



Colorado Climate

Spring 2001 Vol. 2, No. 2

Colorado
State
University

Knowledge to Go Places

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**Colorado
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Knowledge to Go Places

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Frost: Nature's Artwork

Nolan Doesken

When people think of Colorado weather they think of deep powder-light snows, clear blue skies, and towering summertime thunderheads. But a subtle and often overlooked feature of our climate is those chilly mornings when we wake up to see frosty white roofs and finely decorated yards and fields glistening white from countless crystals of frozen water. This is a particularly intimate experience for those of us who don't have a garage (or room in our garage). We get to see the frost up close and personal as we hurry to scrape our windshields and get on the road to work or school.

As a child, I used to study with fascination the patterns of frost. In our poorly insulated house in Illinois, fern-shaped fans of frost often formed on my bedroom window on frigid mornings. But now, sadly enough, I often fail to stop to marvel at the artwork. Instead I rush to scrape or brush it off so as not to be late again in delivering our children to school.

Frost is a part of our climate here in Colorado. While our humidity is often low, clear skies in fall, winter and early spring allow heat to escape rapidly into space at night creating cold pockets of air, especially in valleys and local hollows. Here, frost forms when the air temperature at ground level dips to the dewpoint and temperatures drop below freezing.

Our historical weather station here in Fort Collins is one of very few weather stations in the country that measure and report frost and dew each morning. We've done this for more than 100 years and continue to examine the surface each morning around sunrise on the CSU campus near the Lory Student Center. This past winter (2000-2001) got off to a cold start with a very cold November. After that, eastern Colorado was often under the influence of high pressure over the plains and Great Lakes states that pushed cool but fairly damp air into the state from the east. Day after day frost formed overnight. Sometimes, dense fog also formed and produced tiny particles of drizzle which froze in contact with any cold surface. While Colorado is not known for ice storms which often create winter chaos from Texas to New England, weighing down trees, snapping power lines, and sending cars in all directions, this fog and drizzle created thin layers of clear ice which we refer to as glaze. If you think scraping frost from your windshield on a cold winter's morning is a pain, just wait until you get to scrape glaze. It adheres tightly to whatever it lands on and takes four times longer to clear from your car windows even if it is just a paper thin layer.

When it was all said and done, this past winter (2000-2001) was an unusually frosty and glazy one for eastern Colorado. It fact, in brought back memories of 1977-1978, a frigid winter over the upper Midwest and



Above: Frost on rooftop of a car. Photo by Grant Godge.



Photo by Grant Godge.

one which brought nearly an entire month of fog to portions of eastern Colorado in February 1978. Rural electric cooperatives have no fond memories of that year as literally hundreds of miles of power lines came down under the weight of fluffy but thick rime ice

Since we have the data, lets compare the winters of 1977-78, 1999-2000, and 2000-2001 (see page 2).

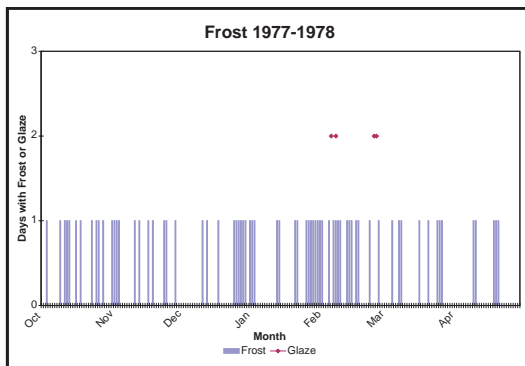
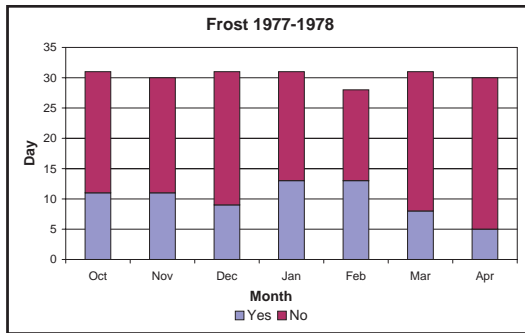
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Frost: Nature's Artwork *(continued from page 1)*



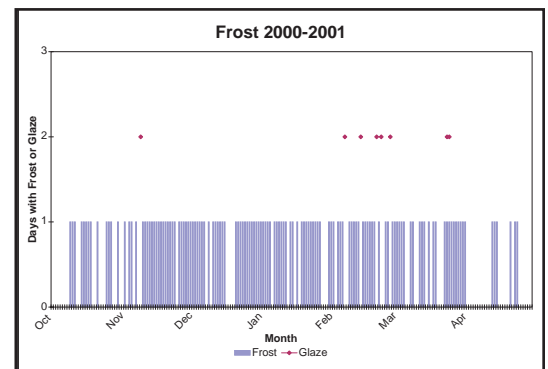
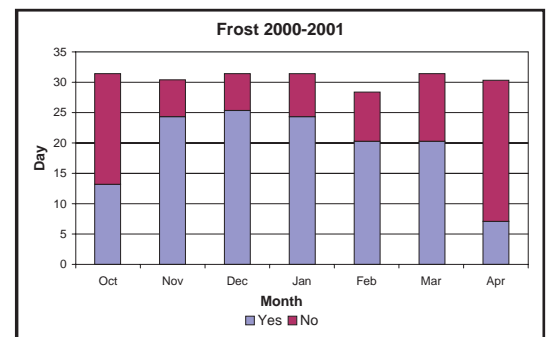
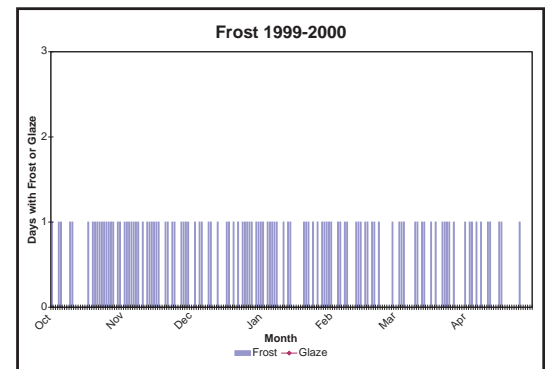
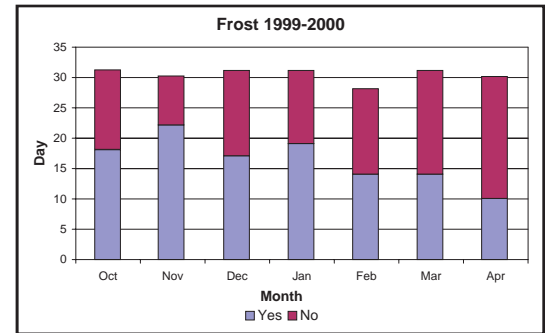
An example of rime on a tree.

Do you have a picture of frost or glaze taken in Colorado that would look good in Colorado Climate? Send it in (or any other eye-catching weather phenomenon) along with a description of where you were and what weather conditions were occurring that day. We will periodically select photos for publication in Colorado Climate based on the quality of the photograph and the phenomenon it captured.



As you can see, this past winter was really a frosty one in Fort Collins, morning frost was reported on 133 days from October through April with glaze reported on 8 days. By comparison, in 1977-78, frost was reported on 70 days with glaze on 4 days with most of these days concentrated in February, 1978. The 1999-2000 season had no glaze.

I like frost. Glaze is beautiful, too, in its own way. But both can be dangerous. Last year several traffic accidents were attributable directly or indirectly to poor visibility on windshields that had not been adequately scraped or defrosted. Slippery roads from glaze caused many traffic accidents, some with fatalities. Beautiful as it may be, it is a hazard to our normal daily activities. But if you recognize the hazard and adjust your activities you may be able to join the ranks



of those who treasure the beauty of frost and delight in the shimmer of glaze and know that it is a part of our Colorado climate.

Folklore – The East Wind

Nolan Doesken

Living in east central Illinois I learned at a very young age that an east wind often preceded wet weather. Rarely did we have clear skies and east winds, and if we did, it wasn't long until the clouds began to gather. I figured that out myself without reading any meteorology text books. I just watched and paid attention. I loved storms, especially winter snows, and the really big storms seemed to always begin with east winds.

When I moved to Colorado in the 1970s, I discovered that the ole east wind had a reputation here, too. Here in Fort Collins, we get many days, both clear and cloudy, with winds from the south or southeast during the day, but if the wind blows from the east or northeast, then expect cloudy, chilly and damp weather.

It turns out that I wasn't the only one who paid attention to the east wind. In fact, those early meteorologists working in the 1880s for the U.S. Signal Service interviewing observant citizens from all across the country and compiling all the weather forecasting folklore they could find to try to improve their forecasting skills turned up a lot of information about the east wind. Let me share a few of the bits of folklore they turned up from the 19th Century.

If the wind blows from the northeast, the storm will be a hard one.

If the wind comes out of the east, 'twill rain twenty four hours at least.

When the east wind doth blow, there shall be snow.

The northwest wind brings a short storm, but a northeast wind brings a long storm.

When the wind is in the east, 'tis good for neither man nor beast.

If the wind on New Year's Eve blows out of the east, the trees will bear much fruit, but a New Year's Eve wind out of the south betokeneth warmth and drought. (That's the first time I've ever seen that word "betokeneth".)

When the wind is from the east, the fish bite the least.

I can't vouch for the last two, but the first few do stand up to scientific scrutiny. Did these early observers understand weather systems? They may not have known about high pressure, low pressure, warm fronts, overrunning, upslopes, or any of that meteorological jargon, but they did know what they saw and they could literally feel the weather patterns changing. They didn't just make this up. Now, with a wealth of weather data, we know that an east wind here in the mid latitudes of the northern hemisphere means that high pressure lies to the north or northeast and that

low pressure is positioned to the south or southwest. Since most storms move from the west toward the east, this means a storm is headed your way. The counterclockwise flow of air around a low pressure area also draws humid air northward from near the Gulf of Mexico to provide moisture for storms over the Great Plains and Midwest. And here in Colorado, the easterly wind is the "Upslope" that you will sometimes hear the weather broadcaster mention as moist air rises up the east slope of the Colorado Front Range producing low clouds, fog, rain, snow and sometimes heavy rains. Twenty-five years after the Big Thompson Flood of 1976, many residents who lived in Larimer County back then still remember the easterly winds that blew so strong that day feeding tons of moisture into the developing storm.

You may complain about the weather forecasts that you get and how wrong they often are, but the reality is weather forecasters are doing better than ever. We don't have to rely on our senses and our powers of observation. We can just get on the internet to get the latest forecast. But best of all is a combination of both. Keep your eyes on the skies and learn the cloud and wind patterns that characterize our climate. By the way, even as I write this we have a light northeast wind – and it is snowing and cold. HmMMM.



For Teachers – Teaching to the Drumbeat of the Seasons

Nolan Doesken

There is nothing like teaching school to keep you in touch with the changing seasons. Sports, community events, holidays, birthdays – even if you never left the school building (some teachers say that’s too close to the truth) – you could tell the changing seasons by watching the children. Their interests, their moods and attitudes, their energy level, and the clothes they wear (at least the younger students), give strong clues as to the time of year. The cycle of the seasons, repeated year after year during the time of our lives that we like counting, leaves an indelible mark that carries through all of our lives.

