.4	1.5	96	50	0	206	625	1.11	-0.11	91.0	10
DELTA	90.5	48.8	69.7	-1.3	101	42	2	155	563	0.39	-0.47	45.3	5
GUNNISON	78.3	39.6	59.0	0.6	87	35	179	0	448	1.50	0.06	104.2	8
COCHETOPA CREEK	78.1	40.0	59.0	0.0	87	33	180	3	443	2.16	0.32	117.4	10
MONTROSE NO. 2	84.3	54.4	69.3	-0.3	93	48	3	143	587	0.64	-0.40	61.5	6
URAVAN	92.6	58.5	75.5	0.9	103	54	0	334	685	0.54	-0.65	45.4	5
NORWOOD	81.6	49.5	65.5	1.5	90	41	31	55	507	0.28	-1.35	17.2	3
YELLOW JACKET 2W	83.4	52.5	68.0	0.2	95	46	14	112	550	2.04	0.34	120.0	7
CORTEZ	84.0	52.0	68.0	0.6	93	47	6	107	551	1.83	0.48	135.6	6
DURANGO	83.5	47.8	65.7	-0.4	95	40	28	60	512	3.11	0.80	134.6	10
IGNACIO 1N	80.6	48.2	64.4	-1.3	90	42	46	34	488	1.50	-0.20	88.2	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.

AUGUST 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	10	13	8	--	--
Denver	8	15	8	68%	73%
Fort Collins	6	17	8	--	--
Grand Junction	11	13	7	75%	76%
Pueblo	10	13	8	77%	78%

FT. COLLINS TOTAL HEMISPHERIC RADIATION
AUGUST 1990



"Colorado Water -- Liquid Gold": continued

The overall display was composed of several components. Beginning with the hydrologic cycle and the history of water development, it went on to include such topics as water law and administration, interstate compacts, transmountain diversions, ground water, water quality, sewage treatment, wetlands, industrial water use, agricultural water use, recreation, water management and conservation. There were weather videos, demonstrations of satellite communications, laboratory equipment and various measurement devices. There were photographs of droughts, floods, skiers and white-water rafters. Best of all, there was a lot of moving water. A waterfall tumbled down a pine and aspen covered hillside in the middle of the pavilion. A stream babbled past several exhibits eventually spilling into a quiet pond. In one corner of the exhibit hall, a marsh (wetland) sported several native plant species. Snakes, frogs, crickets and dragon flies (lifelike, but not alive) delighted the small children who dared to peek through the tall grasses. Faucets pouring water out of thin air amazed children and adults alike. Water dripped or sprayed from a number of irrigation systems on display. A well pumped water. The Pueblo Water Department handed out ice water to passersby. And, of course, there were fish -- catfish, tiger muskies and some gorgeous trout.

In one corner of the exhibit was a very conspicuous shabby-looking performance stage. Every two hours throughout the Fair, exhibit personnel, primarily from the Colorado Division of Water Resources, took to the stage and enticed fair-goers to play "Water Wheel of Fortune." While the MC told water jokes, lovely "Vanna Waterdrop" spun a hokey looking wheel and called on people from the audience to step up on the stage to try to answer questions about Colorado water. Hundreds of people participated, and most went home a winner -- and learned something about our water in the process.

The amount of information in the water exhibit was far greater than could easily be absorbed in a casual stroll through the pavilion. But let me pass on a few key points and facts that caught my attention. Some of this will be obvious. Other parts may surprise you.

"Colorado Water -- Liquid Gold"
Water Facts from the 1990 Colorado State Fair

- Colorado statewide average annual precipitation = 17.1 inches. Over the entire 104,247 square mile area of Colorado, that equals 95 million acre-feet of water or 31 trillion gallons.

- About 14% or approximately 13 million acre-feet leaves Colorado as streamflow in an average year -- mostly in the Colorado River and its tributaries.

- About 85% of our streamflow originates as snowpack. (Summer rains contribute a sizeably portion of Colorado's annual precipitation but contribute little to streamflow.)

- Colorado reservoirs can store about 8.6 million acre-feet of water.

- Approximately 5 billion gallons of water are consumed daily in Colorado.

- Domestic and industrial water use in Colorado has been growing steadily but still accounts for only about 12% of Colorado's consumptive use. Agriculture consumes the remaining 88%. Denver accounts for less than 3% of the water consumed in Colorado.

- Ground water provides 18% of the water used in Colorado. Our ground water supply is about 40 times greater than the annual flow of all rivers and streams in Colorado.

- There are 40 hydroelectric generation plants in Colorado which produce about 13% of Colorado's electricity.

- Irrigation efficiency ranges from about 45% for traditional furrow irrigation to as much as 95% low energy precision application.

- Colorado's first legal water right was the San Luis People's Ditch from the Culebra River -- April 10, 1852. The first reservoirs were built in the 1880s. The Grand Ditch, the first major transmountain diversion, was completed in 1894. The first reservoir constructed for Denver was Lake Cheesman, 1905.

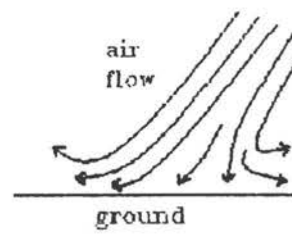
I am leaving out a lot of interesting information. The complexity of our water systems are truly amazing. Please don't take our water for granted.

If you would like more information about the water display, please contact John Kaliszewski, Office of the State Engineer, Division of Water Resources, 1313 Sherman Street, Room 818, Denver, CO 80203, (303) 866-3581.

WIND SHEARS

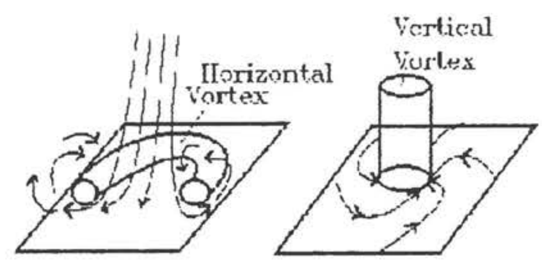
As another committee discusses plans for the new Denver airport, think about wind shears. Wind what? Are those the new hair styles kids are wearing today?

Well, no. Wind shears are "downbursts" of wind so powerful that they can push a jet down, but they are too small to be detected by ground anemometers. (Devices that measure wind speed) The best way to picture what a wind shear is like is to think of a garden hose. If one points the nozzle of the garden hose downward, the water will spray out in a starburst pattern on impact with the ground. By changing the slant angle of the nozzle, a fan-shaped outburst occurs, as pictured above. It is a strong downdraft which produces an outburst of damaging winds on or near the ground.



Fan-Shaped Downburst

Now that more is known about them, the downburst are classified into macroburst and microbursts according to the extent of their horizontal winds. Macrobursts have outburst winds that extend beyond 2.5 miles horizontally. They can cause damage on the scale of a tornado, last from 5 to 30 minutes, and have velocity as high as 134 mph. Microbursts are smaller in size. Horizontal winds only extend up to 2.5 miles, but the winds can reach 168 mph.



Microburst Tornado

Since downbursts have the same destructive power as tornadoes, they are often mistaken for tornadoes. The picture on the right demonstrates the difference in the two. The air in a microburst is pushed down and out around the vortex, but in a tornado it swirls inward toward the center of the vortex. It has been said that a microburst is an "upside-down tornado."

Unlike tornadoes, microbursts and macrobursts can not be predicted to occur with a certain type of storm. They can appear in tornado-like storms or innocuous small storms. Before you swear never to fly in an airplane again, technology has saved you. Doppler radar can measure and display macrobursts so they can be safely avoided.

Even with Doppler radar, we do not know what causes wind shear. Weather data plays an important part in discovering the causes. Relative humidity and temperature changes have been noted before a downburst appears. Until enough weather data are correlated, we must rely on Doppler radar to protect us from the whims of mother nature.

