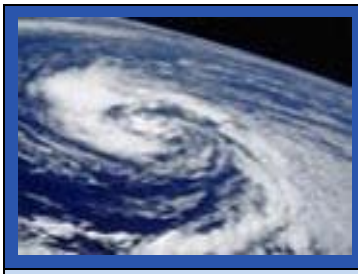


The Weather Wire

July 2015 Volume 22 Number 7

Contents:

A Wet Summer in Store…

North American 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 the North American 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 Plateau 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.

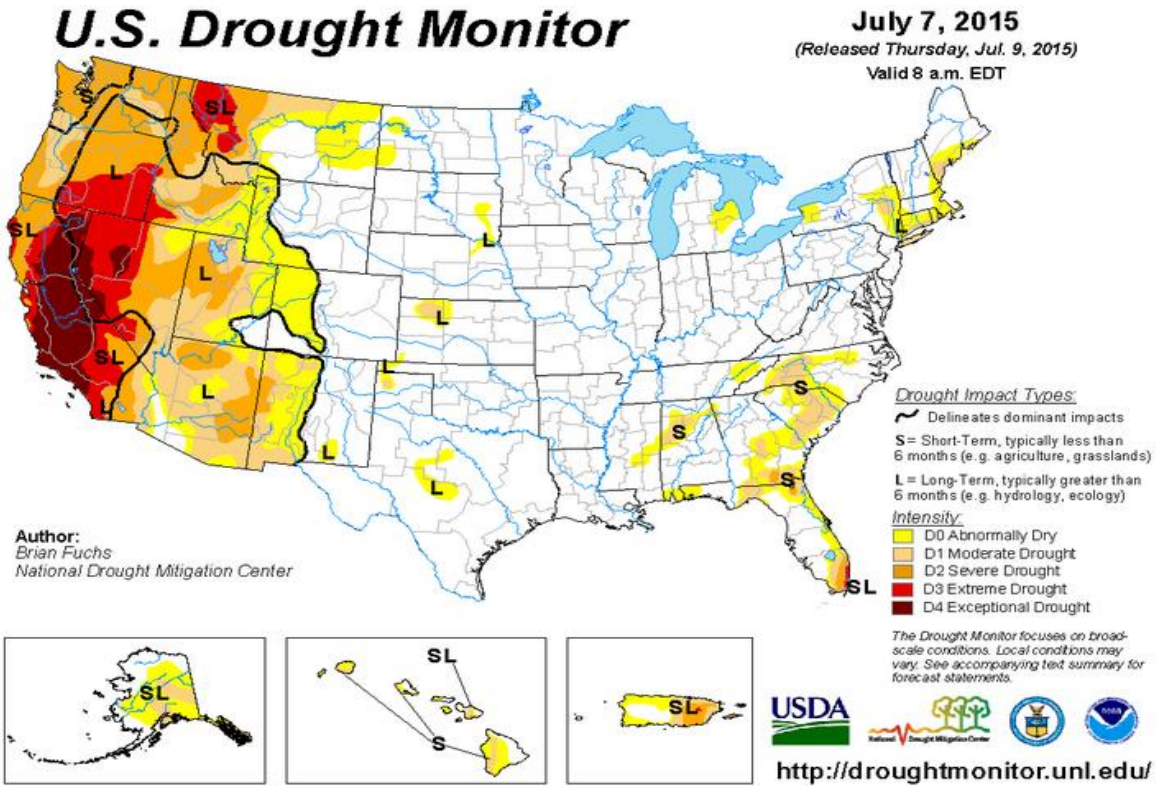
This monsoon ridge is almost as strong as the one which develops over Asia during the summer. However, since the lower level moisture flow is not as persistent as in the Indian monsoon, the upper level steering pattern and disturbances around the ridge are critical for influencing where thunderstorms 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:

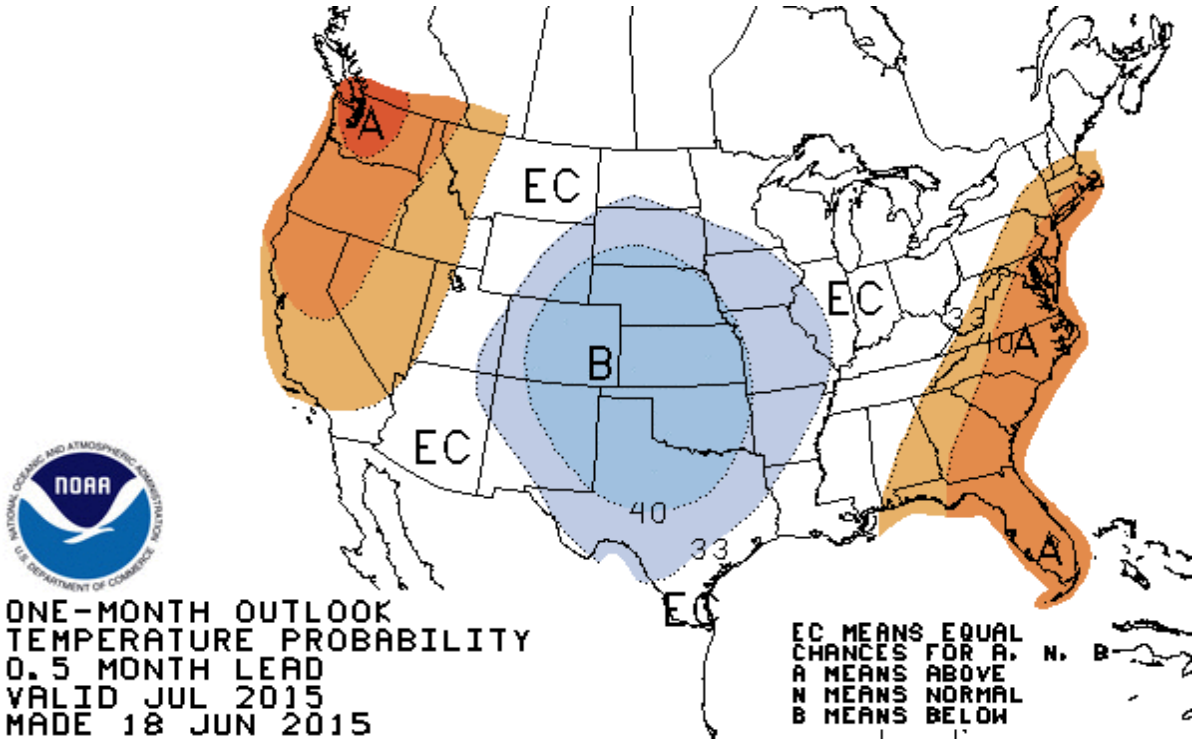
http://www.wrh.noaa.gov/twc/monsoon/monsoon_NA.php

Drought Update

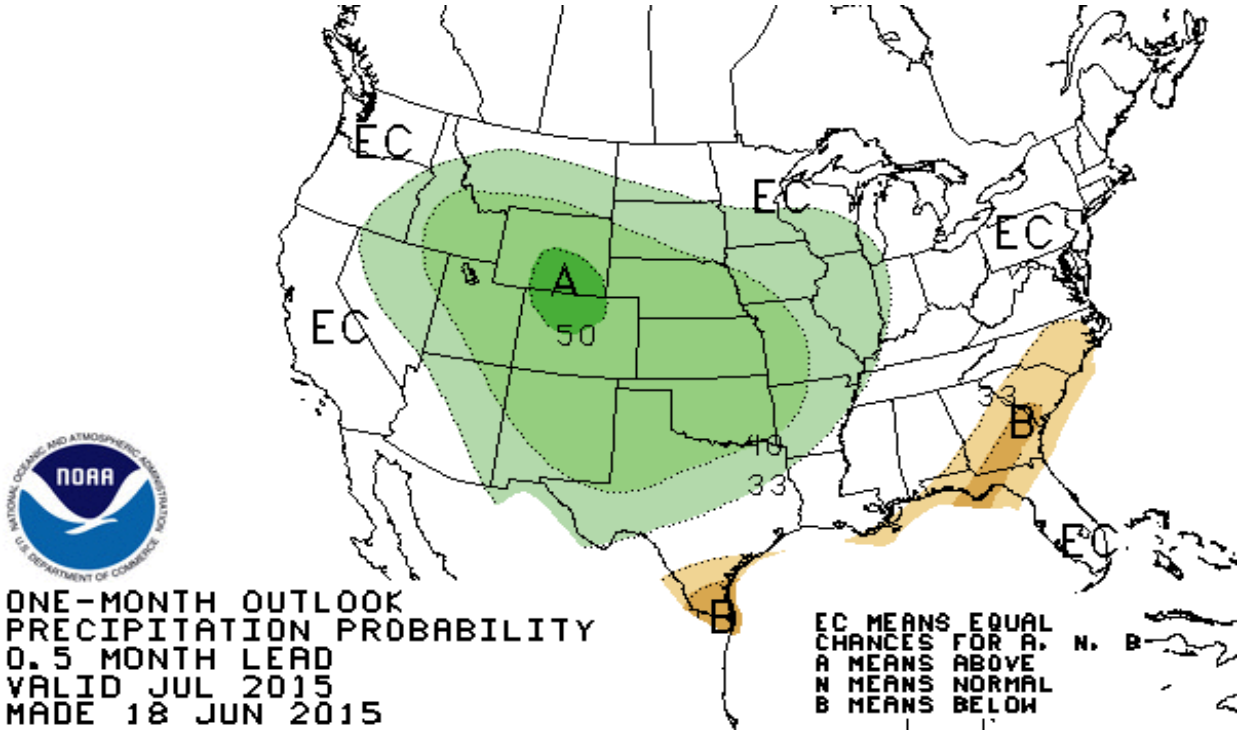
Drought has been removed from SE CO and much of TX due to the wet May with exceptional drought continuing over portions of CA, NV and OR.