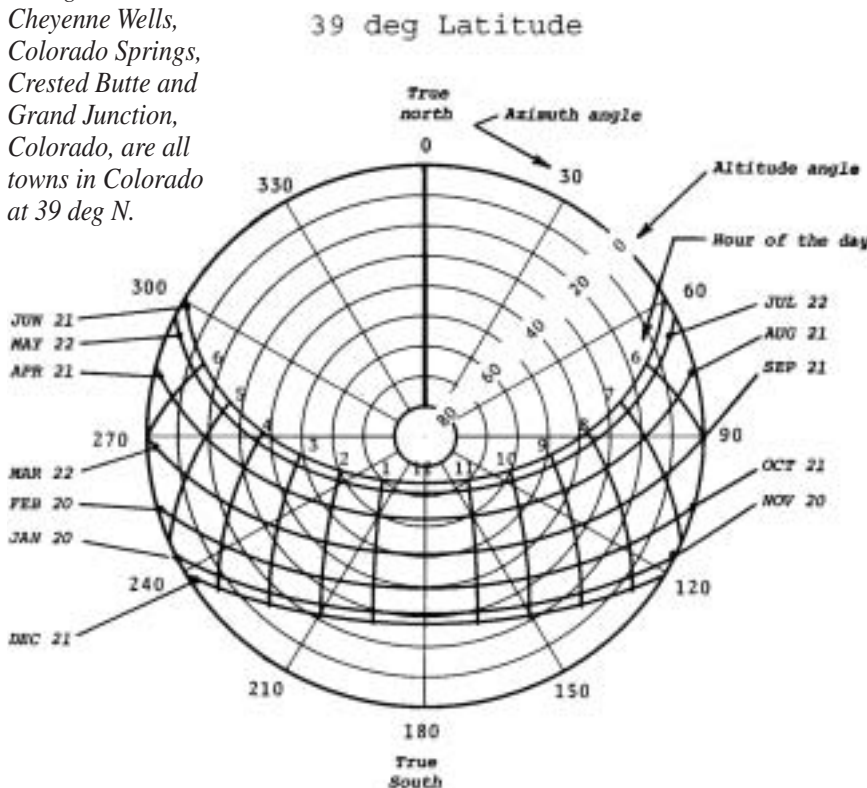
Think back to your own youth. Raking leaves, football games, pumpkin pie, favorite hats, putting on skis for the first time, green grass and blossoms, the first baseball game, the amusement park in summer, family vacations, fresh produce. Sort your memories and you may find they too are in harmony with the song of the seasons. For me, weather events were always part of how I marked the passing of time – the fresh smell of the first drops of rain from a spring storm, the first rumbles of thunder, the smell of corn pollen in summer, a distance lightning on a muggy summer evening, the deeper blues and darker grays

that shade the autumn skies and finally the absolute thrill of the first snowflakes. For me, each new year was a fresh opportunity to sense with wonder the cloud progressions, the winds, the cycles of warm and cold and the thrill and fear of Midwestern storms that defined each season. Church, chores, school, sports, friends, family, food and fun all were touched and tinted by the changing weather so masterfully led by the drumbeat of the seasons.

It seems that seasons were made for children. They provide such a marvelous and predictable method to track the passing of time. Even the older kids (7th grade and up) may appear to be defying the seasons with their choice of clothing and their sometimes-rebellious attitudes, but down inside they too feel and follow the changes in daylength, temperatures, vegetation, colors, smells and activities that accompanies the annual cycle. The holidays and festivities that accompany simply accentuate the feelings and emotions and solidify memories.

Without waxing too poetic, let’s think how we can use the seasons to capture for our students some important information about climate.

Sun path diagram shows the position of the sun in terms of azimuth and elevation angle as a function of time of day and time of year. This graph is valid for a latitude of 39 degrees N, i.e., Cheyenne Wells, Colorado Springs, Crested Butte and Grand Junction, Colorado, are all towns in Colorado at 39 deg N.



The Sun Path Diagram – Mapping the Position of the Sun

Most introductions to weather and climate include an attempt to show the tilt of the earth’s axis of rotation, and the orbit of the earth around the sun. This is a very important concept that you must convey to your students. It truly is the reason for the seasons. I remember holding a flashlight in 3rd grade and being shown how the same amount of energy is concentrated overhead during the summer season while being spread over much larger areas during winter when the northern hemisphere is tilted away from the sun. Even now after all these years of knowing what causes the seasons I get a chill thinking about the incredible journey we take on earth spinning hundreds of times (365 1/4 to be nearly exact) and traveling some 585 million miles in our orbit within our solar system just to make it through one year. It is amazing the safety, warmth and protection that our greenhouse atmosphere affords us on this wild journey.

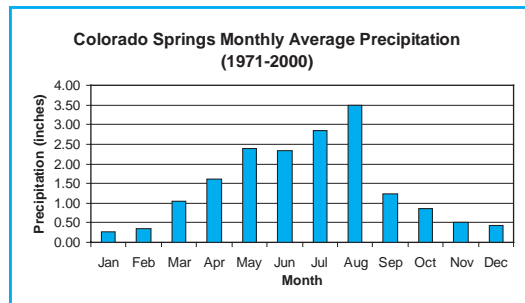
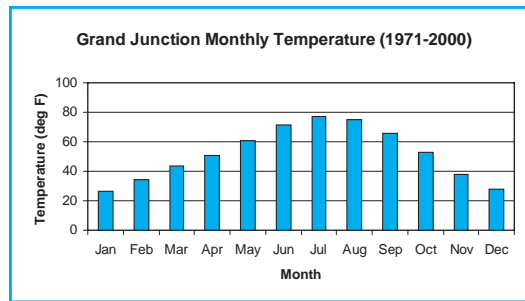
I’ll let you decide how to best show your students the nature of our solar system that cause our seasons. But I would like to show you a graph that I really enjoy. The results of our orbit, our tilted axis and our daily rotation have been graphed in a way that show where the sun is with respect to our location on earth for any time of day and any day of the year. This graph is called a sun path diagram.

I was probably 28 when I saw my first sun path diagram. I was fascinated how one single graph could show so much. Having watched the sun all my life I immediately understood the complicated curves. It wasn't designed with teaching children in mind. How well your kids catch on will likely be determined by how well you can help them visualize what it tells us. For certain, it is a chance to measure some angles and plot them on a graph.

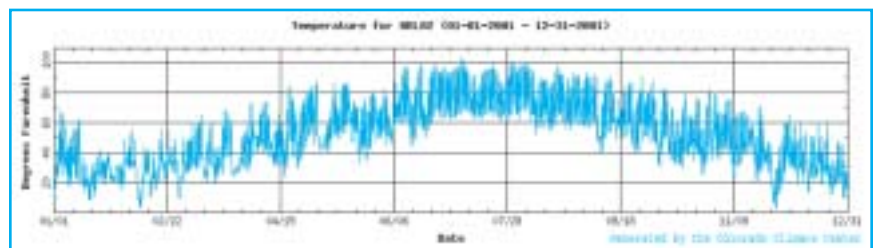
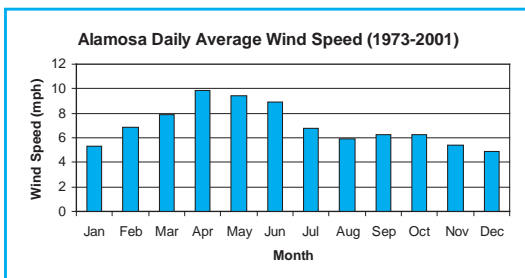
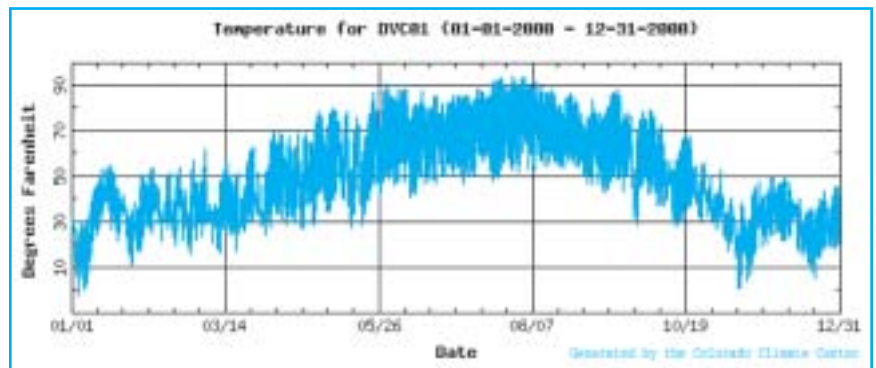
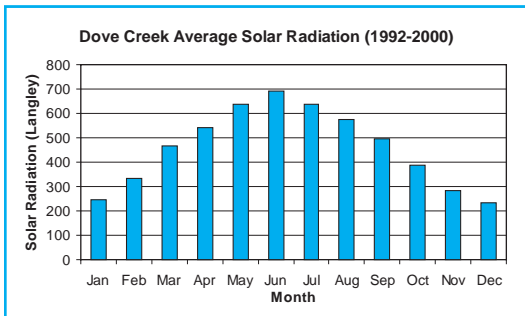
Tracking the Elements of Climate

The path of the sun and the changes in energy that reach the earth profoundly affect all other aspects of the climate. You can start with solar energy and temperature and work your way to pressure, wind and precipitation. You can look at long-term averages or the frequency of events. For example, it is rare in most parts of Colorado to receive an inch or more of precipitation in one day in the winter. At cold winter temperatures, the atmosphere simply has trouble delivering that much water. But in the warmer days of spring and summer much more water vapor can be present in our atmosphere contributing to occasional very intense storms. Tornadoes, hail and lightning also have a seasonal cycle that is easy to see and show.

Here are just a few examples of graphs that students can research and prepare that help show the amazing march of the seasons that is such a part of our lives.



These graphs are simple and descriptive but to really understand the climate you need to know how changeable daily weather is. A graph of daily temperatures for a month, a season or a year can show other important factors - variability, range extremes, and persistence. With understandable data you can create as complex of an exercise as your students can handle.

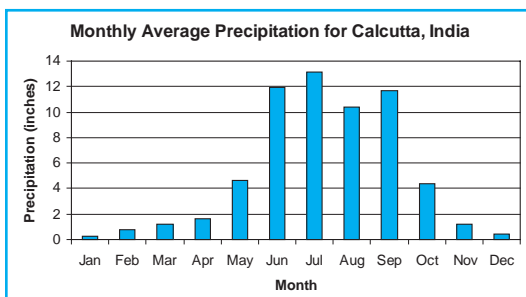


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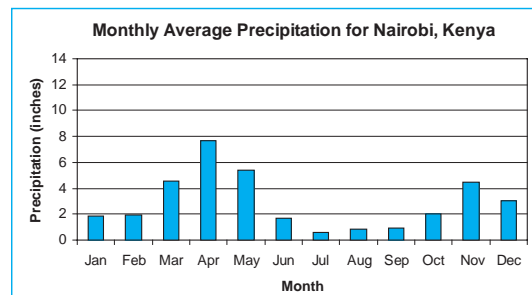
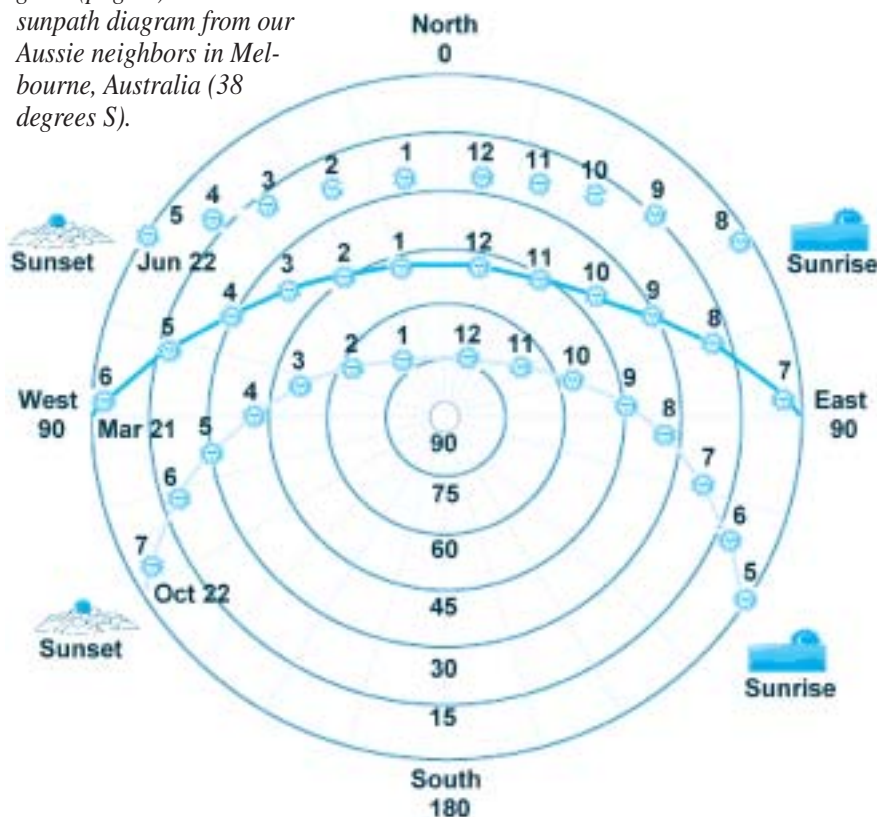
For Teachers *(continued from page 5)*

The Seasons Around the World

Almost every aspect of your local climate follows the drumbeat of the seasons. But the results are not the same in all areas. If you have time and make the effort, you and your students can compare the seasons in different parts of the county or different parts of the world. Comparing northern and southern hemisphere locations is certainly interesting. But the tropics – are there seasons there? Temperatures don't change too much, but it's amazing to track the changes in precipitation as the intertropical convergence zone moves northward and southward in the annual cycle driven by the drumbeat of the seasons.