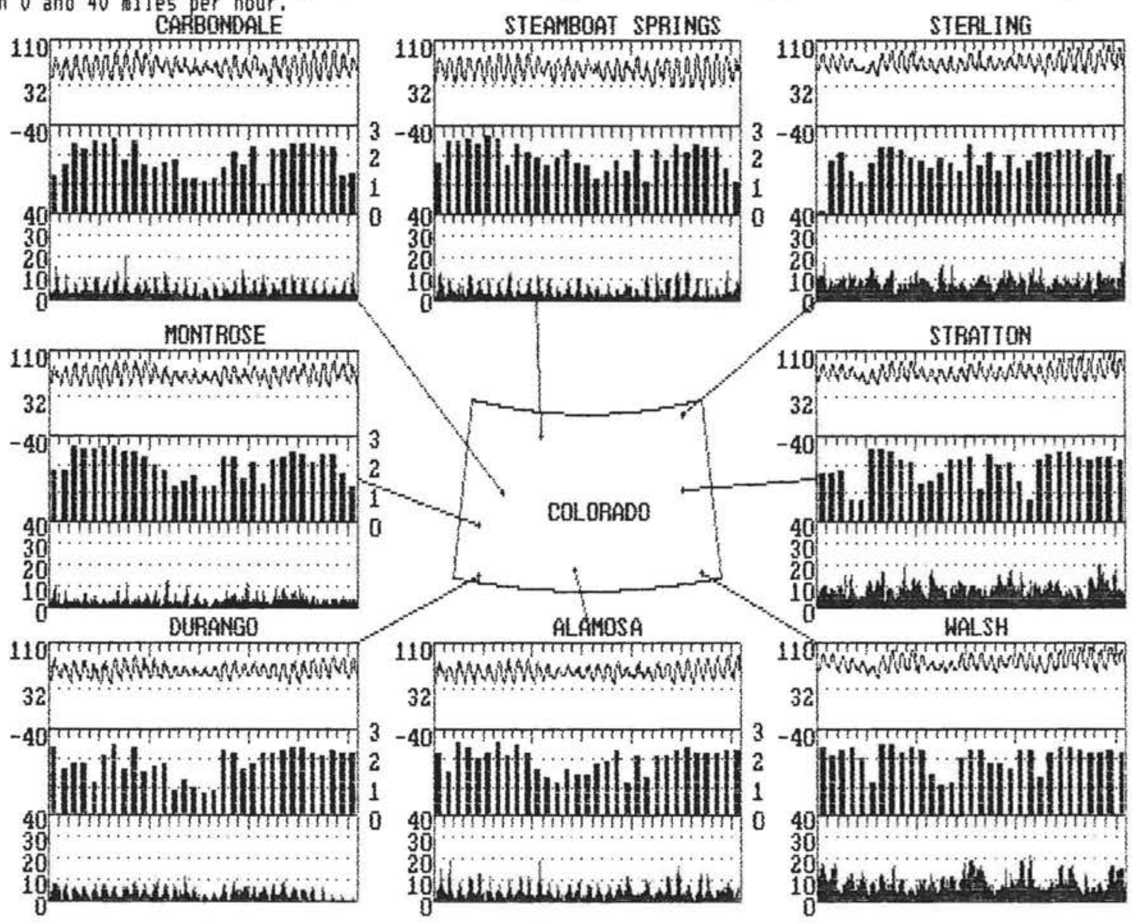
This article was written by Erika Komito of the Joint Center for Energy Management, University of Colorado, Campus Box 428, Boulder, CO. 80309-0428. Information on acquiring our weather data can be obtained by writing Mary Sutter at this address.

WTHRNET WEATHER DATA AUGUST 1990

	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)								
	59.3	60.9	63.0	66.1	59.0	70.8	71.8	74.4
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	84.2 31/16	84.4 29/15	93.0 29/15	90.5 29/16	89.4 7/16	99.5 30/15	102.2 30/15	100.4 28/15
minimum:	37.8 3/ 4	39.7 6/ 5	36.9 26/ 6	43.9 6/ 5	28.8 28/ 6	50.7 7/ 5	51.8 7/ 5	50.4 7/ 2
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	94 / 42	87 / 44	90 / 42	79 / 45	97 / 38	61 / 42	70 / 48	82 / 56
11 AM	51 / 48	54 / 52	38 / 45	46 / 52	41 / 47	30 / 40	34 / 45	44 / 56
2 PM	37 / 43	47 / 50	27 / 39	39 / 49	32 / 42	22 / 37	28 / 44	35 / 52
5 PM	39 / 41	47 / 48	31 / 39	38 / 47	33 / 40	24 / 36	29 / 43	35 / 50
11 PM	69 / 44	74 / 47	62 / 43	61 / 46	73 / 43	48 / 41	55 / 47	62 / 53
monthly average wind direction (degrees clockwise from north)								
day	178	184	223	237	223	156	147	154
night	157	86	169	147	112	196	216	213
monthly average wind speed (miles per hour)								
	3.96	3.07	3.42	3.05	2.91	6.93	8.10	8.35
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	335	387	452	416	487	70	19	33
3 to 12	392	329	286	326	249	627	636	571
12 to 24	17	0	6	2	4	47	89	140
> 24	0	0	0	0	0	0	0	0
monthly average daily total insolation (Btu/ft²·day)								
	1957	1837	1870	2015	1970	1847	1920	2021
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	223	107	147	141	164	128	207	247
40-60%	72	79	74	74	88	85	62	75
20-40%	62	73	76	62	61	58	54	60
0-20%	40	69	45	31	25	60	53	24

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour.



COLORADO CLIMATE

SEPTEMBER 1990

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 13 Number 12

September in Review:

Above average temperatures were the rule across Colorado in September. In parts of northern Colorado this was the hottest September in the past 100 years. Good moisture also accompanied the warm weather. Precipitation totals were above average over more than 3/4 of the State. Despite the moisture, sunshine was still fairly abundant. There was no snow or unusually early freezes at low elevations, and the higher mountains had only a minor dusting of snow. Winds were also quite light. These conditions produced excellent and long-lasting fall colors in the mountain foliage.

Colorado's November Climate:

I have some bad news and some good news. The bad news is that cloudiness should be on the increase in November as strengthening winds aloft direct more Pacific moisture toward Colorado. The percent of possible sunshine (the percent of time the sun is shining between sunrise and sunset) decreases by several percentage points from October to November especially from the mountains westward. But the good news is that we still are sunnier than much of the country. In an average November, Grand Junction can still expect about 63% of their possible sunshine, Denver receives about 65% and Pueblo gets close to 74%. Values are probably down to 50% in parts of the northern and central mountains but may reach as high as 80% near Alamosa. By comparison, Atlanta gets about 59% of their possible November sunshine, New York City receives 52%, Chicago only gets 41% and Seattle comes in with 28%.

Cold fronts cross Colorado more frequently in November, and more episodes of brisk and occasionally very strong westerly or northwesterly winds sweep down the eastern foothills out onto the plains. There tend to be more travelling storm systems, but with less solar heating and a cooler atmosphere, not much widespread low-elevation precipitation falls. Most of what falls comes in the form of snow. But in the higher mountains, stronger winds aloft mean more orographic (mountain-induced) lifting which equates directly to more mountain snows. The expected number of precipitation days ranges from about 3 in the San Luis Valley and across southeastern Colorado to 4 over the northeast plains, 4-5 along the Front Range, 5-7 on the Western Slope on up to 7 to 15 in the high mountains. The northern mountains almost always see more frequent November snowfalls than the southwestern mountains. Average November precipitation is about 1-4" in the mountains (15-60" snow) but decreases to 0.60-1.00" along the Front Range, less than 0.75" over the Western Slope (3-8" snow) and only about 0.50" (2-8" snow) across the eastern plains.

Temperatures in November continue to plunge. Early November isn't too bad as low elevation temperatures average in the 50s during the day and sometimes reach the 60s and 70s. But as the month progresses, warm days are fewer. Nighttime temperatures drop into the 20s, but teens become more common by Thanksgiving. After a snow, its even possible to see temperatures dip to near zero. Meanwhile, winter temperatures are well established higher in the mountains with daytime temperatures normally in the 30s and 40s dropping to the teens, single digits, or colder at night.

1990 Water Year Wrap-Up:

Each year at the end of September we look back upon the climate of the past year and assess how Colorado fared. After years of abundant moisture in the mid-1980s, 1987 and 1988 brought a drying trend especially for the northern mountains of Colorado. This dryness expanded in 1989 to include much of the State. Coloradoans were seriously threatened by drought as the 1990 water year began last fall. Statewide drought concern grew steadily during the fall and early winter as precipitation lagged far behind average.

