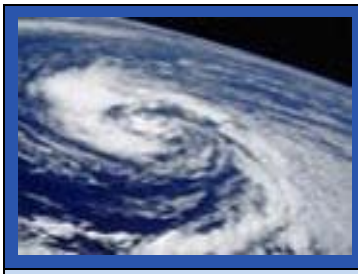


The Weather Wire

July 2012 Volume 19 Number 7

Contents:

Summer Monsoon

In Colorado the word monsoon is used by many to describe heavy, flooding rainfall from slow moving thunderstorms. The heavy rain and thunderstorms are actually a byproduct of a larger scale weather patter change called a monsoon. The word monsoon describes a seasonal wind shift created by uneven heating of the land versus larger bodies of water like an ocean. The "monsoon season" here in Colorado typically begins in the first or second week of July and comes to an end by the first or second week of September. The thunderstorms during the month of July and August are fueled by subtropical moisture drawn northward from the south. Moisture from both the Gulf of California and the Gulf of Mexico can be imported into the state providing the necessary fuel(moisture) for daytime heat driven thunderstorms. The NWS in Tucson, AZ has devoted many links for monsoon information:

http://www.wrh.noaa.gov/twc/monsoon/monsoon_tracker.php

Below is some of the interesting information that can be found there.

What is a Monsoon?

The word monsoon is derived from the Arabic word *mausim,* which means season. Traders plying the waters off the Arabian and Indian coasts noted for centuries that dry northeast winds in the winter suddenly turn to the southwest during the summer, and bring beneficial yet torrential rains to the Asian subcontinent. We now know that these large scale wind shifts, from dry desert areas to moist tropical areas, occur in other parts of the Earth, including the Oceanic subcontinent, Southeast Asia, Australia, North America, Africa and South America.

These wind shifts, and the dramatic change in weather they bring, are all more or less driven by a similar mechanism. For much of the year, low level winds in dry subtropical regions tend to blow from the land toward the sea. However by late spring, strong solar heating causes temperatures to soar over these land areas. The intense heat causes surface air pressure to fall, forming an area of low pressure known as a

thermal low. Adjacent large bodies of water are also warmed, but not as quickly. Thus air pressures remain high relative to the land. Eventually, the pressure difference increases to the point that the cooler and much more humid air over the ocean is drawn toward the hot, dry air over land. This moist air moving onto the hot land eventually becomes unstable and develops into thunderstorms. Once this occurs and rain begins to fall, humidity levels increase over land, which only triggers more thunderstorms. This cycle will continue until land areas begin to cool in the early fall and water temperatures reach their peak in early fall. This reduces the pressure difference, which in turn causes the moist onshore flow to diminish, and the monsoon gradually ends. Full version with graphics from NWS can be found here:

http://www.wrh.noaa.gov/twc/monsoon/monsoon_whatis.php

The North American or SW Monsoon

Until the late 1970s, there was serious debate about whether a monsoon truly existed in North America. However, considerable research, which culminated in the Southwest Arizona Monsoon Project (SWAMP) in 1990 and 1993, established the fact that a bonafide monsoon, characterized by large-scale wind and rainfall shifts in the summer, develops over much of Mexico and the intermountain region of the U.S. Published papers at the time called this pattern by different names, including the "Summer Thunderstorm Season," The Mexican Monsoon," "The Southwest Monsoon," and the "Arizona Monsoon."

In 2004, a major multinational research project was conducted in northwest Mexico and the southwest U.S. The North American Monsoon Experiment (NAME) sought to better describe the monsoon in North America, and increase our ability to predict it on a daily, weekly and seasonal basis. NAME showed that despite its many names, the weather pattern we see during the summer is not only a true monsoon, but it also affects the weather over a large portion of North America. Thus the generally accepted name is now "North American Monsoon."