Note the difference between our sunpath diagram (page 4) and this sunpath diagram from our Aussie neighbors in Melbourne, Australia (38 degrees S).



The Seasons of Life

As we get older the seasons remain exciting. There is nothing better than falling in love in springtime. Then again, summer is a wonderful time to fall in love. Oh, and the fall – walking hand in hand with the one you love through the falling leaves – what could be finer, expect perhaps winter. The cold and the roar of the winter winds are such a fine reason to snuggle together and to await the first snowflakes. Each season is perfect when you are in love.

Each season is also perfect when you're a sports fan. Each season brings new life and new opportunities no matter how badly your team did last year. Baseball, football, basketball, hockey and other athletic pursuits all in an endless cycle lead by the drumbeat of the changing seasons.

Changing seasons can lose their luster if we let them. We hold on tight to the wild ride of raising children, dressing them for the weather, rushing them out the door to get to school on time, getting ready for each holiday, celebrating each birthday – then suddenly they are grown and gone – as independent as a summer thunderhead. We think we will finally be able to relax, slow down and catch up with all the things that we have put aside only to discover we're tired. But then some of us are lucky enough to become grandparents and watch with amazement the thrill of the seasons brought back to us by the children. And then, the seasons move so fast – too fast. And while the children love to count each cycle and add one more year and one more party, we see those years add up so very fast until our years number too many to still feel like a child and run and jump like a child – leaping in autumn leaves, tumbling in winter snows, dancing in spring puddles, and resting in summer shade. No, we can't always run and play, but we can watch and wonder as we feel the drumbeat of the seasons. We can always cut loose a good story about what the seasons were like in our own good ole days.

Volunteer Weather Watchers Honored

Nolan Doesken

Volunteer weather observers have long played a vital role in climate monitoring, weather prediction, and atmospheric research both here in Colorado and all across the U.S. But these volunteers rarely receive the thanks they deserve. In April 2001, we tried to change that. After several months of planning, the Colorado Climate Center at CSU teamed up with the National Center for Atmospheric Science (NCAR) and the National Oceanic and Atmospheric Administration (NOAA) in Boulder, to host a very special day for volunteer weather watchers from the Rocky Mountain Region. The result was the first of its kind – “Rocky Mountain Weather and Climate Workshop.” This workshop was geared specifically for volunteer weather watchers and official “Cooperative Observers” welcoming them as fellow scientists in the pursuit of the study of our amazing weather and climate.

On April 21, 2001, despite darkening skies and the forecast of bad weather, nearly 100 volunteer weather observers arrived from Nebraska, Wyoming and Colorado. Some traveled up to 400 miles to attend. Young and old, farmers, ranchers, teachers, students – a wonderful roomful of weather enthusiasts came eager to learn more about a subject that they have long watched with wonder.

After a “get acquainted” coffee hour as people filed in, the volunteers were treated to a morning of talks by world-renowned scientists who were eager to share their passion for weather and climate. Dr. Charles Knight, who has spent close to 4 decades in intensive study of hailstones and the storms that produce them, welcomed the group to NCAR. Larry Mooney, Meteorologist in Charge at the Boulder National Weather Service Office extended a warm welcome from NOAA. I was given the fun job of conveying the Colorado State University welcome.

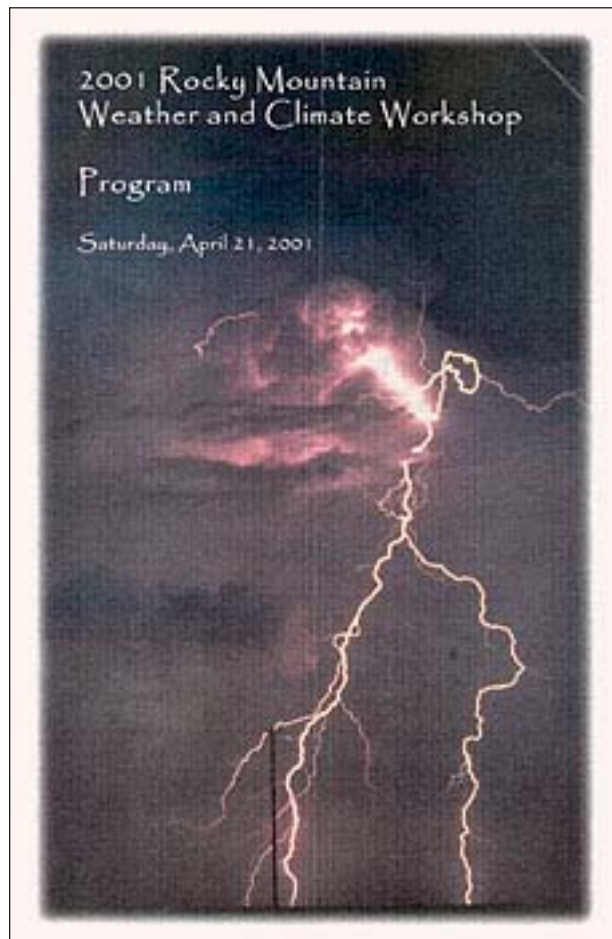
The first presentation was given by Dr. Tom Schlatter, a contagiously enthusiastic weather watcher in his own right, and author of “Weather Queries,” a column that has been published for many years in WeatherWise Magazine. Using only words and a few hand drawings, Tom gave a very clear and understandable talk on what causes thunderstorms. After seeing how well he explained difficult concepts, some in the audience were overheard saying “If I had it to do over again, I would have studied meteorology.”

Then came a talk on global climate and climate change issues by world-renowned climatologist, Dr. Kenneth Trenberth from NCAR. He shared some of his opinions and insights from his involvement in the International Panel on Climate Change. While climate change remains a controversial topic due to the con-

(continued on page 8)



Photo by Susan Q Foster, UCAR.



Volunteer Weather Watchers Honored *(continued from page 7)*



Brevin (9) and Remy (11) Currier of Collbran, Colorado, were honored as Colorado's youngest official National Weather Service Cooperative Observers. Photos by Susan Q Foster, UCAR.



flicts that arise between observation and prediction and future political and economic ramifications, Dr. Trenberth brought the complex topic down to earth for the audience.

Lunch for all was provided in the NCAR cafeteria overlooking the fog-shrouded Flatirons to the west and the expanses of Colorado's plains to the east where storm clouds continued to gather. Merle Lord, State

Farm Insurance agent from Canon City and a long time weather enthusiast, sponsored the luncheon. A number of very special volunteer weather observers were acknowledged including Wayne Warner from Gering, Nebraska, who has been diligent recording daily weather information for the National Weather Service for 60 plus years. Also featured were the youngest official weather observers in Colorado, Brevin and Remy Currier, ages 9 and 11, respectively. They record weather observations at the Collbran weather station, southeast of Grand Junction.

After a good feed and a special cake decorated with the words "Hail to the Weather Observers," the large group migrated down into Boulder for an afternoon of talks and demonstrations at the new NOAA Building on Broadway Street. Highlights included tours of the National Weather Service forecast office and the Solar Forecast Center where military and civilian experts keep a watch on sun spots, solar flares and all sorts of solar phenomena. Volunteers were treated to a state of the art weather briefing by meteorologist Patrice Kucera of the NOAA Forecast Systems Lab. Imminent thunderstorms and a potential blizzard situation for the Great Plains stirred up everyone's weather fervor, and sent a few nervous travelers on their way early. Finally, the day ended with a stirring presentation by one of America's top tornado and severe thunderstorm experts, Erik Rasmussen. What a day it was for weather volunteers!!

Soon after the first ever citizen's Rocky Mountain Weather and Climate Workshop ended, rain began, some lightning flickered and thunder rolled and by the next morning a blizzard blasted Wyoming, Nebraska and northeastern Colorado. Everyone made it home, but some were delayed a day or two. Such is life in the Rockies. When all is said and done, the weather still has the upper hand.

It was indeed a good day for volunteer weather observers. Based on the responses by scientists and volunteers alike, similar programs will be offered in the future. After all, there are far more than 100 weather enthusiasts in the Rocky Mountain Region. Already a 2002 Rocky Mountain Weather and Climate Workshop is being planned for June.

If you would like more information sent to you about the 2002 Rocky Mountain Weather and Climate Workshop, please contact the Colorado Climate Center or the National Center for Atmospheric Research.

Colorado Climate in Review

January 2001

Climate in Perspective

Winds aloft over Colorado, often very strong out of the northwest or west during mid winter, were lighter than average this January. Several storm systems did track across the Rockies during the month, but the preferred storm track was over New Mexico and southern Colorado. The result was very little snow for Colorado's northern and central mountains, but generous snows over southern Colorado. Colorado's typically dry southeastern plains looked like a winter wonderland. Areas such as Lamar, Walsh and Springfield reported close to 20 inches of snowfall for the month, as much as they sometimes get in an entire winter. Meanwhile, Steamboat Springs only measured 19.5 inches of new snow, far below their average.

Precipitation

Practically no precipitation fell in Colorado for the first 12 days of the January, lowering the spirits just a bit of Colorado's winter recreation industry. Storms became more numerous later in the month. There were no dumps of heavy snow in the mountains, and no appreciable increase in snow depth in the high country, but enough new snow fell to keep things looking like winter. At lower elevations east of the mountains, the ground was bare and dry early in the month, but fields and pastures were covered with snow for most of the last 3 weeks of the month. Overall, precipitation totals were much below average for the month over the northern and central mountains of Colorado and most western valley from the Gunnison River northward. Precipitation totals were above average over the southern mountains and most of the eastern plains. Storm systems that tracked across New Mexico were responsible for most of this welcome moisture.

Temperature

Temperatures were generally near to above average during the first two weeks of January but colder than average in many areas later in the month. Dry, sunny weather allowed cold air to collect in the Yampa and White River Valleys early in the month. For the month as a whole, January ended up colder than average in northwestern Colorado and near to slightly below average over central and southeastern counties. Above average temperatures were found over northeastern Colorado and some western and southwestern valleys.