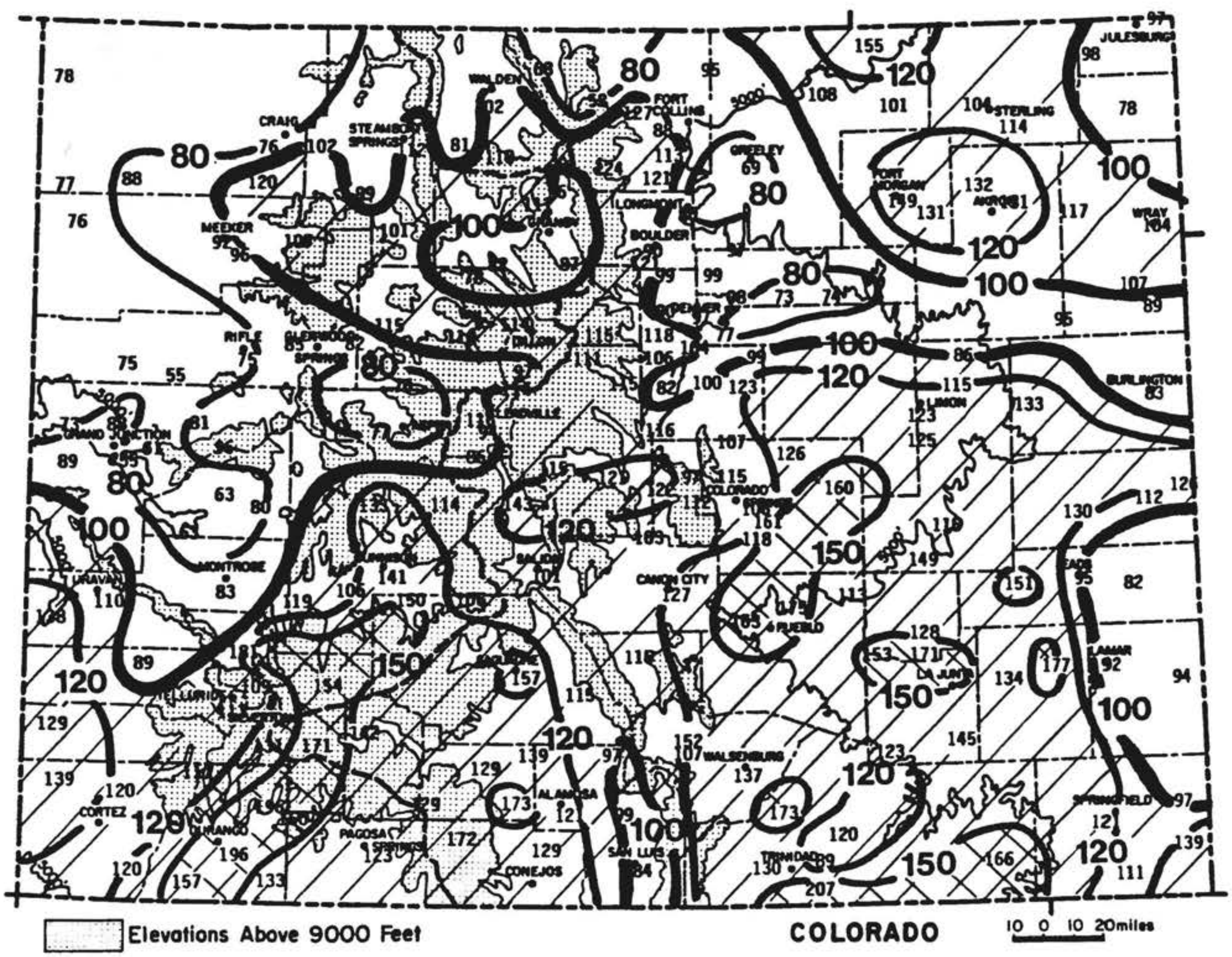
(continued on page -2- and -3-)

1 9 9 0 W A T E R Y E A R W R A P - U P : continued

At of the end of January, precipitation shortages were almost as severe as they had been in the record drought of 1976-77 over parts of western Colorado. In spite of the lack of moisture, the Colorado ski industry remained surprisingly healthy. This appears to have been a result of a combination of factors. Fortunately, Colorado's northern mountains received quite a bit more snow than central and southern areas. Also, Europe was suffering through a poor snow season. Finally, and perhaps of most significance, extensive snowmaking operations were sucessfully employed at major Colorado ski resorts. This year was a good example of how important snowmaking is as a drought mitigation strategy.

The months of February through May each brought a few good beneficial storms to various parts of Colorado but left other areas dry. Parts of the Front Range and much of the eastern plains enjoyed very plentiful late winter and spring precipitation. Southeastern Colorado had unusually heavy snows in late February. The storm of March 5-7 put down more than 4" of water content in the form of wet snow along parts of the northern Front Range. Southwestern Colorado received very abundant April moisture. A record snow for early May again helped areas of southern Colorado. In total, the precipitation during this period greatly reduced the immediate impacts from drought, but mountain snowpack remained below average nearly everywhere in the State.

June brought bouts of severe weather including the devastating Limon tornado on June 6th. But for the state as a whole it was a hot and very dry month. Forest fires began and drought concern again rose quickly. Then a remarkable change occurred in July that carried through for the remaining months of the water year. Summer precipitation was very plentiful, especially in a band from southwestern counties northeastward almost to the Front Range. Summer rains usually produce little runoff, but this year surface water supplies in several watersheds in the southwest were greatly helped.

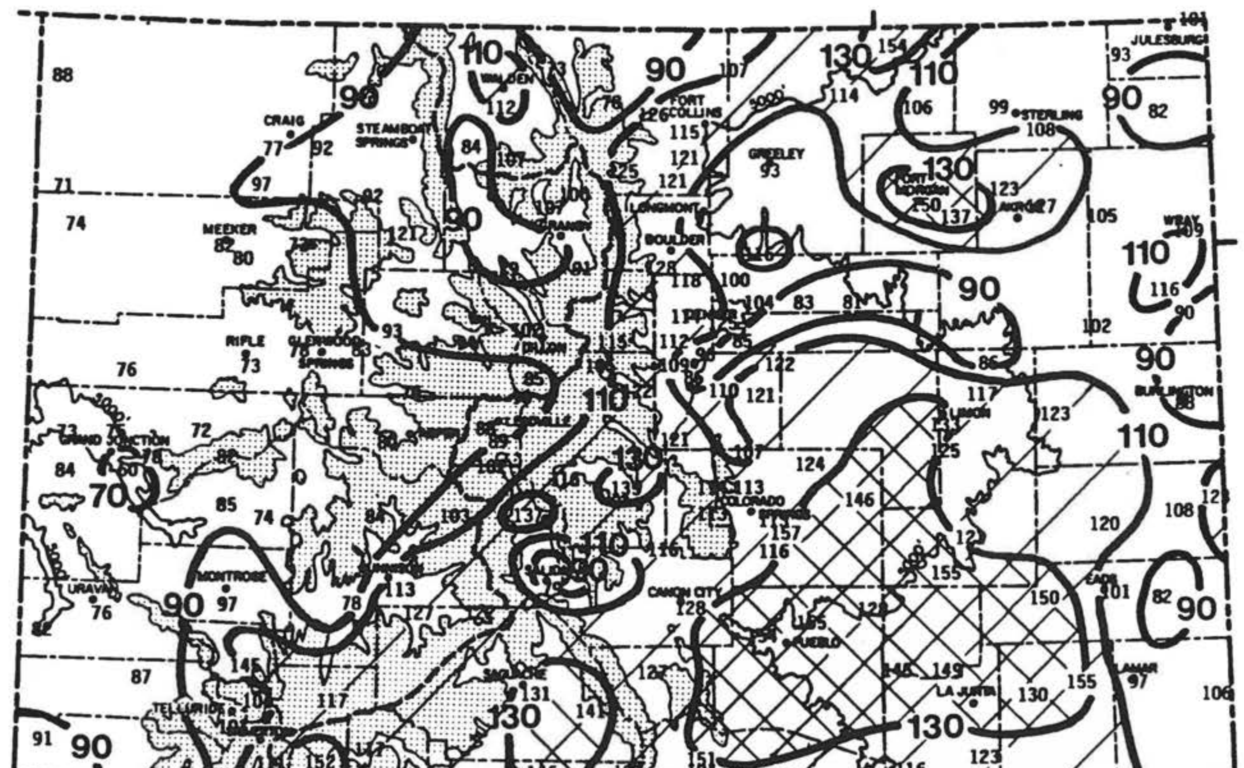


Precipitation for May-September 1990 (growing season)
as a percent of the 1961-80 average.