The North American Monsoon is not as strong or persistent as its Indian counterpart, mainly because the Mexican Pleateau is not as high or as large as the Tibetan Plateau in Asia. However, the North American Monsoon shares most of the basic characteristics of its Indian counterpart. There is a shift in wind patterns in summer which occurs as Mexico and the southwest U.S. warm under intense solar heating. As this happens, the flow reverses from dry land areas to moist ocean areas. In the North American Monsoon, the low level moisture is transported primarily from the Gulf of California and eastern Pacific. The Gulf of California, a narrow body of water surrounded by mountains, is particularly important for low-level moisture transport into Arizona and Sonora. Upper level moisture is also transported into the region, mainly from the Gulf of Mexico by easterly winds aloft. Once the forests of the Sierra Madre Occidental green up from the initial monsoon rains, evaporation and plant transpiration can add additional moisture to the atmosphere which will then flow into Arizona. Finally, if the southern Plains of the U.S. are unusually wet and green during the early summer months, that area can also serve as a moisture source. This combination causes a distinct rainy season over large portions of western North America, which develops rather quickly and sometimes dramatically.

Rainfall during the monsoon is not continuous. It varies considerably, depending on a variety of factors. There are usually distinct “burst” periods of heavy rain during the monsoon, and “break” periods with little or no rain. Monsoon precipitation, however, accounts for a substantial portion of annual precipitation in northwest Mexico and the Southwest U.S. Most of these areas receive over half their annual precipitation from the monsoon. The North American Monsoon circulation pattern typically develops in late May or early June over southwest Mexico. By mid to late summer, thunderstorms increase over the “core” region of the southwest U.S. and northwest Mexico, including the U.S. and Mexican states of Arizona, New Mexico, Sonora, Chihuahua, Sinaloa and Durango. The monsoon typically arrives in mid to late June over northwest Mexico, and early July over the southwest U.S. Once the monsoon is underway, mountain ranges, including the Sierra Madre Occidental and the Mogollon Rim provide a focusing mechanism for the daily development of thunderstorms. Thus much of the monsoon rainfall occurs in mountainous terrain. For example, monsoon rainfall in the Sierra Madre Occidental typically ranges from 10 to 15 inches. Since the southwest U.S. is at the northern fringe of the monsoon, precipitation is less and tends to be more variable. Areas further west of the core monsoon region, namely California and Baja California, typically receive only spotty monsoon-related rainfall. In those areas, the intense solar heating isn’t strong enough to overcome a continual supply of cold water from the North Pacific Ocean moving down the west coast of North America. Winds do turn toward the land in these areas, but the cool moist air actually stabilizes the atmosphere.
In addition to the lower level monsoon circulation, an upper level monsoon (or subtropical) ridge develops over the southern High Plains and northern Mexico. In June, this ridge is too far south over Mexico and actually blocks deep moisture from moving north into Arizona. However by late June or early July, this ridge shifts north into the southern Plains or southern Rockies. As this shift takes place, mid and upper level moisture streams into Arizona, and low level moisture surges from Mexico meet less resistance.