January Daily Highlights

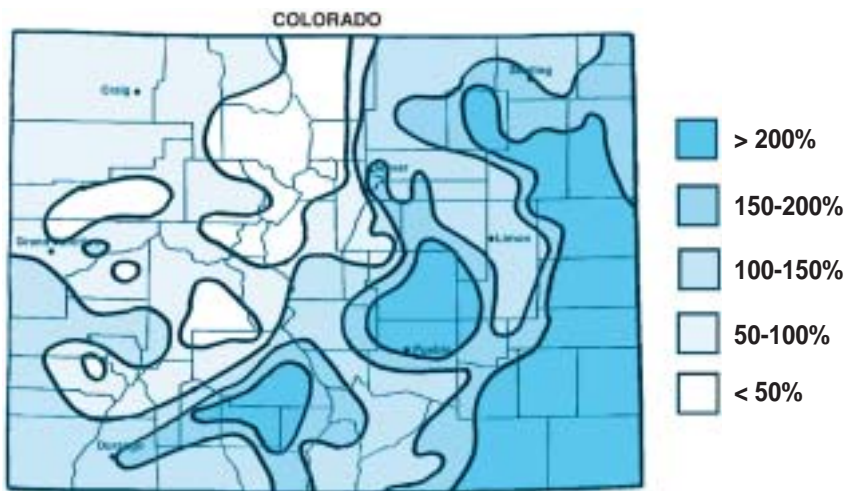
1-8 Mostly dry across all of Colorado as high pressure prevailed over most of the Western U.S. Cold air settled into Colorado's western valleys with temperatures below zero many

nights. Fraser recorded -26°F on the morning of the 8th. Occasional strong northwesterly winds blew along and east of the crest of the Rockies. After a cold start on the 1st, temperatures warmed east of the mountains and soared to near record levels by the 4th. Pueblo hit 74° on the 4th, and highs in the 60s were widespread east of the mountains 4-6th. 40s and a few 50s were noted in the mountains and western slope. A minor disturbance brought cooler (near average) temperatures on the 7th and few mountain snow flurries. Brilliant winter sunshine returned on the 8th.

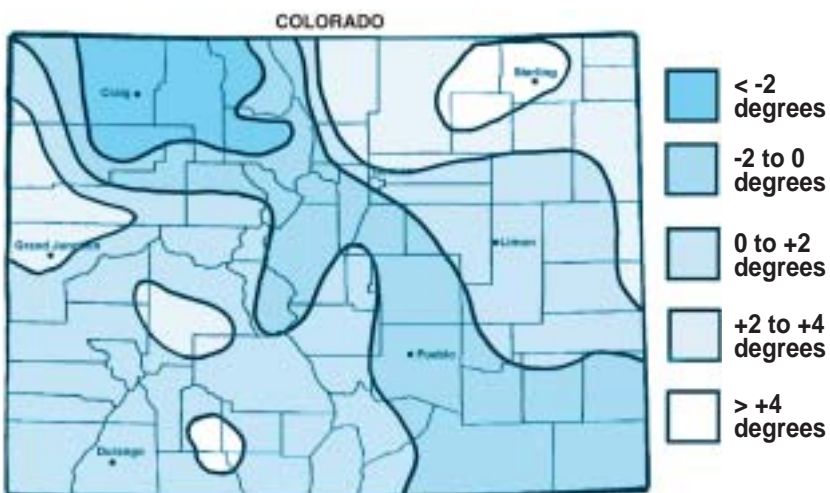
9-11 Still dry and mild for most of the state, but a storm system passed well south of Colorado spreading clouds and a little precipitation to extreme southern Colorado on the 9th. Pagosa Springs measured nearly 3" of snow. The storm passed into Texas on the 10th as a very weak system brought clouds and brief snow showers to the northern mountains.

12-14 A major storm system developed over the Southwest on the 12th and raced eastward across Colorado on the 13th. Breezy and mild conditions prevailed ahead of the storm. Precipitation spread eastward across western Colorado on the 12th. Wolf Creek Pass took a quick hit with 21" of light, powdery snow, but most of western and central Colorado received only a 1-4 inches. The storm packed what appeared to be blizzard potential for eastern Colorado, but moisture was limited and most areas east of the mountains just got strong winds on the 13th. The exception was east central Colorado where up to 5 inches fell near Burlington. Cool but pleasant weather returned statewide on the 14th.

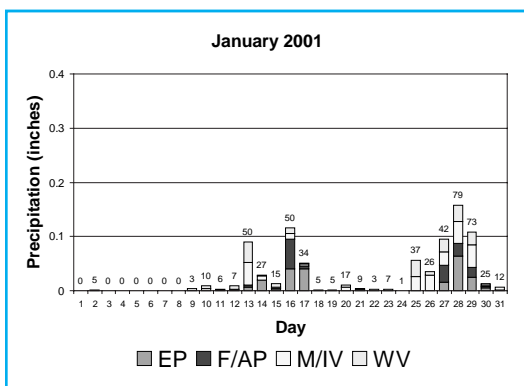
15-18 A broad and slow moving upper level low pressure area dropped into the Southwest as high pressure perched north of Colorado. This brought cold temperatures statewide and created a large area of easterly "upslope" winds along the east slope of the Rockies from southern Wyoming south to New Mexico. Several inches of light, fluffy snow fell from Fort Collins to Trinidad. Fort Collins reported 5" and Boulder 7" but the heaviest snows fell over southeastern Colorado. Pueblo reported 12". 8-14" depths were common across Colorado's southeastern plains by the time the storm diminished on the 17th. Skies then cleared and sub-zero morning temperatures were widespread over southeastern Colorado 17th and 18th. Westcliffe dipped to -18°F. Antero Reservoir reported the coldest temperature of the month, -30° on the 17th.



January 2001 precipitation as a percent of 1961 to 1990 average.



January 2001 temperature departure from 1961-1990 average, degree F.



Statewide Average Daily Precipitation graph(s) (above and throughout this article) shows relative amounts of precipitation for each region. Label on each column indicated percent of stations with measurable precipitation for each day.

19-21 Northwesterly winds aloft accompanied a gradual moderation. A quick-moving disturbance triggered some mountain snow showers on the 20th but with little accumulation. The Eastern Plains remained dry.

22-24 A narrow high pressure ridge straddled the Rockies but Pacific moisture brought cloudiness and a shot of snow to parts of central Colorado. Temperatures were close to the seasonal averages.

25-26 A compact and fast moving storm moved quickly across Colorado from west to east on the 25th. Surprisingly little moisture fell, however, except in southwestern Colorado where 8-14" of fresh snow was reported. Durango enjoyed 7" of wet snow with 0.67" of water content. Chilly winds followed the storm on the 26th east of the mountains but no precipitation fell.

27-29 A large upper level cut-off low pressure area moved slowly across Arizona and New Mexico 27-28th and then picked up speed and left the area on the 29th. Heavy snows blanketed southwestern Colorado on the 27th while only very light snows fell from Gunnison northward. Wolf Creek Pass reported more than 3 feet of new snow in two days. Lighter but widespread snowfall was reported from the Front Range eastward across the plains. Two to 6 inches of new snow were typical east of the mountains, by the time the snows ended on the 29th, but locally heavier amounts were observed. Campo in extreme southeastern Colorado had 9" with a water content of 0.82". Winds picked up on the 29th as the storm pushed across the Midwest.

30-31 Partly cloudy and quite cold with northwesterly flow aloft. A few snow showers fell in the mountains while most of the state remained dry.

January 2001 Monthly Extremes			
Description	Station	Extreme	Date
Precipitation (day):	Lemon Dam	1.46"	Jan 28
Precipitation (total):	Wolf Creek Pass 1E	5.42"	
High Temperature:	Karval	75°F	Jan 5
Low Temperature:	Antero Reservoir	-30°F	Jan 17

February 2001

Climate in Perspective

February 2001 brought back memories of fog and heavy ice deposits that covered so much of eastern Colorado back in February 1978. This year, time after time high pressure areas dropped down out of Canada into the plains and Midwest. Clockwise flow around the high pushed cool and rather moist air into eastern

Colorado from the east. Fog and freezing drizzle came and left several times. Fortunately this year there were not dangerous deposits of ice like 23 years previous. Still, some areas on the plains reported dense fog on up to half of the days in February, which certainly slowed travel. Moisture laden Pacific air was the prevalent air mass over western Colorado during the month and the result was a lot of clouds. Grand Junction reported just 42% of the possible hours of sunshine for the month.

Precipitation

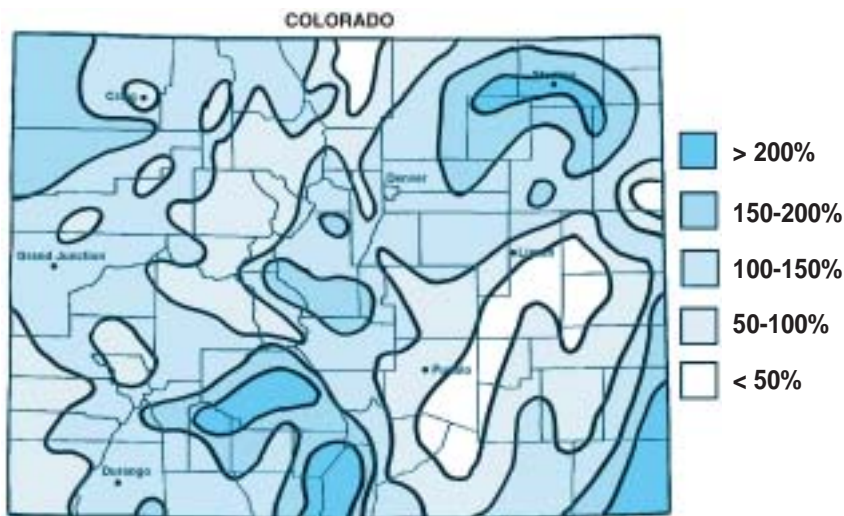
Abundant humidity and several storm systems provided ample opportunities for heavy snows, and several areas ended up above average for the month. Wolf Creek Pass reported nearly seven feet of snow with a water content of more than 6 inches. At the north end of the San Luis Valley, Saguache totaled a seemingly modest 1.25" but this was nearly 5 times the average for that dry, protected site. Other areas that ended the month wetter than average included most of the southern mountains and San Luis Valley, the northwest corner the state, the extreme southeast corner and most of the South Platte valley. The storms skipped across some areas, however, leaving sizeable portions of Colorado drier than average. Dry areas, compared to the 1961-1990 averages, included much of the central mountains, the northern Front Range and a large portion of the southeastern plains. Fowler reported just 0.04" for the month.

Temperature

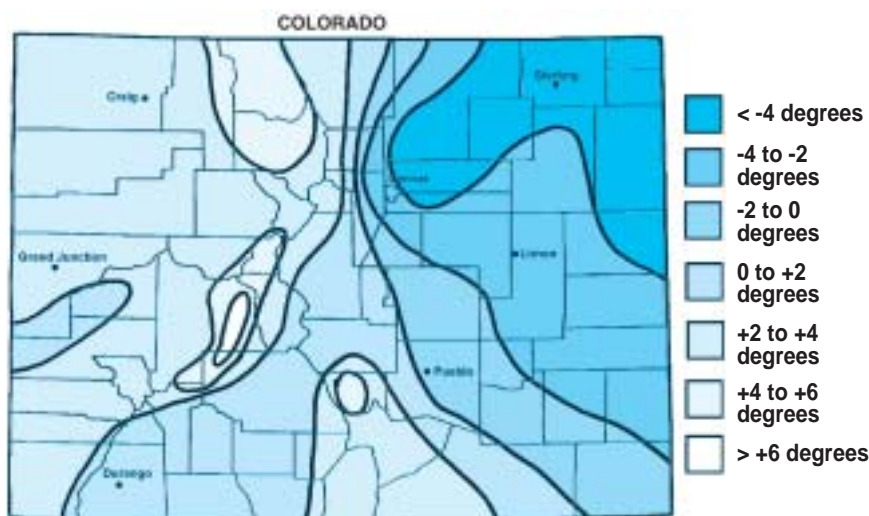
There were often significant temperature contrasts in February as cold, Canadian air masses kept northeastern Colorado well below average. Meanwhile moist Pacific air masses resulted in warmer than average readings in the mountains and western valleys for much of February. For the month as a whole, February temperatures ranged from as much as five degrees F below average over northeastern Colorado to four to six degrees F above average in the northern and central mountains. Taylor Park, Colorado's traditional "ice box" near Gunnison, only saw the thermometer dip below -10°F on 8 nights during the month, many fewer than usual.