The map of growing season precipitation as a percent of average shows that most of Colorado received above average warm-season rainfall and several areas were very wet. In the San Juan Mountains where summer precipitation exceeded 150% of average in some areas (Durango actually had 14.24" of May-September rainfall, almost double their average), the Palmer Drought Severity Index improved to +3.2 by the end of September, a remarkable improvement of more than 6 points in 6 months. But some areas of the State were not on the receiving end of abundant summer rains. Northwestern Colorado, which has now been drier than average since 1987, received about 75% of their average growing season rainfall. At the end of September 1990, the Palmer Index stood at -5.1 for Moffat and Rio Blanco counties suggesting continued extreme drought conditions.

For the 1990 water year as a whole, statewide precipitation ended up near to a little above average. Most of the western 1/4 of Colorado still ended up below average and there were pockets with drier than average conditions in eastern Colorado. But several areas ended up with unusually wet years. Pueblo, and some other parts of the Arkansas Valley received at least 150% of their average annual precipitation. Parts of the San Juan Mountains and the San Luis Valley reported at least 130% of average. Statewide, out of nearly 200 official weather stations with complete water-year measurements, less than 1% of the stations received less than 70% of their average precipitation. 10% received 70-79% of average, 13% received 80-89%, 10% received 90-99%, 17% received 100-109%, 15% received 110-119% of average, 18% received 120-129% of average, and the remaining 16% of the weather stations received at least 130% of their average water-year precipitation. By comparison, in 1977, 31% of the Colorado stations received less than 70% of average.

While year-end precipitation totals suggest adequate moisture, the seasonal distribution within the year resulted in below average streamflow in most major rivers and streams across the State. Reservoir storage also declined somewhat from this time last year. While 1990 drought impacts were minimal and soil moisture improved over most of Colorado during the year, some areas of the State still show the effects of drought. As always, we look forward to this winter with hopes of abundant mountain snow accumulation.



Precipitation for October 1989 through September 1990
as a percent of the 1961-80 average.

SEPTEMBER 1990 DAILY WEATHER

Date	Event
1-5	Persistent summerlike weather with hot days (80s and 90s except 70s in the higher mountains) and mild nights. South-southwesterly winds aloft continued to supply moisture to fuel scattered thundershowers each day, most numerous in the mountains and over the northern Front Range. A fierce lightning storm pounded Weld County during the evening of the 1st. Briggsdale was soaked by a 1.31" downpour. More locally heavy rains fell late on the 2nd over the northern Front Range and produced local high water and mudslides. The most widespread shower activity occurred late on the 5th as a weak disturbance crossed Colorado.
6-14	Unseasonably warm summerlike temperatures continued. The large high pressure ridge that had been east of Colorado retrograded westward. Winds aloft shifted around to northwesterly, and drier air gradually moved into the State. Still, some thunderstorms popped up each day 6-10th most numerous in southern Colorado. Fort Lewis recorded 1.55" of rain and hail on the 6th. Walsenburg reported 0.99" on the 7th. Aguilar's 3.00" rainfall on the 8th was the greatest 1-day total for the month anywhere in the State. A system of heavy storms developed near the Kansas border late on the 10th. Stonington measured nearly 1" of rainfall. Then the entire state became hot and dry 11-14th with temperatures reaching record levels in many areas, especially on the 13th. Dillon hit 79° and Aspen reached 82°. Some locations reached the highest temperatures ever measured during the month of September. The 97° reading at Fort Collins was a new record for September. Eagle's 93° reading on the 14th tied their all-time September maximum. Cooler air slipped into eastern Colorado on the 14th.
15-21	It was unusually hot again on the 15th. Ordway 21N matched Las Animas for the warmest in the State with 103°. But a weather change was in progress. A big and nearly stationary low pressure trough west of Colorado provided moisture and destablized the atmosphere while a large cool high pressure area east of Colorado produced damp "upslope conditions" east of the mountains. Most of the State ended up getting substantial precipitation (all in the form of rain) 16-20th, with many reports in excess of 1 inch. Durango recorded 1.79" just on the 17th. Denver totalled 1.02" on the 18th. A Pacific cold front crossed Colorado on the 20th kicking off more thundershowers but bringing an end to this stormy episode. Showers lingered in southeastern Colorado early on the 21st. Limon reported 0.58" of chilly rain before the clouds began to lift. Stonington received 1.70".
22-25	Pleasant autumn weather with daytime temperatures warming through the period but with chilly nighttime lows. A touch of spotty frost might have been possible on the plains 22-24th. Sterling had a low of 36° on the 23rd. Hohnholz Ranch (on the Laramie River) had a low of 21° on the 24th, the coldest in the State in September. It was a dry period over most of Colorado, but afternoon and evening thundershowers developed 24-25th near the mountains as a little moisture snuck into Colorado from the southwest.
26-30	September ended with another episode of widespread precipitation. A modest upper-level low pressure area spun over the Southwest and pumped moisture into Colorado. Scattered showers developed on the 26th and 27th especially near the mountains. Then a large Canadian high pressure dome pushed cold air southward into Colorado on the 27th and created another "upslope" situation for the Front Range and eastern plains 28-29th. Rainfall was heaviest in southern and eastern parts of Colorado. Wolf Creek Pass and Rio Grande Reservoir reported 2.00" and 2.05", respectively, on the 29th. Cheyenne Wells totalled 2.10" on the 28-29th. The entire San Luis Valley had a soaking rain of close to 1.00" -- very unusual for that high, arid region. The first snow of the season fell high in the mountains above 10,000 feet. Then on the 30th dry weather returned although there was some patchy dense fog that morning.