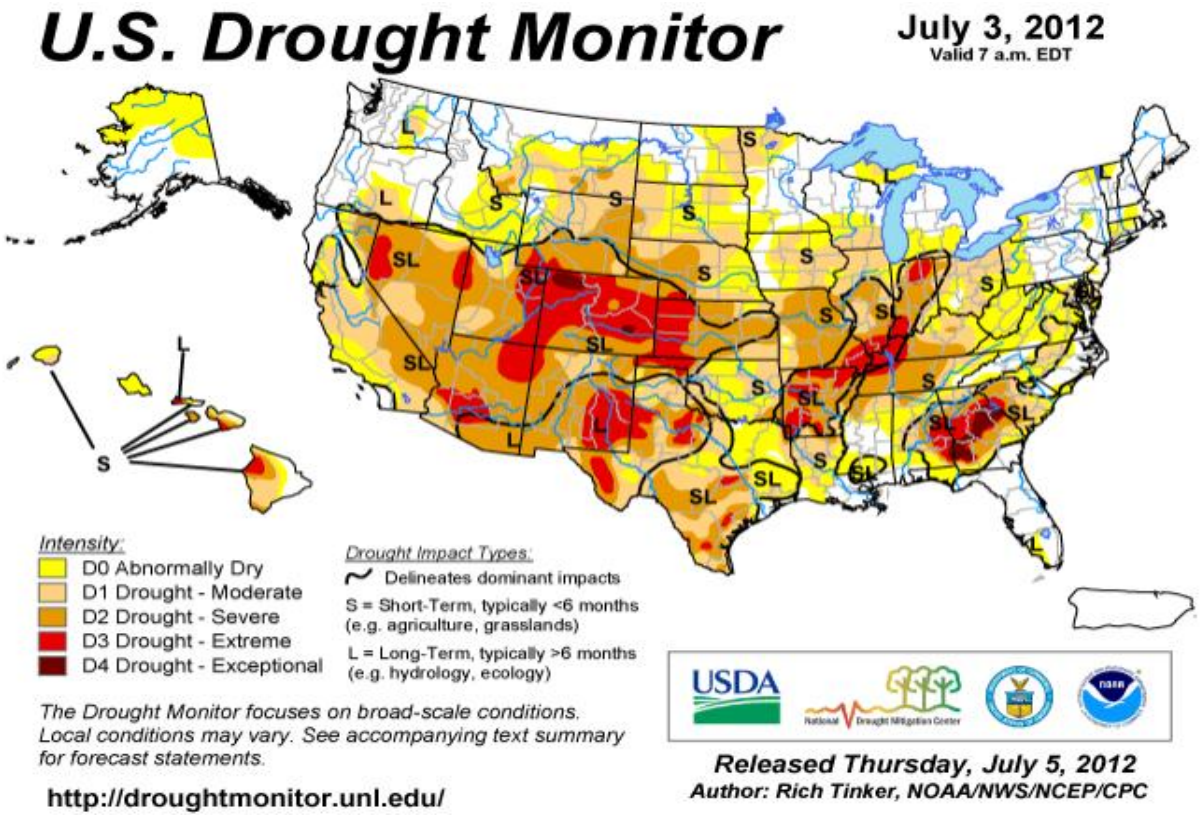
This monsoon ridge is almost as strong as the one which develops over Asia during the summer. However, since the lower level moisture flow is not as persistent as in the Indian monsoon, the upper level steering pattern and disturbances around the ridge are critical for influencing where thunderstorms develop on any given day. The exact strength and position of the subtropical ridge also governs how far north the tropical easterly winds aloft can spread. If the ridge is too close to a particular area, the sinking air at its center suppresses thunderstorms and can result in a significant monsoon “break.” If the ridge is too far away or too weak, the east winds around the high are inadequate to bring tropical moisture into the mountains of Mexico and southwest U.S. However, if the ridge sets up in a few key locations, widespread and potentially severe thunderstorms can develop.

It is important to note that the monsoon is not an individual thunderstorm. While the word “monsoon” accurately conjures up images of torrential rains and flooding, calling a single thunderstorm a “monsoon” is incorrect. A monsoon is a large scale weather pattern which *causes* our summer thunderstorms. Full version with graphics from NWS can be found here:

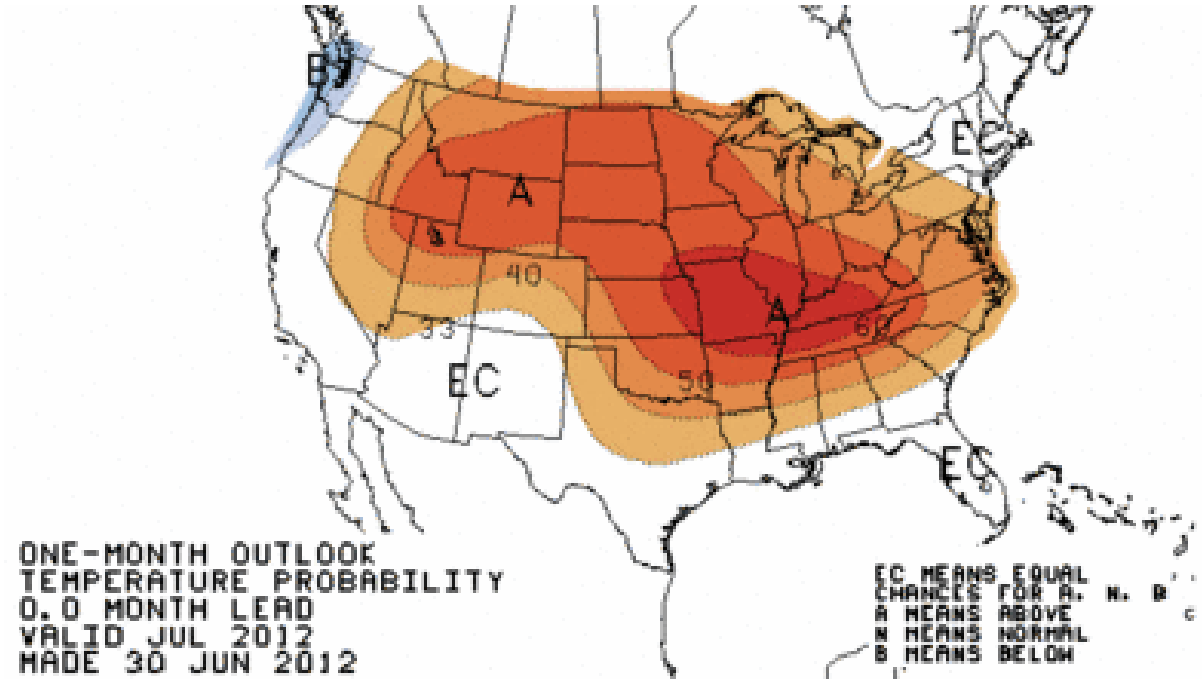
http://www.wrh.noaa.gov/twc/monsoon/monsoon_NA.php

Drought Update

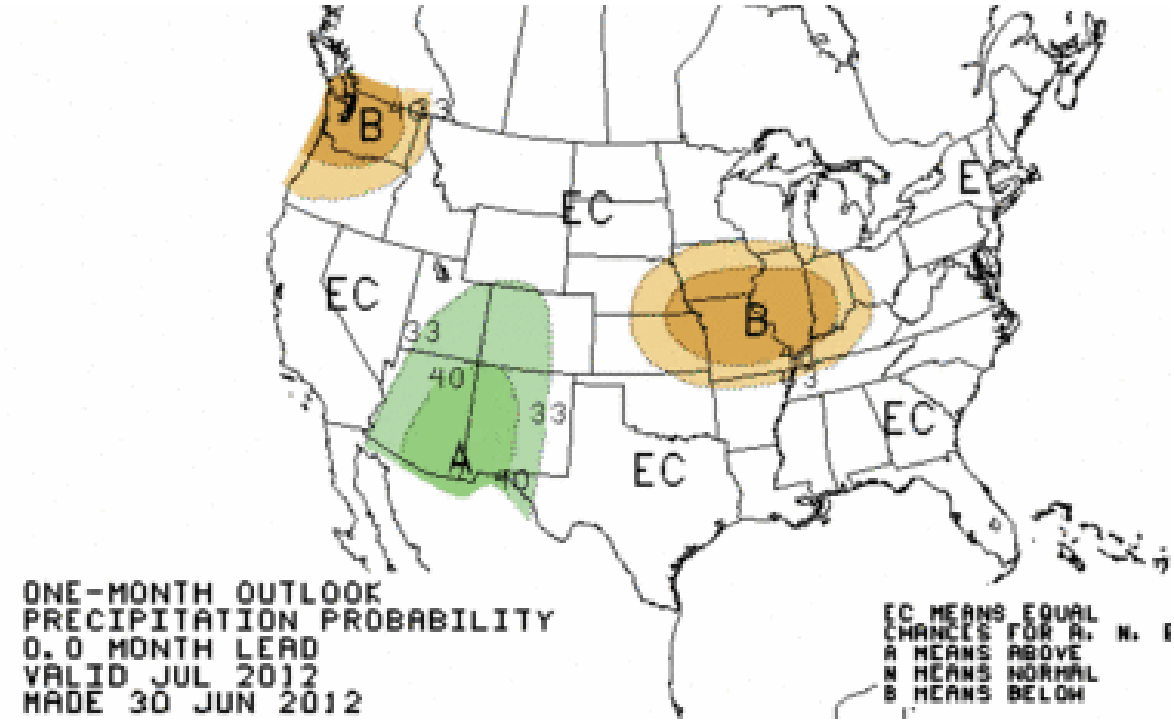
Above normal heat and below normal precipitation through the month of June has resulted in extreme drought developing over the Front Range and eastern plains. Drought has become exceptional over NW Colorado.