February Daily Highlights:

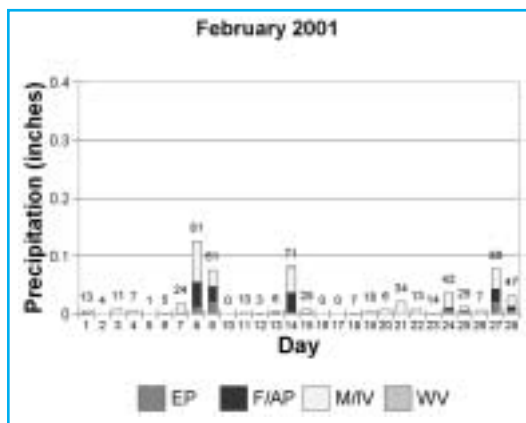
- 1-5 Strong northwesterly winds aloft over Colorado. Cold on the 1st, especially in the mountains with scattered light snow showers. Then gradually warmer with periods of strong winds along the Front Range with some gusts as high as 60 to 80 mph in wind prone areas. High temperatures by the 5th were in the 50s and 60s east of the mountains. A dry period for the state but scattered snow showers 1-4th in the northern and central mountains.
- 6-9 A shallow layer of cool moist air slipped into eastern Colorado on the 6th bringing low clouds and local fog, while a storm system began to gather over the western States. Arctic air reached northeastern Colorado on the 7th accompanied by dense fog and freezing drizzle. Meanwhile, western and southern Colorado enjoyed a warm but very windy day with valley temperatures in the 50s with some 60s in southeast Colorado. Snow began overnight in western Colorado, heaviest in the southwest. Temperatures dropped statewide. Highs were only in the teens on the 8th across northeast Colorado. Freezing drizzle gave way to dry, fluffy snow east of the mountains with 2-4" of snow over much of eastern Colorado but locally 6-12" from Evergreen southward to Trinidad. The storm rapidly crossed the Midwest on the 9th, but left very cold air behind over Colorado. The 9th brought the coldest morning of the winter to portions of Colorado with lows well below zero from the mountains eastward. The -33°F reading at Antero Reservoir was the coldest in the state.
- 10-16 The next low pressure system moved into place along the Pacific coast putting Colorado in mild southwesterly flow aloft. Meanwhile, shallow cold air circulating around a large high pressure area over the Great Lakes brought pulses of low clouds, fog and occasional freezing drizzle to eastern Colorado. Mostly sunny and cold over eastern Colorado on the 10th with some morning fog. Temperatures west of the mountains were warmer, and clouds increased during the day. Cold temperatures continued at high elevations on the 11th as an upper level disturbance brought clouds and a few snow showers. At lower elevations, a warming trend continued. Light rain began late in the day on the 13th at low elevations of western Colorado. At the same time, a strong cold front pushed into northeastern Colorado. Fog and freezing drizzle covered much of eastern Colorado on the 14th with temperatures only in the teens and 20s. Drizzle turned to snow over northeastern Colorado. Fort Morgan measured nearly 5" of powder light snow. Their morning low on the 15th dipped to -10°F. A little snow fell in the southern mountains on the 15th as the upper level low pressure system began moving eastward. This storm moved quickly eastward on the 16th, bringing behind it another shot of cold arctic air to eastern Colorado. High temperatures only reached into the 20s east of the mountains while temperatures reached the 40s under clear to partly cloudy skies over western Colorado.



February 2001 precipitation as a percent of 1961-1990 average.



February 2001 temperature departure from 1961-1990 average, degree F.



- 17-19 A dry and mild period for most of the state with some gusty westerly winds in the foothills. Some light snow reached the mountains on the 19th. Moist air still lingered near the ground across the eastern plains leading to periods of night and early morning fog. Highs were mostly in the 40s and 50s except for 30s in the high mountains and some 60s in southeast Colorado 18-19th.
- 20-22 Western Colorado was dry and mild on the 20th while east of the mountains chilly air circulating around a large high pressure area over the northern plains kept daytime temperatures in the low 30s with low clouds, fog and some freezing drizzle. A few hours of wet snows and valley rains dampened west central Colorado on the 21st as an upper level disturbance passed quickly. Crested Butte welcomed the 7" snowfall. Mild temperatures returned statewide on the 22nd with daytime readings mostly in the 40s and 50s except colder at very high elevations.
- 23-25 A potent looking storm developed west of Colorado early on the 23rd and tracked quickly eastward. Northeast Colorado had another bout with fog and local freezing drizzle on the 23rd. Winds and clouds increased as a deep low pressure area crossed southern Colorado early on the 24th. Colorado's southern mountains picked up a few inches of new snow, and some plains areas reported an inch or two of snow. But mostly it was a lot of bark and very little bite. The storm rapidly reached the Great Lakes early on the 25th leaving Colorado in mild westerly winds aloft.
- 26-28 February ended with a dose of wintry weather. An upper level low spun over California sending clouds and moisture into Colorado from the southwest. Nearly all of western Colorado received some precipitation, but most totals were very light. Once again, the heaviest precipitation fell over the southern mountains. A few inches of snow covered the San Luis Valley by the 28th, while Wolf Creek Pass added nearly two more feet of snow to their generous February total. Yet another surge of Canadian air pushed a shallow layer of cold, moist air up against the Rockies from the east. Fog, some freezing drizzle, and a dusting of snow accompanied the cold in eastern Colorado. Highs on the 27th were only in the teens and 20s east of the mountains. Holyoke enjoyed 6" of snow from the storm. Some clearing took place over northern Colorado on the 28th while southern parts of the state remained cloudy and cold with periods of snow.

February 2001 Monthly Extremes

Description	Station	Extreme	Date
Precipitation (day):	Wolf Creek Pass 1 E	1.60"	Feb 8
Precipitation (total):	Wolf Creek Pass 1 E	6.28"	
High Temperature:	LaJunta 20S	70°F	Feb 6
	Las Animas	70°F	Feb 7
	LaJunta 1S	70°F	Feb 8
Low Temperature:	Hohnholz Ranch	-38°F	Feb 9

March 2001

Climate in Perspective

March was damp and stormy with rapidly changing weather patterns all month. There were no monsoonal storms, but precipitation fell somewhere in the state practically every day during the month. Once again, mild Pacific air masses dominated Colorado's weather patterns, particular over the western half of the state. Fraser, for example, only had two nights with below zero temperatures all month.

Precipitation

One storm system after another crossed or neared Colorado during March. Only one, however, early in the month brought widespread moderate precipitation totals. All other storms brought more localized precipitation. As a result, monthly precipitation totals fell short of the 1961-1990 averages over much of the state. While there were a few local wet spots, the northern tier of counties in Colorado and most of western Colorado was below average for the month. Dry spots were also found in parts of southeastern and east central Colorado. The wettest areas, compared to average, were the high elevations of the central mountains, the San Luis Valley (which has been abnormally wet for the past several months), and scattered areas east of the mountains. Monte Vista's 1.25" March total may not sound like much but was more than three times the average.

Temperatures

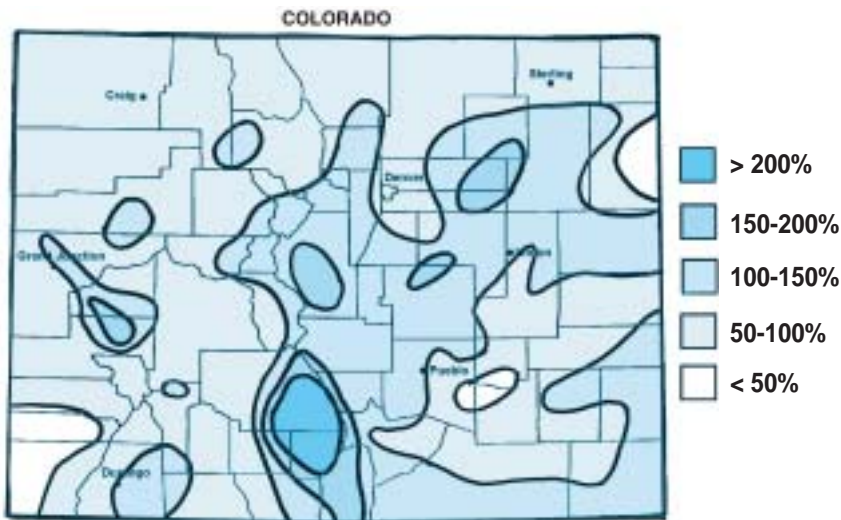
There were no unusual hot or cold temperatures or extremely abrupt changes observed during March 2001 in Colorado. For most of the state, temperatures for the month as a whole ended up two to five degrees F above average over the western half of the state. Over eastern Colorado, temperatures decreased from about two degrees F above average along the Front Range to slightly below the 30-year averages near the Kansas and Nebraska borders.

March Daily Highlights

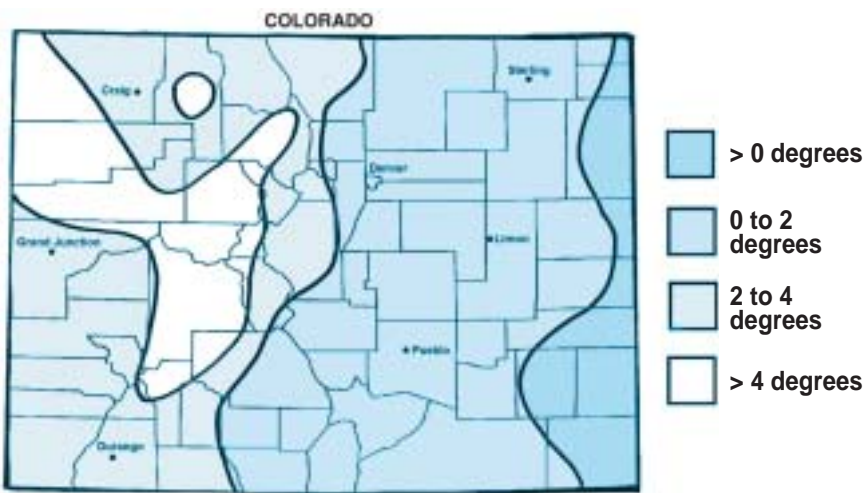
1-3 An upper level low pressure trough lingered over Colorado and gradually weakened. A little

snow fell near the mountains, especially on the 1st. Temperatures were chilly, especially over southern Colorado, but warmed nicely by the 3rd as sunshine increased.