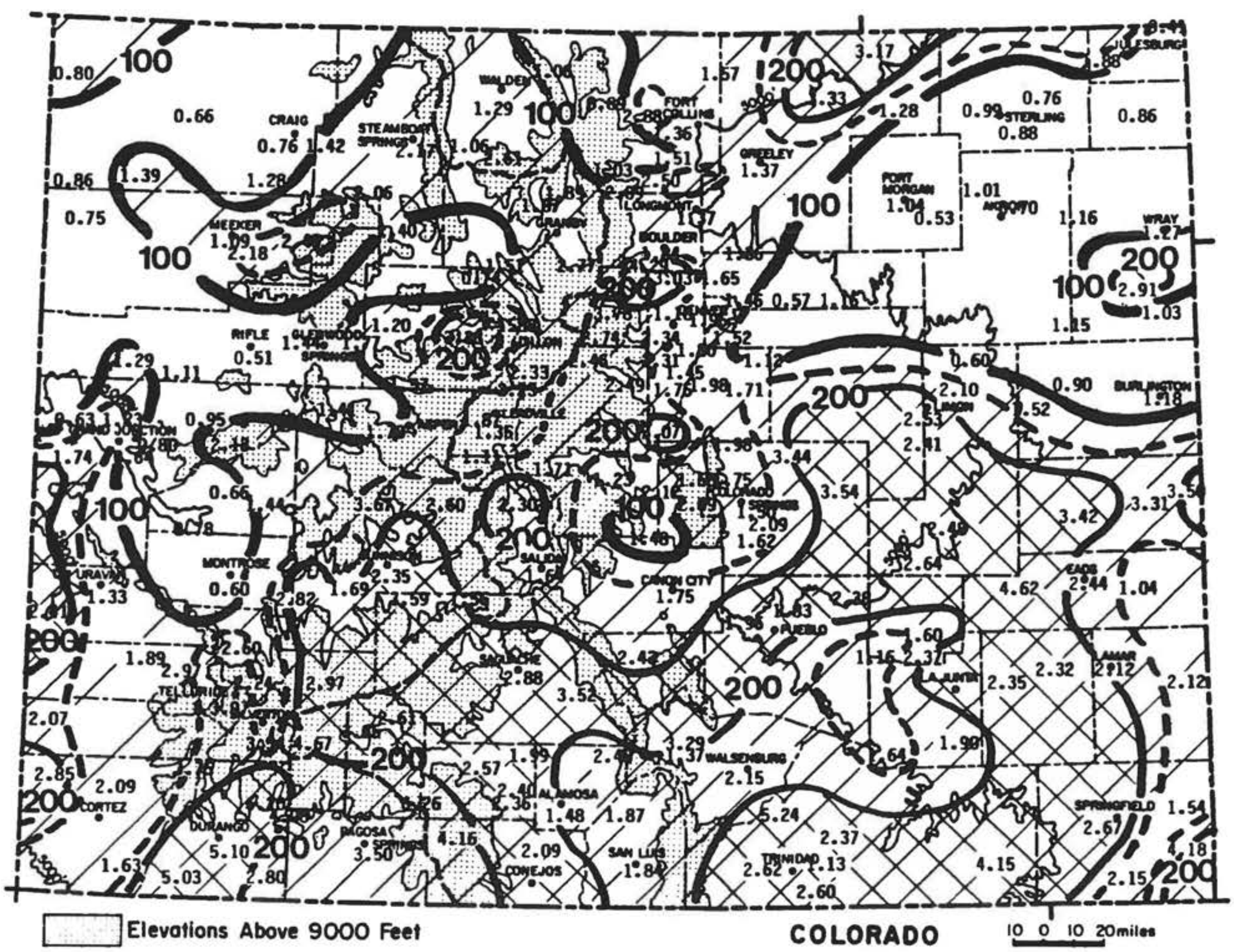
September 1990 Extremes

Highest Temperature	103°F	September 15	Las Animas Ordway 21N
Lowest Temperature	21°F	September 24	Hohnholz Ranch
Greatest Total Precipitation	6.26"		Wolf Creek Pass 1E
Least Total Precipitation	0.41"		Julesburg
Greatest Total Snowfall	3.0"		Leadville Sugarloaf Reservoir

SEPTEMBER 1990 PRECIPITATION

Scattered but frequent summerlike thundershowers early in September were followed by two organized widespread storm systems later in the month. The result was above average precipitation over the majority of Colorado, especially the southern half. 52 official weather stations reported at least double their average precipitation in September. Precipitation was spottier in northern Colorado, and several areas actually ended up drier than average. For example, Craig, Rifle, Green Mountain Dam, Cedaredge, Montrose and Brush only received about 50% of their September average. Bennett (east of Denver) measured just 0.57", 39% of average.

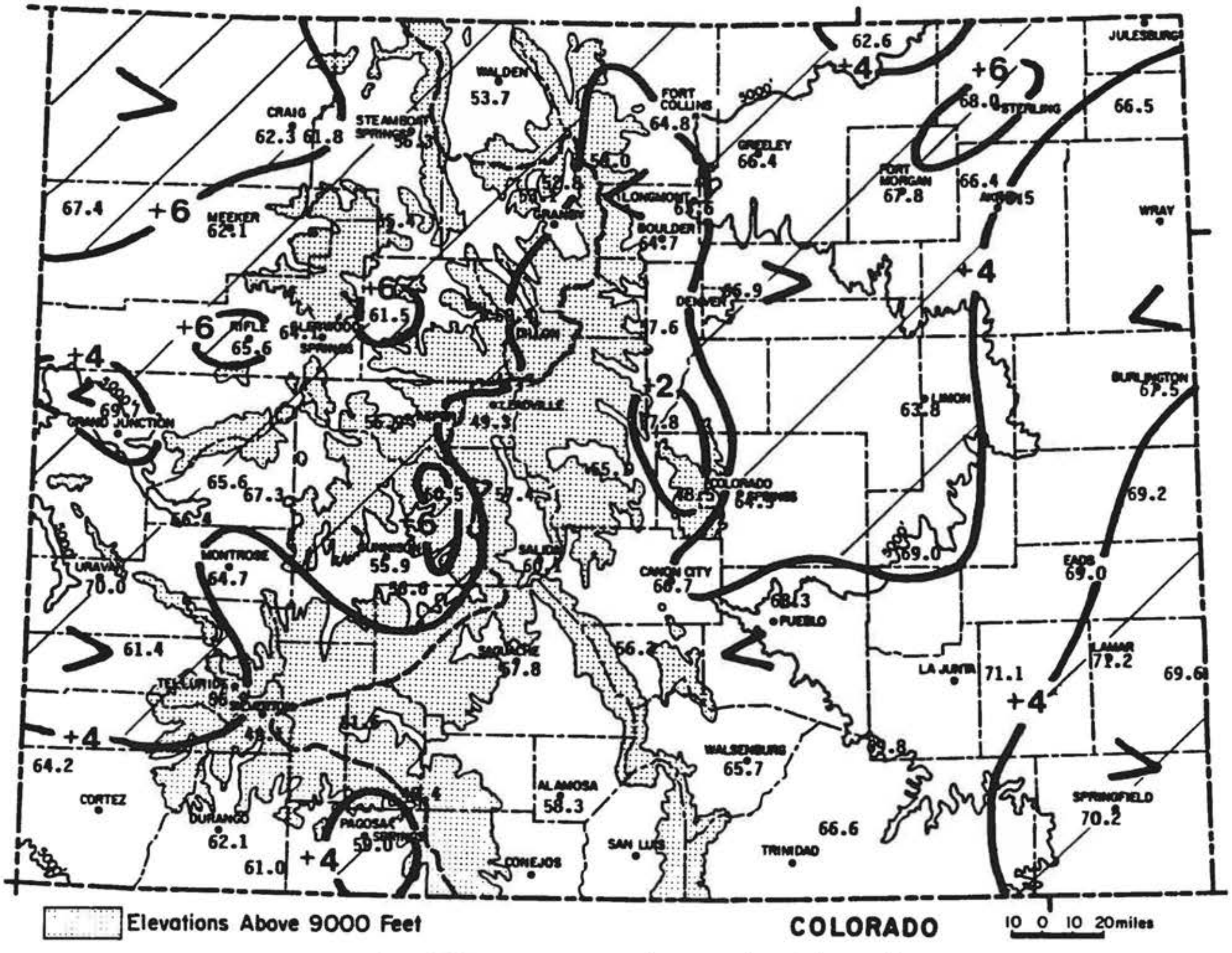
Greatest		Least	
Wolf Creek Pass 1E	6.26"	Julesburg	0.41"
Lemon Dam	6.20"	Rifle	0.51"
Aguilar 1SE	5.24"	Brush	0.53"
Durango	5.10"	Bennett 2ESE	0.57"
Fort Lewis	5.03"	Shaw, Montrose	0.60"



Precipitation amounts (inches) for September 1990 and contours of precipitation as a percent of the 1961-1980 average.

SEPTEMBER 1990 TEMPERATURES AND DEGREE DAYS

There were a few cloudy, coolish days in mid and late September associated with damp and stormy episodes. For the remainder of the month, temperatures were persistently mild with no unusually early freezing temperatures to disturb farmers and gardeners. Temperatures ended up 2 to 7 degrees warmer than average across Colorado. At Fort Collins, the September mean temperature was 64.8 degrees F making this the warmest September on record with records dating back to 1887. New records were also set at Fort Morgan, Sterling and possibly some other cities. Temperatures were not quite as far above average in southern Colorado, but all areas of the State were unusually warm.



September 1990 temperatures (degrees Fahrenheit) and contours of departures from 1961-1980 averages.

SEPTEMBER 1990 SOIL TEMPERATURES

Soil temperature data reflected the unusually warm air temperatures. Nevertheless, the inevitable autumn cooling is evident near the surface while deeper soil temperatures lag further behind.

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.

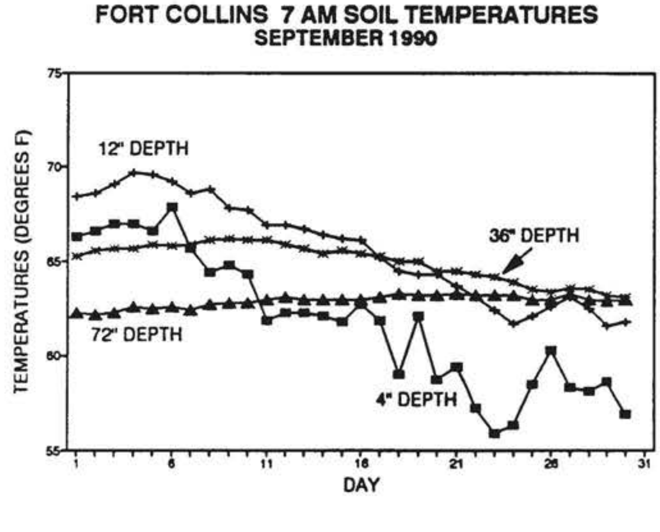


Table 1. Heating Degree Day Data through September 1990 (base temperature, 65°F).