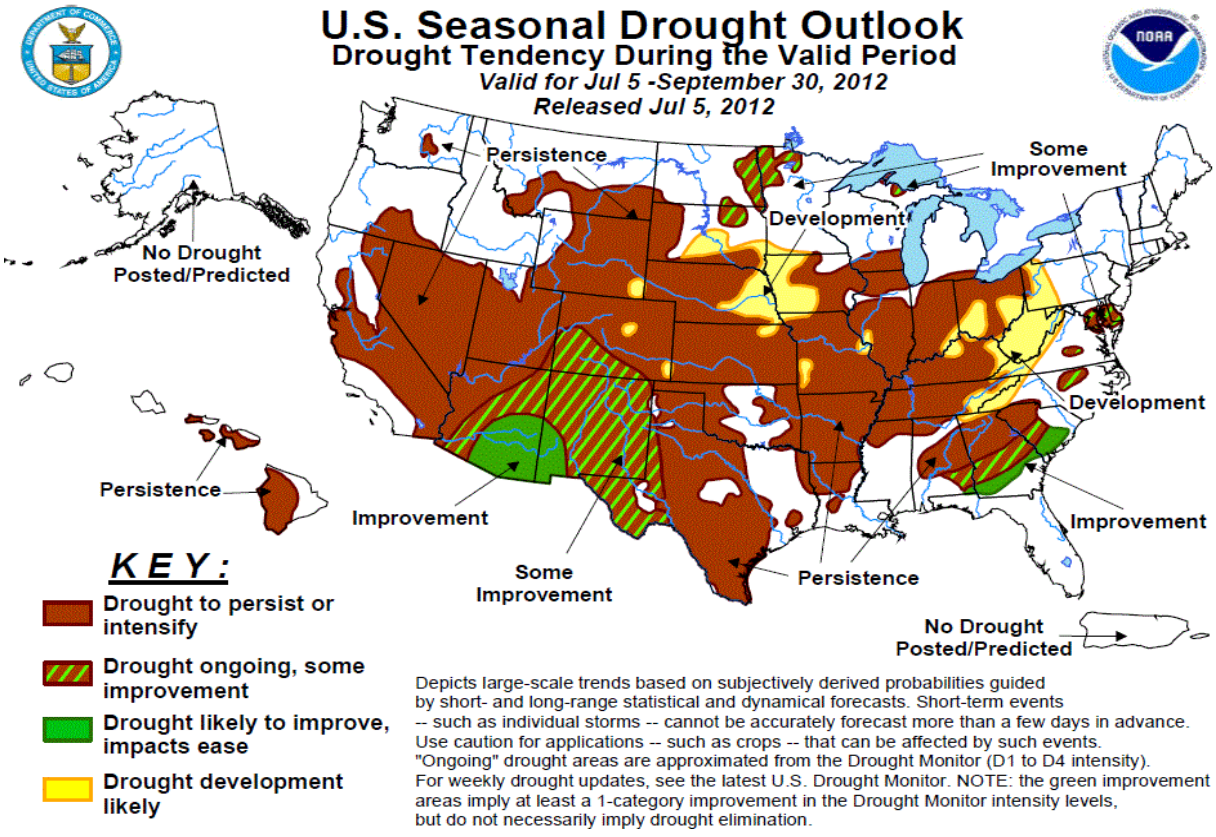
The map below shows forecasted temperature deviances for July 2012. Above normal temperatures are expected to continue in July with near normal temperatures in southern Colorado.