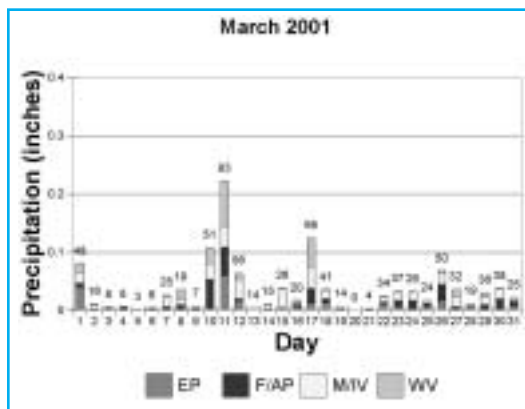
- 4-5 High pressure extended over the Rockies. Morning temperatures were cold in the mountain valleys. Taylor Park recorded -15°F on the 4th. But for most of the state temperatures were very mild. Clouds increased over western Colorado on the 5th.
- 6-8 A storm over southern California on the 6th passed just south of Colorado 7-8th. Valley rains and mountain snows began late on the 6th over southwestern Colorado and continued intermittently, ending early on the 8th. Southern counties of Colorado received significant precipitation totals. Durango, for example reported a storm total of 1.19" of rain and wet snow. Trinidad measured 0.33". Meanwhile, the rest of Colorado enjoyed dry and warm conditions with light winds. Skies cleared over much of the state on the 8th.
- 9-12 A new storm system brought welcome moisture to all of Colorado. An upper level low over the Pacific Northwest on the 9th dropped quickly into the 4-Corners area on the 10th and then crossed Colorado on the 11th. Temperatures were quite warm ahead of the storm on the 9th. Rains began late in the day over western Colorado. Temperatures dropped on the 10th, and snow developed over nearly all of Colorado. Three to eight inches of snow fell over most of eastern Colorado with heavier amounts in portions of the high country. Paonia picked up more than one inch of moisture from the storm. Vail picked up a foot of new snow in town. Wet snow with nearly an inch of water equivalent improved soil moisture in the wheat growing areas from Akron and Yuma to north of Eckley. Temperatures warmed and strong winds of up to 75 mph developed along the Front Range north of Denver on the 12th as the storm moved eastward.
- 13-15 Mild and dry on the 13th, but another storm system soon took aim on Colorado, from the northwest. Strong winds accompanied the storm on the 14th as the northern and central mountains were hit with a quick 4-8 inches of snow. Other areas recorded blustery winds and cooler temperatures 14-15th, but little moisture fell elsewhere.
- 16-18 The progression of storms continued as another system dropped down from the northwest. Much of the state reported some snow from this storm, but the heaviest snows fell on the 17th across southern Colorado. Salida and Buena Vista, where storms often skip over, each reported 6 inches of fresh snow. Moisture of



March 2001 precipitation as a percent of the 1961-1990 average.



March 2001 temperature departure from 1961-1990 average, degree F.



- 0.42" fell on Las Animas in the form of snow that quickly melted. Conditions improved on the 18th, but some mountain snow showers continued as winds increased out of the northwest.
- 19-22 A break from the storm weather. Sunny and dry statewide on the 19th. Some increase in clouds 20-22nd but very warm with daytime temperatures in the 60s and 70s at lower elevations and even some low 50s in the mountains. A few scattered showers and maybe a rumble or two of thunder 21-22nd as Pacific moisture arrived on westerly winds aloft.
- 23-26 Mild and dry over western Colorado 23-25th, but a large pool of cold air arrived in eastern Colorado on the 23rd accompanied by low clouds, fog, freezing drizzle and eventually snow. Some convective snow bursts developed on the 25th, some with lightning and thunder. Boulder got a quick 3" of snow in 40 minutes. Several areas in the mountains experienced a period of wet snow on the 26th.
- 27-31 Strong northwesterly winds aloft carried a series of short waves across Colorado. More fog and drizzle east of the mountains on the 27th. Unsettled for the remainder of the month with cool temperatures and scattered rain and snow each day. Most showers were light, but some moderate amounts were reported. Walsenburg, for example, got 0.42" of water equivalent precipitation on the 30th. Close to six inches of new snow were measured near Virginia Dale (near the Wyoming border in north central Colorado) on the morning of the 31st.

March 2001 Monthly Extremes

Description	Station	Extreme	Date
Precipitation (day):	Wolf Creek Pass 1 E	1.23"	Mar 17
Precipitation (total):	Wolf Creek Pass 1 E	3.99"	
High Temperature:	Camps 7 S	79°F	Mar 22
Low Temperature:	Taylor Park	-15°F	Mar 4

2001 Water Year to Date: October 2000 through March 2001

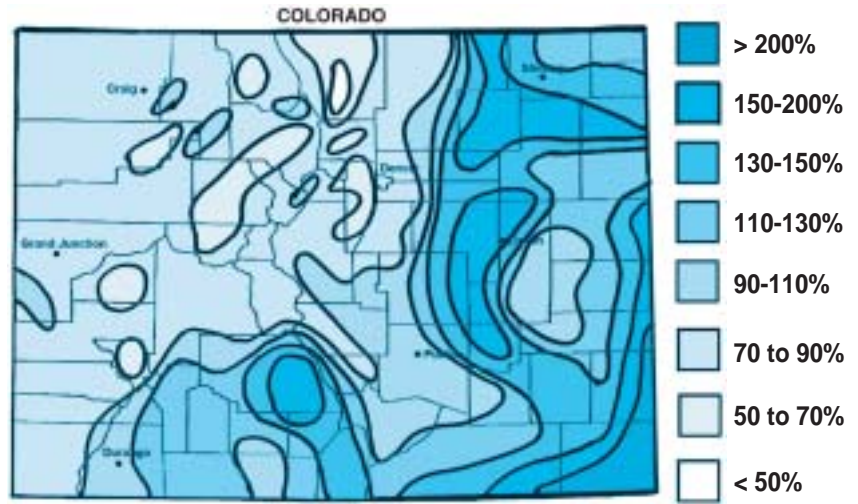
Many storms, but still poor snow accumulations in the mountains.

Each of the past three months brought numerous opportunities for precipitation. Each month, January through March, precipitation totals exceeded the 1961-1990 averages over sizeable areas of Colorado. But each month also saw significant areas of the state skirted by the storms. In general southern parts of the state ended up wetter than average while northwestern and north central Colorado lagged below average. The San Luis Valley, normally the driest region of Colorado, received much above average precipitation in each month. Saguache, for example, received more than 3 times their average January through March precipitation.

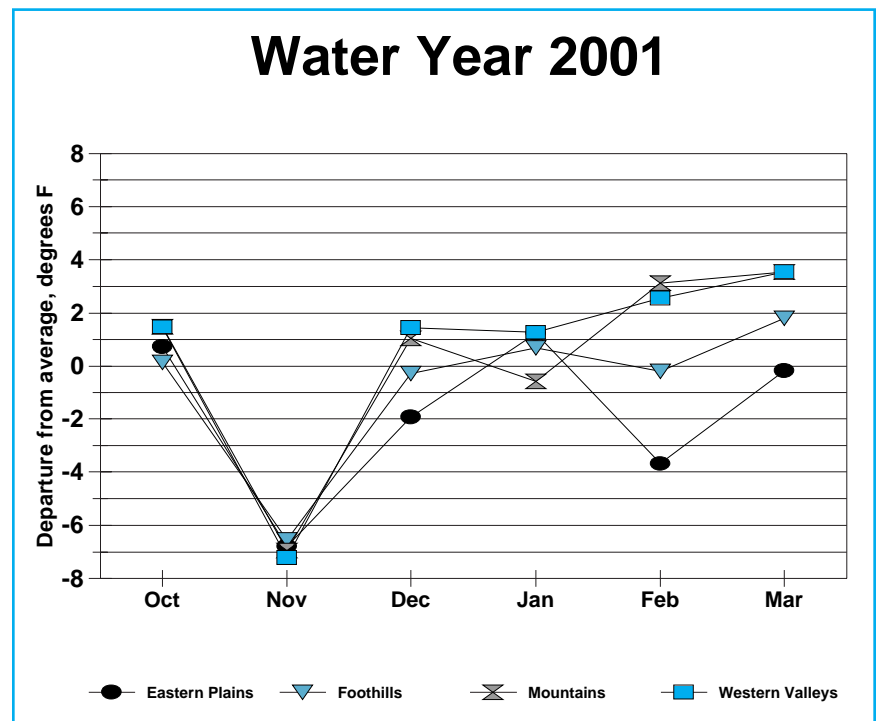
The resulting precipitation pattern for the first six months of the 2001 water year showed much above average precipitation totals over most of eastern Colorado, the San Luis Valley, the Sangre de Cristo Mountains and the southern and eastern slopes of Colorado's southwestern mountains. Several areas of eastern Colorado including Limon, Fort Morgan, Yuma, Burlington, La Junta and Holly have accumulated more the 150% of average. Saguache has totaled nearly double their October-March average. Farmers from across eastern Colorado have been more than happy to accept this winter moisture following the very hot, dry weather of the previous spring and summer.

For other parts of the state, unfortunately, the news has not been so good. Nearly all of north central and western Colorado is below average with several areas such as Ridgeway, Cedaredge, Paonia, Steamboat Springs and Kremmling receiving less than 70% of average for the primary snow accumulation season. The Front Range from Fort Collins to Walsenburg is also drier than average. Estes Park has only received 43% of their October through March average while Evergreen reported 65% of average. The Front Range foothills, already very dry from last year and so far missing the brunt of most winter storms, will dry out very quickly this spring after such a dry winter. Fortunately, April and May can be very wet in these areas, so it is too soon to predict another severe wild fire season.

Temperature patterns with respect to historical averages are shown here for the first half of the 2001 Water Year. After the extremely cold month of November, temperatures have been tending on the mild side.



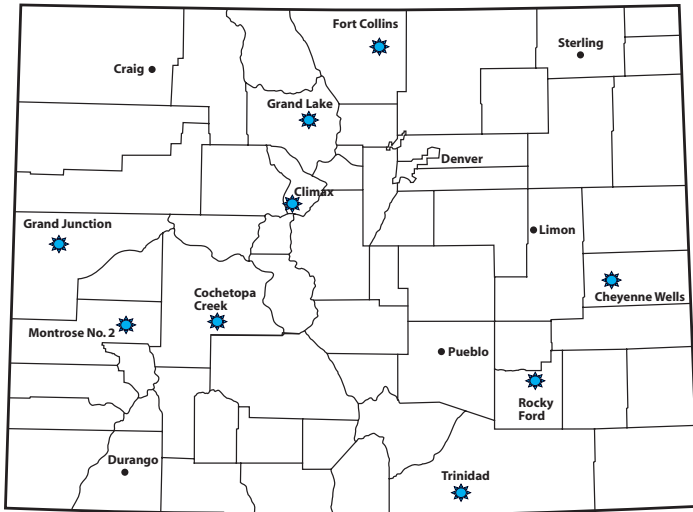
Water Year 2001 (October 2000 through March 2001) as a percent of the 1961-1990 average.



While not nearly as warm as some recent winters, the tendency for above average temperatures is not good news for Colorado's water supplies. Above average temperatures usually mean that more of Colorado's low and mid-elevation snowpack will melt and evaporate, therefore not contributing to the spring snowmelt and summer water supplies.