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
	89-90	17	82	271	698	1001	1400	1554	1089	880	640	480	105	8217
	90-91	59	118	201										378
ASPEN	AVE	95	150	348	651	1029	1339	1376	1162	1116	798	524	262	8850
	89-90	68	176	303	671	974	1365	1365	1086	915	697	543	171	8334
	90-91	134	146	234										514
BOULDER	AVE	0	6	130	357	714	908	1004	804	775	483	220	59	5460
	89-90	1	M	M	M	M	M	M	M	M	502	321	21	M
	90-91	32	13	81										126
BUENA VISTA	AVE	47	116	285	577	936	1184	1218	1025	983	720	459	184	7734
	89-90	39	112	270	628	812	1202	1184	991	857	660	518	106	7379
	90-91	66	130	226										422
BURLING-TON	AVE	6	5	108	364	762	1017	1110	871	803	459	200	38	5743
	89-90	M	4	M	415	684	1229	990	957	757	459	280	3	M
	90-91	10	4	76										90
CANON CITY	AVE*	0	10	100	330	670	870	950	770	740	430	190	40	5100
	89-90	0	0	131	379	584	1076	859	827	687	421	325	22	5311
	90-91	14	12	58										84
COLORADO SPRINGS	AVE	8	25	162	440	819	1042	1122	910	880	564	296	78	6346
	89-90	0	4	172	473	699	1163	966	928	805	526	345	24	6105
	90-91	28	21	83										132
CORTEZ	AVE*	5	20	160	470	830	1150	1220	950	850	580	330	100	6665
	89-90	0	16	142	494	850	1166	1222	959	776	490	377	59	6551
	90-91	1	6	151										158
CRAIG	AVE	32	58	275	608	996	1342	1479	1193	1094	687	419	193	8376
	89-90	4	46	235	586	892	1420	1319	1257	879	530	453	144	7765
	90-91	14	18	116										148
DELTA	AVE	0	0	94	394	813	1135	1197	890	753	429	167	31	5903
	89-90	M	M	M	330	M	M	1161	865	626	355	237	22	M
	90-91	0	2	58										60
DENVER	AVE	0	0	135	414	789	1004	1101	879	837	528	253	74	6014
	89-90	0	0	153	424	658	1160	879	882	781	469	265	7	5678
	90-91	12	3	64										79
DILLON	AVE	273	332	513	806	1167	1435	1516	1305	1296	972	704	435	10754
	89-90	226	357	502	861	1124	1495	1506	1271	1124	886	764	349	10465
	90-91	284	355	430										1069
DURANGO	AVE	9	34	193	493	837	1153	1218	958	862	600	366	125	6848
	89-90	2	19	106	520	789	1133	1278	965	724	479	359	44	6418
	90-91	4	28	118										150
EAGLE	AVE	33	80	288	626	1026	1407	1448	1148	1014	705	431	171	8377
	89-90	1	60	217	593	896	1348	1286	986	806	545	269	68	7075
	90-91	15	23	134										172
EVER-GREEN	AVE	59	113	327	621	916	1135	1199	1011	1009	730	489	218	7827
	89-90	49	118	325	657	818	1221	1115	1030	932	662	513	140	7580
	90-91	120	131	219										470
FORT COLLINS	AVE	5	11	171	468	846	1073	1181	930	877	558	281	82	6483
	89-90	0	3	169	458	711	1166	930	910	848	495	307	19	6016
	90-91	19	6	74										99
FORT MORGAN	AVE	0	6	140	438	867	1156	1283	969	874	516	224	47	6520
	89-90	0	2	156	416	721	1285	1087	1010	776	M	274	10	M
	90-91	18	7	63										88
GRAND JUNCTION	AVE	0	0	65	325	762	1138	1225	882	716	403	148	19	5683
	89-90	0	0	40	316	729	1103	1124	820	557	271	139	20	5119
	90-91	0	0	28										28

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

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
	89-90	168	306	427	768	1132	1449	1401	1205	1043	833	689	266	9687
	90-91	264	268	350										882
GREELEY	AVE	0	0	149	450	861	1128	1240	946	856	522	238	52	6442
	89-90	1	2	166	454	729	1230	985	922	787	449	275	9	6009
	90-91	14	2	62										78
GUNNISON	AVE	111	188	393	719	1119	1590	1714	1422	1231	816	543	276	10122
	89-90	61	155	341	749	1069	1574	1647	1254	906	672	540	188	9156
	90-91	65	179	264										508
LAS ANIMAS	AVE	0	0	45	296	729	998	1101	820	698	348	102	9	5146
	89-90	0	0	99	323	684	1176	1030	887	638	309	188	2	5336
	90-91	4	0	21										25
LEAD-VILLE	AVE	272	337	522	817	1173	1435	1473	1318	1320	1038	726	439	10870
	89-90	285	412	545	880	1138	1507	1499	1265	1188	920	793	377	10809
	90-91	331	402	464										1197
LIMON	AVE	8	6	144	448	834	1070	1156	960	936	570	299	100	6531
	89-90	1	6	204	508	762	1252	1078	991	815	555	364	33	6569
	90-91	36	11	96										143
LONGMONT	AVE	0	6	162	453	843	1082	1194	938	874	546	256	78	6432
	89-90	2	8	200	484	749	1302	1048	994	917	552	319	25	6600
	90-91	24	11	101										136
MEEKER	AVE	28	56	261	564	927	1240	1345	1086	998	651	394	164	7714
	89-90	0	41	198	543	869	1261	1169	1071	795	507	387	91	6932
	90-91	9	23	121										153
MONTROSE	AVE	0	10	135	437	837	1159	1218	941	818	522	254	69	6400
	89-90	0	10	110	439	768	1156	1186	895	654	425	285	27	5955
	90-91	0	3	81										84
PAGOSA SPRINGS	AVE	82	113	297	608	981	1305	1380	1123	1026	732	487	233	8367
	89-90	24	118	284	646	964	1298	1491	1160	873	630	524	164	8176
	90-91	44	108	177										329
PUEBLO	AVE	0	0	89	346	744	998	1091	834	756	421	163	23	5465
	89-90	0	0	94	373	676	1204	964	877	695	394	233	2	5512
	90-91	1	0	34										35
RIFLE	AVE	6	24	177	499	876	1249	1321	1002	856	555	298	82	6945
	89-90	0	2	103	473	M	1130	1191	923	657	392	281	37	5189
	90-91	0	4	69										73
STEAMBOAT SPRINGS	AVE*	90	140	370	670	1060	1430	1500	1240	1150	780	510	270	9210
	89-90	18	117	315	M	974	1533	1580	1332	971	658	576	M	M
	90-91	129	M	255										M
STERLING	AVE	0	6	157	462	876	1163	1274	966	896	528	235	51	6614
	89-90	M	3	144	428	719	1254	1074	1026	760	427	275	8	M
	90-91	17	7	68										92
TELLURIDE	AVE	163	223	396	676	1026	1293	1339	1151	1141	849	589	318	9164
	88-89	72	175	270	644	869	1264	1273	1023	922	664	509	145	7830
	89-90	117	179	267										563
TRINIDAD	AVE	0	0	86	359	738	973	1051	846	781	468	207	35	5544
	89-90	0	1	111	369	633	1153	980	874	681	420	266	8	5496
	90-91	4	6	46										56
WALDEN	AVE	198	285	501	822	1170	1457	1535	1313	1277	915	642	351	10466
	89-90	132	279	461	802	1075	1490	1359	1287	1068	796	674	273	9696
	90-91	202	258	332										792
WALSEN-BURG	AVE	0	8	102	370	720	924	989	820	781	501	240	49	5504
	89-90	0	2	117	345	581	1047	848	800	666	408	289	10	5113
	90-91	15	8	53										76