The map below shows forecasted precipitation deviances for July 2012. Normal to above normal precipitation is expected over Colorado which will likely bring some relief for the severe drought conditions that have developed this spring.



Drought conditions are expected to persist with some improvement over isolated areas of the state that pick up beneficial rains from thunderstorms.



June Summary

If you though June of 2012 was abnormally hot and dry you were absolutely right! June of 2012 is now the warmest June in Denver History. Many areas such as Castle Rock and Colorado Springs that can go many years without touching 100 degrees not only touched it but warmed into the lower 100's. Denver tied the ALL TIME RECORD HIGH of 105 not just once but twice on back to back days on the 25th and 26th. In all there were 7 new daily temperature records set and a stretch of 5 days with 100 degree or more heat. The 5 day stretch of 100 degree heat was only the 3rd time this has occurred in Denver history and the only time this has happened during the month of June. The average high for the month was 91.7 degrees more than 9 degrees above normal. The average low was 58.4 degrees which was around 6 degrees above normal. There were 17 days during the month with temperatures of 90 degrees or more. The heat combined with below normal precipitation has resulted in drought conditions becoming worse for many areas. There were numerous days when the air filled with smoke from all the fires burning as strong winds helped to fan flames all across not only Colorado but surrounding states as well. For the month there was 1.22" of rainfall measured at DIA which is 0.76" below normal and now puts the yearly total at only 4.81", 2.63" below the normal of 7.44". All of the measureable rain fell on the 6th and 7th with no precipitation greater than a trace reported the other days in the month. Average relativity for the month was only 33% which indicates how dry the air mass was over the state.

June Stats

TEMPERATURE (IN DEGREES F)

AVERAGE MAX	91.7	NORMAL	82.4	DEPARTURE 9.3
AVERAGE MIN	58.4	NORMAL	52.3	DEPARTURE 6.1
MONTHLY MEAN	75.0	NORMAL	67.4	DEPARTURE 7.6
HIGHEST	105 on the 25th and 26th			
LOWEST	43 on the 11th			

DAYS WITH MAX 90 OR ABOVE	17	NORMAL	8
DAYS WITH MAX 32 OR BELOW	0	NORMAL	0
DAYS WITH MIN 32 OR BELOW	0	NORMAL	0
DAYS WITH MIN ZERO OR BELOW	0	NORMAL	0

TEMPERATURE RECORDS

All time record high of 105 set on the 25, 26th. Tied or set new daily record highs of 98 on the 17th, 100 on the 18th, 102 on the 22nd, 104 on the 23rd and 102 on the 24th

HEATING DEGREE DAYS

MONTHLY TOTAL	6	NORMAL	62	DEPARTURE -56
SEASONAL TOTAL	5399	NORMAL	6058	DEPARTURE -659

COOLING DEGREE DAYS

MONTHLY TOTAL	314	NORMAL	133	DEPARTURE	181
YEARLY TOTAL	365	NORMAL	155	DEPARTURE	210

PRECIPITATION (IN INCHES)

MONTHLY TOTAL	1.22	NORMAL	1.98	DEPARTURE	-0.76
YEARLY TOTAL	4.81	NORMAL	7.44	DEPARTURE	-2.63
GREATEST IN 24 HOURS		0.69" during the 6th to 7th			
DAYS WITH MEASURABLE PRECIP.			2		