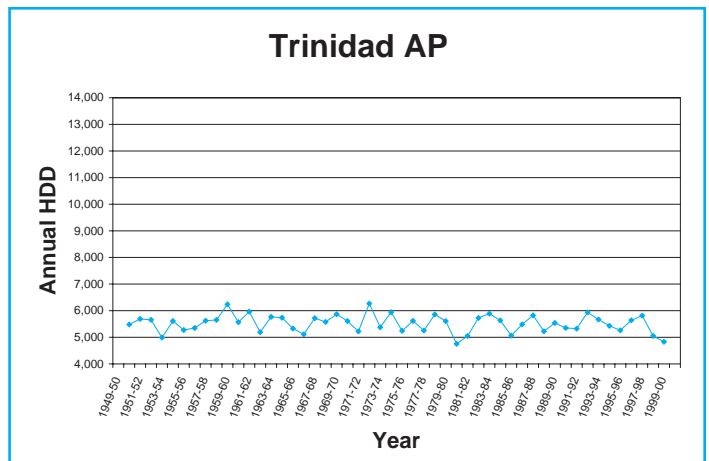
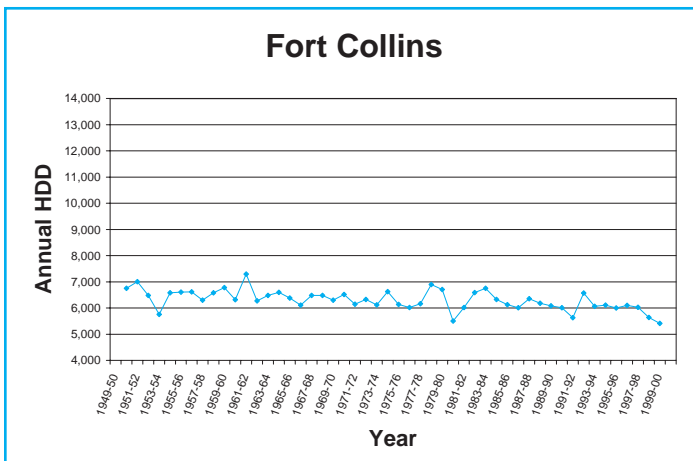
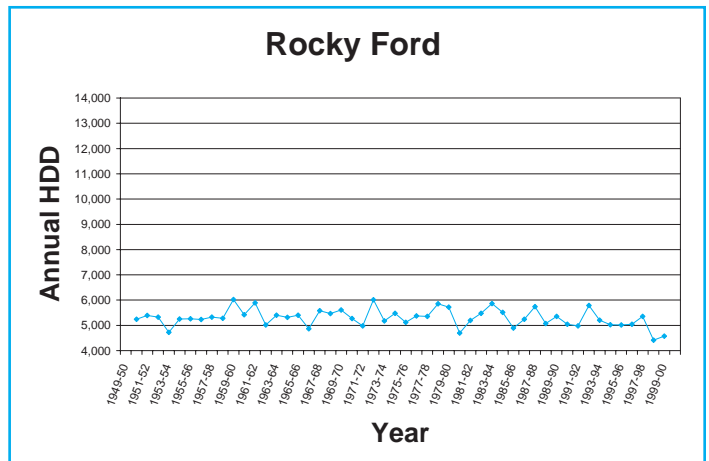
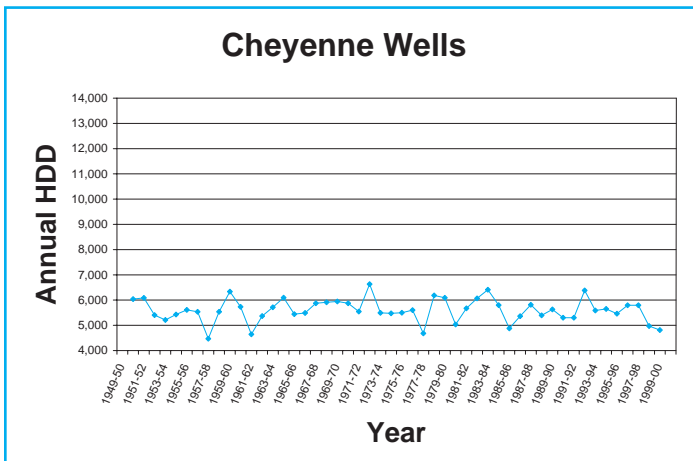
A Time for Time Series – Heating Degree Days

Nolan Doesken



A few months ago (Vol. 1, No. 4) we discussed heating degree days, a simple way to relate daily high and low temperatures to the amount of energy needed for heating our homes, schools and businesses. I thought it would be interesting to take a look at heating degree day totals for the past 50 years (1951-2000) at a number of sites in Colorado. The most recent heating season (2000-2001) is not included since this year was still in progress as we conducted this study.

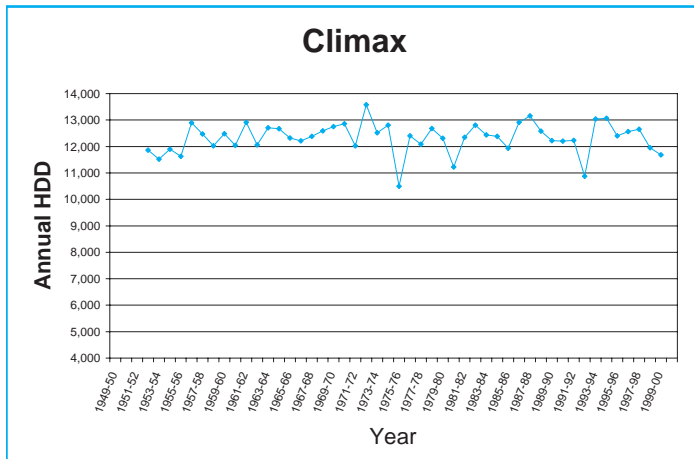
I think many of us have the perception that winters have been warmer lately. If this is true, we should be seeing a reduction in heating degree day totals. Let's take a look at some data. Here are a set of 50-year time series of total seasonal (July-June) heating degree day totals for four stations east of the mountains (Fort Collins, Trinidad, Rocky Ford and Cheyenne Wells), one station on the crest of the continental Divide at an elevation of 11,320 feet (Climax), two stations in high mountain valleys (Grand Lake and Cochetopa Creek near Gunnison), and two stations on the Western Slope (Montrose and Grand Junction). These 9 stations may not represent the largest cities in Colorado,



but they are each weather stations that have remained at or near the same location for the past 50 years with few changes in instruments, procedures, or observation times. Including data from places like Denver or Crested Butte where the weather station has been moved several

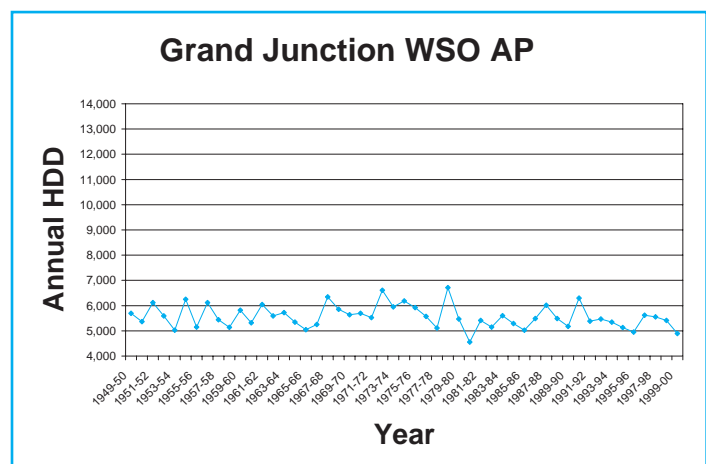
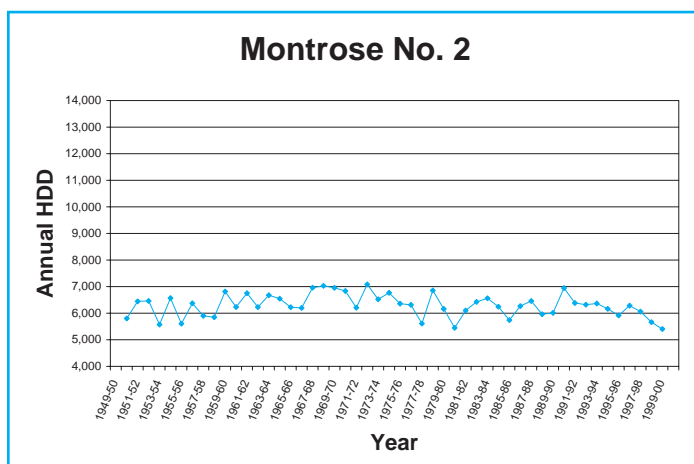
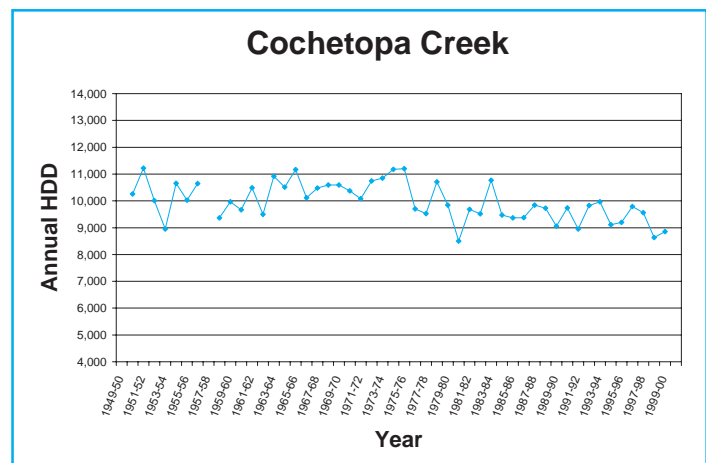
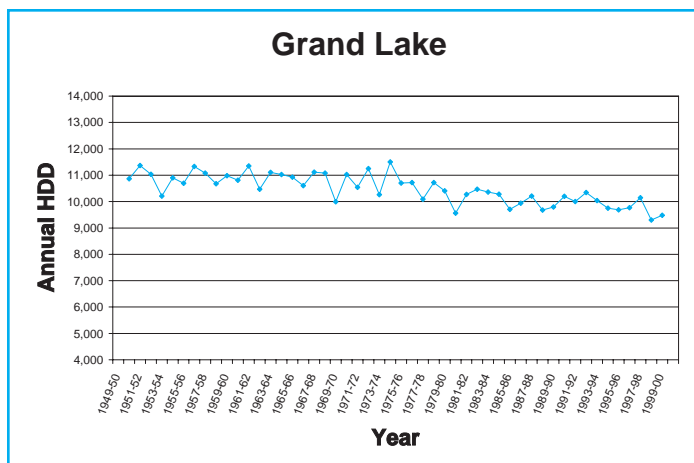
times introduces artificial changes that don't help us answer our question.

As the table shows, seasonal heating degree day totals vary greatly from an average of 5,205 per season at Rocky Ford to more than 12,000 per season up at Climax. Elevation is not the only factor controlling annual heating degree day totals, but it is clearly an important one.

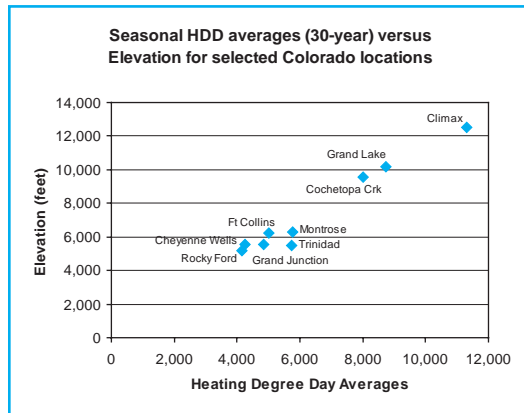


Station	Elevation Feet	1971- 2000 Average	Heating Season Extremes 1951-2000	
			Maximum	Minimum
Cheyenne Wells	4,250	5,535	6,633	4,625
Climax	11,320	12,517	13,578	10,498
Cochetopa Creek	8,000	9,557	11,217	8,501
Fort Collins	5,004	6,238	7,296	5,413
Grand Junction	4,858	5,552	6,713	4,557
Grand Lake 1NW	8,720	10,182	11,501	9,302
Montrose	5,785	6,320	7,083	5,403
Rocky Ford	4,170	5,205	6,026	4,312
Trinidad	5,746	5,512	6,267	4,754

(continued on page 18)



A Time for Time Series *(continued from page 17)*



As we look at the nine time series graphs, we note that there are year-to-year variations in heating degree day totals, but the differences are not dramatic. Heating degree day totals for most seasons are within $\pm 10\%$ of the long-term average. Precipitation and snowfall may vary widely (sometimes by 50-100%) from one year to the next, while seasonal heating degree day totals are more steady and predictable. But close examination of these selected stations does show what appears to be a downward trend at several stations. A downward trend suggests warmer winter temperatures and less energy required for maintaining comfortable indoor temperatures in a home or office, assuming all other conditions remain unchanged.