* = AVES ADJUSTED FOR STATION MOVES M = MISSING E = ESTIMATED

SEPTEMBER 1990 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	77.1	48.1	62.6	3.1	90	38	124	57	434	3.17	2.00	270.9	9
STERLING	85.2	50.8	68.0	6.9	102	36	68	164	510	0.99	-0.11	90.0	4
FORT MORGAN	83.3	52.2	67.8	5.6	100	39	63	153	510	1.04	-0.14	88.1	8
AKRON FAA AP	79.9	53.0	66.4	4.7	96	41	85	136	497	1.01	-0.07	93.5	8
AKRON 4E	81.5	49.6	65.5	3.5	98	35	95	119	477	0.70	-0.35	66.7	8
HOLYOKE	80.0	52.9	66.5	3.7	96	37	90	143	499	0.86	-0.43	66.7	6
BURLINGTON	81.4	53.7	67.5	3.4	97	38	76	163	504	1.18	-0.32	78.7	6
LIMON WSMO	78.2	49.5	63.8	4.2	95	39	96	67	434	2.53	1.63	281.1	11
CHEYENNE WELLS	84.2	54.2	69.2	5.2	99	38	54	190	537	3.31	1.52	184.9	7
EADS	83.3	54.7	69.0	3.7	98	41	46	173	534	2.44	1.12	184.8	7
ORDWAY 21N	86.4	51.6	69.0	5.5	103	42	38	167	527	2.64	1.77	303.4	9
LAMAR	87.1	55.2	71.2	4.4	102	42	27	219	574	2.12	0.99	187.6	9
LAS ANIMAS	86.9	55.4	71.1	3.8	103	42	21	214	576	2.35	1.31	226.0	8
HOLLY	83.6	55.6	69.6	4.2	99	40	24	171	565	2.12	0.57	136.8	8
SPRINGFIELD 7WSW	85.8	54.6	70.2	4.9	99	40	23	188	569	2.67	1.50	228.2	9
TIMPAS 13SW	84.6	54.9	69.8	4.9	100	49	27	180	548	1.64	0.47	140.2	5

Foothills/Adjacent Plains

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
FORT COLLINS	78.8	50.8	64.8	4.8	97	39	74	76	469	1.36	0.12	109.7	9
GREELEY UNC	81.3	51.6	66.4	4.3	99	37	62	113	500	1.37	0.24	121.2	9
ESTES PARK	71.7	40.4	56.0	2.7	88	31	264	1	333	1.03	-0.32	76.3	13
LONGMONT 2ESE	81.3	45.9	63.6	3.0	97	34	101	66	459	1.37	-0.06	95.8	9
BOULDER	77.9	51.5	64.7	2.1	95	40	81	81	465	1.84	-0.02	98.9	12
DENVER WSFO AP	81.0	52.8	66.9	5.0	96	42	64	130	507	1.46	0.08	105.8	9
EVERGREEN	74.1	41.0	57.6	3.7	90	33	219	4	368	2.34	0.89	161.4	12
CHEESMAN	78.4	37.3	57.8	1.4	92	29	214	5	413	3.07	1.80	241.7	10
LAKE GEORGE 8SW	69.7	40.4	55.1	3.3	82	32	291	0	305	1.23	0.15	113.9	12
RUXTON PARK	65.1	31.9	48.5	0.7	79	26	486	0	238	2.09	0.21	111.2	13
COLORADO SPRINGS	77.7	51.3	64.5	4.1	94	41	83	73	447	1.50	0.14	110.3	10
CANON CITY 2SE	80.8	52.6	66.7	4.0	94	40	58	117	505	1.75	0.66	160.6	7
PUEBLO WSO AP	84.5	52.1	68.3	2.7	100	43	34	140	522	1.83	0.94	205.6	11
WESTCLIFFE	73.7	39.0	56.3	2.6	85	31	253	0	362	2.43	1.16	191.3	12
WALSENBURG	80.3	51.0	65.7	3.2	92	43	53	80	489	2.15	0.93	176.2	9
TRINIDAD FAA AP	81.4	51.9	66.6	3.1	93	45	46	104	500	2.37	1.30	221.5	9

Mountains/Interior Valleys

	Temperature						Degree Days			Precipitation			
Name	Max	Min	Mean	Dep	High	Low	Heat	Cool	Grow	Total	Dep	%Norm	# days
WALDEN	73.4	34.1	53.7	5.6	87	24	332	0	356	1.29	0.17	115.2	11
LEADVILLE 2SW	65.8	32.8	49.3	2.8	76	25	464	0	244	1.35	-0.05	96.4	11
SALIDA	77.5	42.6	60.1	3.2	89	35	163	23	415	1.64	0.72	178.3	6
BUENA VISTA	74.6	40.2	57.4	2.3	87	31	226	5	376	2.30	1.25	219.0	9
SAGUACHE	73.2	42.4	57.8	3.7	85	31	210	1	357	2.88	1.93	303.2	12
HERMIT 7ESE	69.6	33.7	51.6	4.2	81	27	391	0	302	3.65	2.22	255.2	6
ALAMOSA WSO AP	75.5	41.1	58.3	3.6	87	33	201	7	387	1.48	0.65	178.3	8
STEAMBOAT SPRINGS	76.3	36.2	56.3	4.7	89	26	255	1	396	2.17	0.57	135.6	11
YAMPA	70.1	40.8	55.4	3.7	81	32	280	0	308	1.40	-0.08	94.6	12
GRAND LAKE 1NW	71.5	34.1	52.8	5.5	83	26	359	0	333	1.89	0.27	116.7	17
GRAND LAKE 6SSW	70.4	35.8	53.1	4.1	82	27	350	0	311	1.82	0.58	146.8	15
DILLON 1E	67.5	33.4	50.4	2.6	79	27	430	0	272	1.88	0.54	140.3	13
CLIMAX	60.6	35.1	47.9	5.0	71	27	505	0	167	2.23	0.67	142.9	16
ASPEN 1SW	72.0	41.9	56.9	4.4	82	33	234	0	333	1.78	-0.02	98.9	13
TAYLOR PARK	65.6	35.5	50.5	6.6	77	29	426	0	241	2.60	1.06	168.8	10
TELLURIDE	72.7	39.2	55.9	4.5	88	31	267	1	345	3.97	1.83	185.5	18
PAGOSA SPRINGS	78.4	39.7	59.0	4.5	92	35	177	5	420	3.50	1.40	166.7	11
SILVERTON	67.3	30.8	49.1	3.6	80	25	470	0	267	3.54	1.00	139.4	14
WOLF CREEK PASS 1	61.8	35.1	48.4	3.3	81	27	488	0	190	6.26	2.27	156.9	17