SNOWFALL (IN INCHES)

MONTHLY TOTAL	0.0	NORMAL	1.0	DEPARTURE	-1.0
SEASONAL TOTAL	55.6	NORMAL	57.7	DEPARTURE	-2.1
GREATEST IN 24 HOURS		NA			
GREATEST DEPTH		NA			

WIND (IN MILES PER HOUR)

AVERAGE SPEED	12.2mph
PEAK WIND GUST	67mph from the West

MISCELLANEOUS WEATHER

NUMBER OF DAYS WITH THUNDERSTORM	8	NORMAL	6
NUMBER OF DAYS WITH HEAVY FOG	1	NORMAL	1
NUMBER OF DAYS WITH HAIL	1		
NUMBER OF SUNNY DAYS	8		
NUMBER OF PARTLY CLOUDY DAYS	21		
NUMBER OF CLOUDY DAYS	1		
AVERAGE RELATIVE HUMIDITY	33%		

July Preview

The monsoon season is now underway over the desert southwest and has already provided some beneficial rains to many areas of Colorado in the first couple weeks of the month. As the subtropical moisture band wobbles over the SW thunderstorms with the potential for localized heavy rainfall becomes the primary weather threat. There are typically daily thunderstorm chances in the mountains with many days during the month with isolated to widely scattered thunderstorms on the plains. At a minimum there is usually an increase in cloud cover in the afternoon hours that provides some relief from the heat. On average there are 11 thunderstorm days in the month which equates to about 1 storm every 3 days. With all of the storm activity and the potential for heavy rains the average monthly precipitation for July is 2.16". Temperatures usually peak in the month of July and it is the warmest month of the year for the Denver area. Average highs are near 90 and average lows are close to 60. Temperatures this month are expected to remain above normal but not to the magnitude of June. Precipitation looks like it may end up closer to normal than previous months with some areas likely receiving above normal precipitation especially if a heavy rainfall producing thunderstorm moves through your area providing a quick 2-3" in just one afternoon. The area of greatest concern this month is flooding from the fire burn scars as it only takes a fraction of the rainfall as it normally would to produce flash flood conditions that can put lives and property in jeopardy.

DENVER'S NOVEMBER CLIMATOLOGICALLY NORMAL
(NORMAL PERIOD 1971-2000)

TEMPERATURE

AVERAGE HIGH	89.4
AVERAGE LOW	58.9
MONTHLY MEAN	74.2
DAYS WITH HIGH 90 OR ABOVE	16
DAYS WITH HIGH 32 OR BELOW	0
DAYS WITH LOW 32 OR BELOW	0
DAYS WITH LOWS ZERO OR BELOW	0

PRECIPITATION

MONTHLY MEAN	2.16"
DAYS WITH MEASURABLE PRECIPITATION	8
AVERAGE SNOWFALL IN INCHES	0.0"
DAYS WITH 1.0 INCH OF SNOW OR MORE	0

MISCELLANEOUS AVERAGES

HEATING DEGREE DAYS	6
COOLING DEGREE DAYS	289
WIND SPEED (MPH)	8.3mph
WIND DIRECTION	South
DAYS WITH THUNDERSTORMS	11
DAYS WITH DENSE FOG	Less than 1
PERCENT OF SUNSHINE POSSIBLE	71%

EXTREMES

RECORD HIGH	105 on 7/20/2005
RECORD LOW	42 on 7/4/1903
WARMEST	77.8 in 1934
COLDEST	67.4 in 1895
WETTEST	6.41” in 1965
DRIEST	0.01” in 1901
SNOWIEST	0.0”
LEAST SNOWIEST	0.0”

Sunrise/Sunset (July - December Denver area)