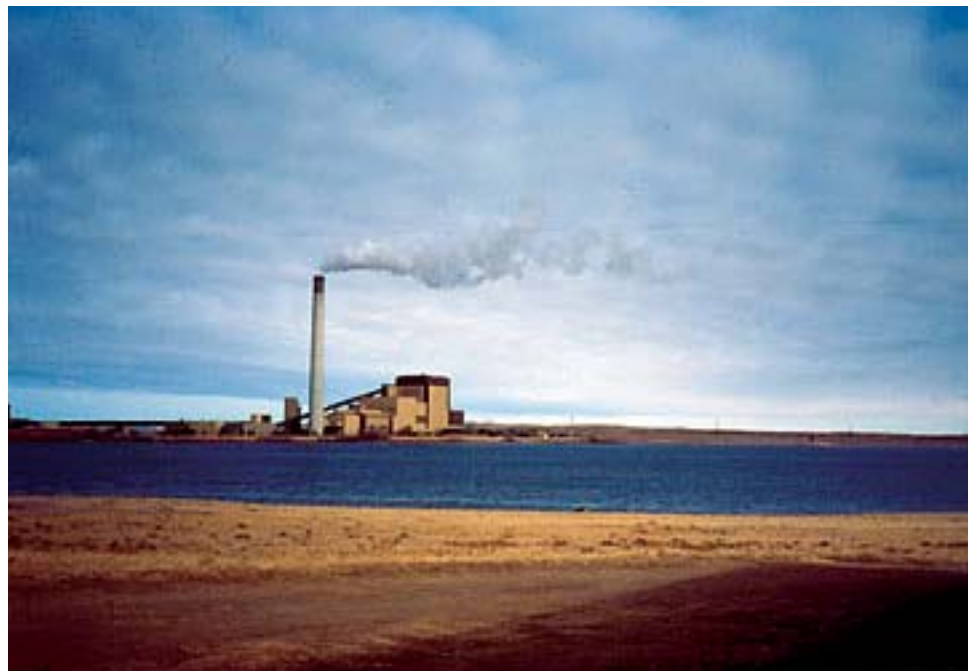
The smallest trend is noted at Climax, the highest elevation site in this comparison, where no appreciable long-term changes are evident from these data. The

largest trend (decreasing number of heating degree days per heating season) appears to be in the high mountain valleys where both Grand Lake and Cochetopa Creek show a 50-year decrease of approximately 20 heating degree days per year using linear regression. Fort Collins also shows a significant decrease over time, but much of this change has been attributed to the significant urbanization in the areas surrounding Colorado State University's historic weather station. Rocky Ford, which also has over 110 years of continuous data shows a much smaller change.

What does stand out at all stations are the two consecutive seasons with very low heating degree day totals; the 1998-99 the 1999-2000 heating seasons. Historically, warm heating seasons have tended to come as isolated events followed immediately by a cooler season. These recent years were the exception. Preliminary data for the 2000-2001 season indicate that totals returned to near the long-term average and did not continue the pattern of the previous two very mild winters. Most of us enjoyed those two mild winters with the associated low energy costs. This past winter (2000-2001) shocked both our bodies and our bank accounts as colder temperatures and higher fuel costs gave us the double whammy.

Trends are fun to look at, and sometimes help us anticipate the future. Speculation continues whether "Global Warming" will lead to a continuation of a downward trend. We will undoubtedly talk about this more in the future, as we continue to monitor our fascinating climate.

*Rawhide Power Plant.
Photo courtesy Clara Chaffin. Climatologists aren't the only ones interested in temperature trends. Climate variations affect the demand for gas and electricity and subsequently affect all of us in our "pocket books."*



Climate on the Web – The National Weather Service

Nolan Doesken

If you're a regular to the Internet and you're reading this magazine, most likely you spend some time now and then checking out weather and climate information on the Web. A common place to browse for weather information, such as weather forecasts, severe weather warnings, satellite pictures and radar maps is the National Weather Service (NWS). Each of the 122 local forecast offices across the country has their own Web pages. Here in Colorado, we have Denver/Boulder (Den/Bou), Grand Junction (GJT), Pueblo (PUB), and Goodland, KS (GLD) office puts out weather information for eastern Colorado. You don't have to turn on the radio and wade through minutes of music or tons of talk show gibberish just to hear a 4-hour old forecast. Now, any time you have the time, you can check out the current weather conditions at airport weather stations across Colorado or around the world. You can read the latest weather forecast minutes after the forecaster issues the latest update. If you don't mind a bunch of weather forecaster jargon, you can even read the forecast discussion. This is the forecaster's personal analysis of what's going on,

what the computer models have to say, and where the forecast might go wrong. This is my favorite – one of the few weather places on the web where you can actually hear the forecasters hemming, hawing and making their decisions.

Most folks go to NWS websites to get current conditions, road reports, severe weather statements, and short or medium range (next few days) weather forecasts. But did you know there is a lot of climatology at some NWS websites. Below are a few examples of what we found at some Colorado NWS websites:

- Climate archives of monthly data
- On this day in the past
- Normals, means and extremes
- Climate descriptions
- Weather highlights of the 1900s
- Historical monthly top 10 statistics
- Monthly snowfall and precipitation maps
- And much, much more!

If you are thirsty for weather information, visit the NWS website at <http://www.nws.noaa.gov>.



<http://www.nws.noaa.gov>

What Is the Wettest Month in Colorado?

Nolan Doesken

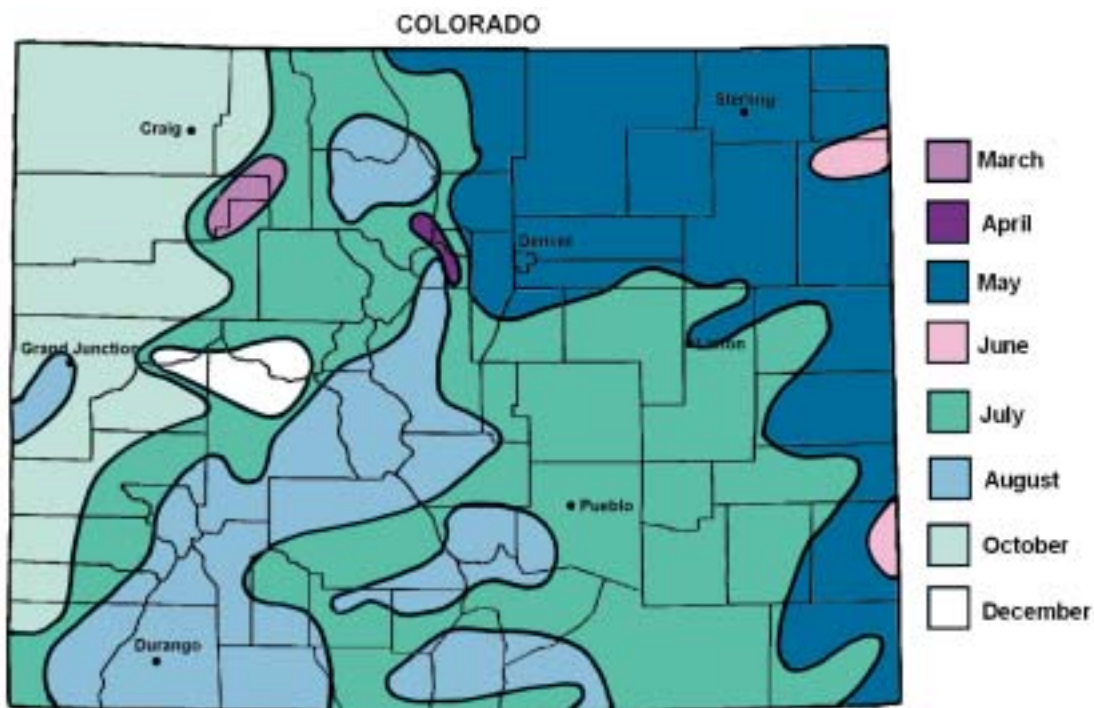
Something that is truly unique about Colorado's climate compared to other parts of north America is the variety of seasonal precipitation patterns that occur here. Almost anywhere in the country, certain seasons are wetter than others, but here in Colorado seasonal difference can be very profound and are very different from one part of the state to another.

Based on 1961-1990 data (we'll be updating to 1971-2000 soon), we examined each of over 200 weather stations in Colorado and identified which month during that 3-decade period received the most precipitation. Then, we plotted those results on a map. The results are fascinating. Overall, July is the wettest month statewide although you wouldn't know by looking at vegetation. Since July is also the hottest month of the year, most of that precipitation evaporates quickly leaving dry soil and drying vegetation.

Many other months are locally the wettest month of the year. For example, March is the wettest month of the year in some mountain locations. A few small areas of the higher eastern foothills of the Rockies get their largest precipitation totals in April. Along

the Front Range and into northeastern Colorado, May reigns as the wettest month while in a small portion of extreme northeastern Colorado, June is number one. As you go farther south in Colorado closer to the influences of the Mexican and Southwest U.S. summer monsoon, August stands out as the wettest month, while September and even October come out on top over portions of the Colorado Plateau near Utah. There are even a few local areas in northwestern Colorado where November competes for the wettest month. Our data set here includes few high mountain stations, but at elevations above 10,000 feet, mid winter (December or January) tends to compete with March for being the wettest month. There might even be a few places where February would come close, but it just doesn't have enough days.

We are currently working on a similar analysis for the driest month of the year and will show this in a future issue. It will also be interesting to see if updating the data to 1971-2000 will have any effect. Precipitation is one of our most highly variable climate elements, so anything could happen.



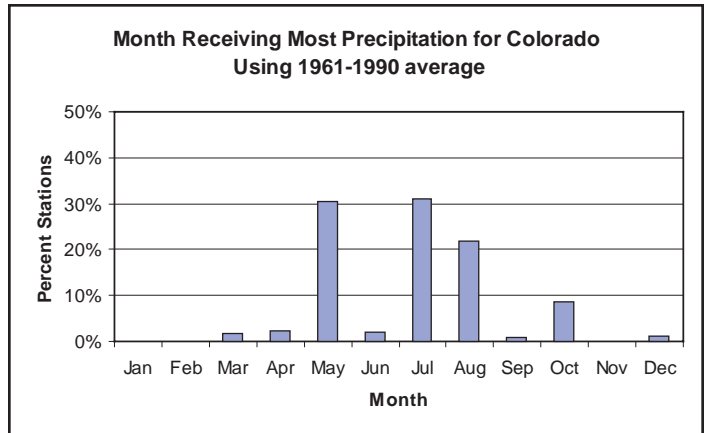
Wettest month of the year based on average monthly precipitation totals for the 1961-1990 period.



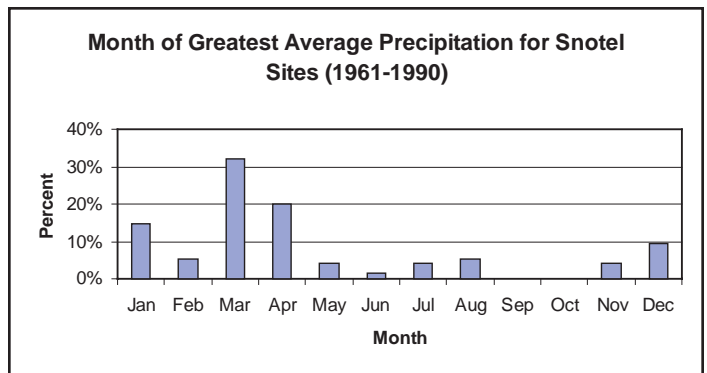
Thunderstorm approaching Fort Collins, CO. May is traditionally the wettest month of the year for much of northeastern Colorado.



Deep winter snow in the mountains near Steamboat Springs, CO. Art Judson, shown on cross country skis, is a long-time Colorado snow scientist and author of many publications about snow. He retired to Steamboat Springs, where heavy midwinter snows are common.



Percent of Colorado experiencing their wettest month of the year for NWS cooperative weather stations (top graph) and snotel sites (bottom graph). SNOTEL stations are all in the mountains at elevations above 8,000 feet and most approximately 11,000 feet.





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