Western Valleys

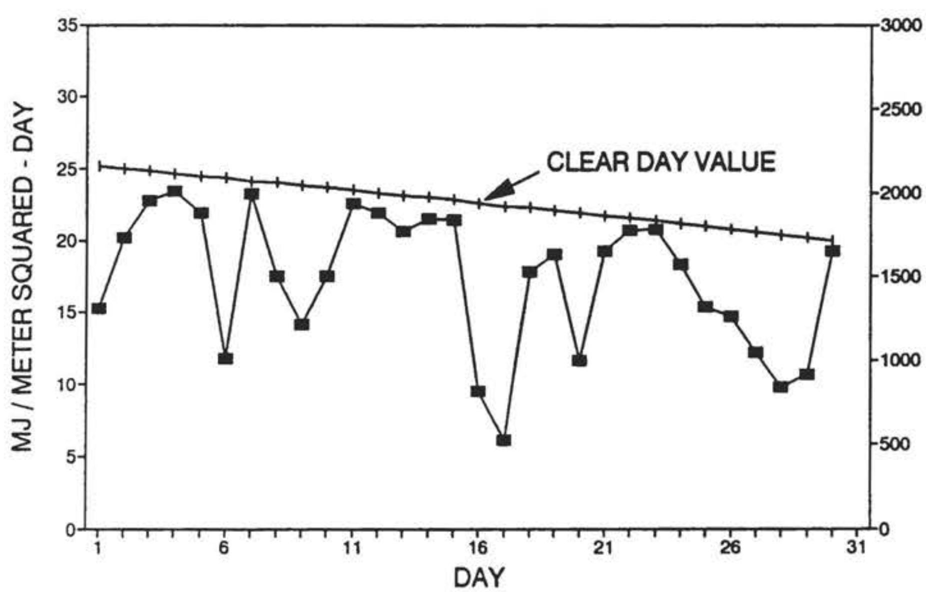
Name	Temperature Max	Min	Mean	Dep	High	Low	Degree Days Heat	Cool	Grow	Precipitation Total	Dep	%Norm	# days
CRAIG 4SW	79.0	45.6	62.3	6.2	91	35	116	44	442	0.76	-0.54	58.5	8
HAYDEN	78.5	45.0	61.8	6.2	90	36	115	26	434	1.42	0.21	117.4	9
MEEKER NO. 2	79.3	44.9	62.1	5.1	91	35	121	39	445	1.09	0.07	106.9	10
RANGELY 1E	83.1	51.7	67.4	7.1	94	40	44	124	529	0.75	-0.34	68.8	7
EAGLE FAA AP	80.0	43.0	61.5	6.2	93	33	134	37	447	1.20	0.02	101.7	7
GLENWOOD SPRINGS	82.2	46.0	64.1	5.4	96	35	92	72	465	1.44	-0.15	90.6	8
RIFLE	83.9	47.2	65.6	6.4	99	39	69	97	489	0.51	-0.57	47.2	4
GRAND JUNCTION WS	83.1	56.3	69.7	3.0	97	47	28	174	567	1.23	0.51	170.8	9
CEDAREDGE	82.2	48.9	65.6	4.3	95	40	69	94	480	0.66	-0.53	55.5	5
PAONIA 1SW	82.2	52.5	67.3	5.3	95	44	55	133	517	1.44	0.09	106.7	8
DELTA	85.0	47.9	66.4	4.2	99	41	58	109	488	0.78	-0.21	78.8	6
GUNNISON	74.7	37.2	55.9	4.7	87	32	264	0	377	2.35	1.44	258.2	7
COCHETOPA CREEK	74.9	38.4	56.6	5.6	87	30	251	7	379	3.59	2.59	359.0	10
MONTROSE NO. 2	79.6	49.8	64.7	3.6	92	40	81	77	467	0.60	-0.57	51.3	8
URAVAN	86.3	53.8	70.0	4.4	100	44	37	197	556	1.33	0.26	124.3	10
NORWOOD	75.9	46.9	61.4	4.9	89	35	136	34	402	1.89	0.29	118.1	8
YELLOW JACKET 2W	78.7	49.7	64.2	3.9	92	39	79	63	455	2.85	1.47	206.5	11
DURANGO	78.3	45.8	62.1	3.6	93	38	118	36	420	5.10	3.37	294.8	18
IGNACIO 1N	76.3	45.7	61.0	3.2	89	38	131	20	405	2.80	1.27	183.0	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.

SEPTEMBER 1990 SUNSHINE AND SOLAR RADIATION

Station	Number of Days clear	partly cloudy	cloudy	% of possible sunshine	average % of possible
Colorado Springs	13	9	8	--	--
Denver	13	11	6	78%	72%
Fort Collins	12	12	6	--	--
Grand Junction	11	12	7	69%	74%
Limon	15	9	6	--	--
Pueblo	16	6	7	76%	78%

FT. COLLINS TOTAL HEMISPHERIC RADIATION
SEPTEMBER 1990



The Ultimate Furnace

Although few cool days have yet occurred, fall is here with winter just around the corner. Now is the time most of us get the furnace cleaned and ready for use and also start budgeting for those higher utility bills that comes with the use of that furnace. All that money goes toward keeping the home around 70 degrees Fahrenheit--which means that the air may be heated to 80-100 degrees in the furnace itself before it is blown into all the rooms. Wouldn't it be nice to tap into some fuel source that could supply HOT air for less money? If the world were perfect, one would just need to drill 1.8 miles down and get temperatures of 194 degrees Fahrenheit! However, the world is not perfect, but it does provide some instances when heat from below is obtainable.

To back track a bit, the earth's center is molten with temperatures in excess of 1800 degrees. The heat is conducted out to the surface giving an average surface temperature of 50 degrees. This is the main reason homes built into the earth use less energy--the outside of the walls are subject to a steady 50 degrees or so instead of the wide fluctuations of ambient temperature. For each kilometer closer to the center, the temperature rises by 54 degrees. In certain areas of the earth, pockets of steam are within man's ability to tap and use.

This energy is called geothermal energy and has three main types; dry steam, wet steam and dry rock. Dry steam is the cleanest, but also the rarest. Only specific geologic formations allow the development of this type of steam. It is by far the hottest of the three types, getting up to six times what the normal temperature would be at the same depth. It can be tapped into and used to turn turbines for electrical production. Wet steam is in greater supply that dry steam. A heat exchanger can be used to supply hot water for space heating. The steam is three times as hot as the normal temperatures at a comparable depth. Both dry and wet steam could theoretically be used for anywhere from 50 to 300 years. The last of the three types, dry rock, has an almost unlimited use. It is basically using the temperatures of the earth as previously mentioned to supply hot water for space heating or domestic hot water heating. With dry rock, water can be pumped down into the rock and warmed and then pumped back up to the surface for use. Colorado has geological formations that provide hot water to the surface. Glenwood Springs, Idaho Springs and other sites within the state are places where hot steam/hot water from under the earth bubble up to give recreational use for many.

With the ongoing need for different fuel supplies, geothermal energy could be one way to spread out the burden of providing space heating, electricity and domestic hot water to the public.

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	Alamosa	Durango	Carbondale	Montrose	Steamboat Springs	Sterling	Stratton	Walsh
monthly average temperature (°F)	56.7	57.6	58.6	60.7	55.5	65.3	65.0	68.8
monthly temperature extremes and time of occurence (°F day/hour)								
maximum:	84.0 13/16	85.6 13/15	92.3 13/16	90.0 12/15	89.4 15/14	100.0 13/14	145.0 30/ 8	95.7 15/14
minimum:	31.8 26/ 6	36.3 19/ 5	32.5 20/ 6	36.9 20/ 6	28.0 11/ 5	32.0 18/ 2	32.0 26/18	41.0 23/ 6
monthly average relative humidity / dewpoint (percent / °F)								
5 AM	90 / 40	89 / 43	95 / 42	91 / 44	97 / 38	41 / 27	49 / 30	81 / 52
11 AM	52 / 46	58 / 51	42 / 44	52 / 51	47 / 45	24 / 28	26 / 31	48 / 53
2 PM	38 / 40	48 / 49	30 / 39	42 / 48	30 / 38	19 / 28	21 / 25	39 / 50
5 PM	37 / 38	51 / 47	36 / 39	46 / 48	35 / 38	19 / 26	21 / 24	41 / 49
11 PM	70 / 41	83 / 46	74 / 43	71 / 46	79 / 41	33 / 25	34 / 23	69 / 52
monthly average wind direction (degrees clockwise from north)								
day	167	183	241	265	236	153	126	131
night	170	65	170	132	110	207	186	198
monthly average wind speed (miles per hour)	3.77	1.79	3.07	2.45	2.45	7.53	8.26	8.00
wind speed distribution (hours per month for hourly average mph range)								
0 to 3	306	539	494	518	498	63	106	42
3 to 12	410	181	223	202	209	565	441	559
12 to 24	4	0	3	0	5	92	173	119
> 24	0	0	0	0	0	0	0	0
monthly average daily total insolation (Btu/ft²·day)	1645	1610	1547	1630	1637	4138	1574	1620
"clearness" distribution (hours per month in specified clearness index range)								
60-80%	202	100	137	136	144	50	200	205
40-60%	65	55	67	59	58	39	39	54
20-40%	53	70	74	55	48	19	28	52
0-20%	33	58	31	37	37	34	34	40

The State-Wide Picture

The figure below shows monthly weather at WTHRNET sites around the state. Three graphs are given for each location: the top graph displays the hourly ambient air temperature, ranging from -40°F to 110°F, the middle one gives the daily total solar radiation on a horizontal surface, up to 4000 Btu/ft²/day, and the bottom graph illustrates the hourly average wind speed between 0 and 40 miles per hour. Stratton station is having difficulties and data should be regarded as unreliable.