	JUL	AUG	SEP	OCT	NOV	DEC	
	sr - ss	sr - ss	sr - ss	sr - ss	sr - ss	sr - ss	
01	0534-0831	0558-0812	0627-0731	0655-0642	0728-0556	0701-0434	01
02	0535-0831	0559-0811	0628-0729	0656-0640	0729-0555	0702-0434	02
03	0535-0830	0600-0810	0629-0727	0657-0639	0730-0554	0703-0434	03
04	0536-0830	0601-0809	0630-0726	0658-0637	0632-0453	0704-0434	04
05	0537-0830	0602-0808	0631-0724	0659-0635	0633-0452	0705-0434	05
06	0537-0830	0603-0807	0632-0723	0700-0634	0634-0451	0706-0434	06
07	0538-0830	0603-0806	0633-0721	0701-0632	0635-0450	0707-0434	07
08	0538-0829	0604-0804	0634-0719	0702-0631	0636-0449	0708-0434	08
09	0539-0829	0605-0803	0634-0718	0703-0629	0637-0448	0709-0434	09
10	0540-0828	0606-0802	0635-0716	0704-0628	0638-0447	0709-0434	10
11	0540-0828	0607-0801	0636-0714	0705-0626	0640-0446	0710-0434	11
12	0541-0828	0608-0759	0637-0713	0706-0624	0641-0445	0711-0434	12
13	0542-0827	0609-0758	0638-0711	0707-0623	0642-0444	0712-0435	13
14	0543-0827	0610-0757	0639-0710	0709-0621	0643-0443	0712-0435	14
15	0543-0826	0611-0755	0640-0708	0710-0620	0644-0442	0713-0435	15
16	0544-0825	0612-0754	0641-0706	0711-0618	0645-0442	0714-0435	16
17	0545-0825	0613-0753	0642-0705	0712-0617	0646-0441	0714-0436	17
18	0546-0824	0614-0751	0643-0703	0713-0616	0648-0440	0715-0436	18
19	0547-0824	0615-0750	0644-0701	0714-0614	0649-0440	0716-0437	19
20	0547-0823	0616-0749	0645-0700	0715-0613	0650-0439	0716-0437	20
21	0548-0822	0617-0747	0646-0658	0716-0611	0651-0438	0717-0438	21
22	0549-0821	0618-0746	0647-0656	0717-0610	0652-0438	0717-0438	22
23	0550-0821	0619-0744	0648-0655	0718-0609	0653-0437	0718-0439	23
24	0551-0820	0620-0743	0649-0653	0719-0607	0654-0437	0718-0439	24
25	0552-0819	0620-0741	0650-0651	0720-0606	0655-0436	0718-0440	25
26	0552-0818	0621-0740	0651-0650	0721-0605	0656-0436	0719-0441	26
27	0553-0817	0622-0738	0652-0648	0723-0603	0657-0436	0719-0441	27
28	0554-0816	0623-0737	0652-0647	0724-0602	0658-0435	0719-0442	28
29	0555-0815	0624-0735	0653-0645	0725-0600	0659-0435	0719-0443	29
30	0556-0814	0625-0734	0654-0643	0726-0558	0700-0435	0720-0443	30
31	0557-0813	0626-0732		0727-0557		0720-0444	31

Rainfall

Oct 2011 to Apr 2012

City	May	Jun	Jul	Aug	Sept	Total
Aurora (Central)	1.38	1.65				3.03
Brighton	1.89	0.63				2.52
Broomfield	1.30	0.08				1.38
Castle Rock	1.38	0.12				1.50
Colo Sprgs Airport	0.78	0.59				1.37
Denver DIA	1.01	1.22				2.23
Denver Downtown	1.46	0.39				1.85
Golden	2.06	0.69				2.75
Fort Collins	1.70	0.00				1.70
Highlands Ranch	1.57	2.09				3.66
Lakewood	2.24	1.77				4.01
Littleton	1.54	1.34				2.88
Parker	1.26	2.17				3.43
Sedalia - Hwy 67	1.42	0.94				2.36
Thornton	0.87	0.04				0.91
Westminster	1.73	0.16				1.89
Wheatridge	1.85	0.43				2.28

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