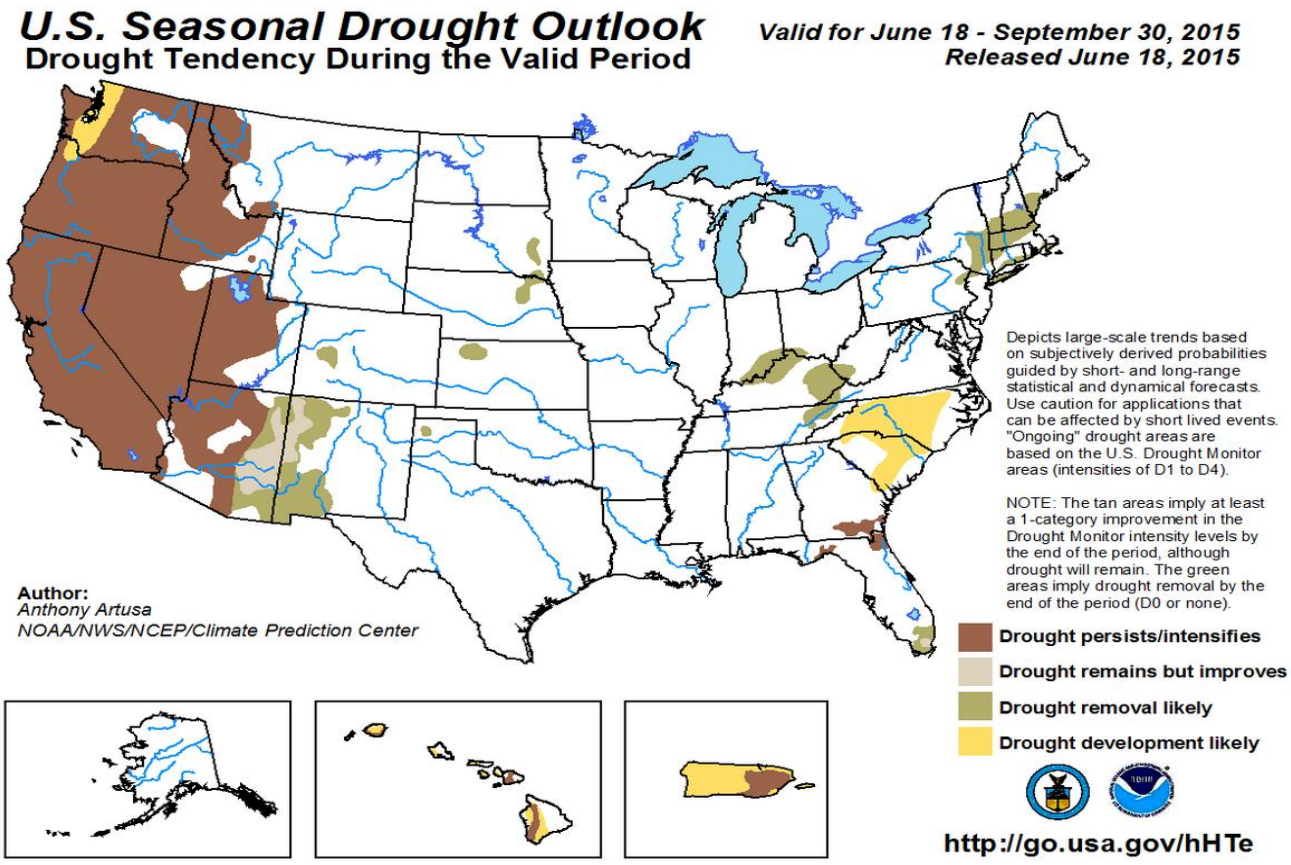
The map below shows forecasted temperature deviances for July 2015. There is a bias towards below normal temperatures for the month of July over Colorado.



The map below shows forecasted precipitation deviances for July 2015. There is a strong bias towards above normal to well above normal precipitation over the entire state of Colorado.



Drought conditions are forecast to improve over W Colorado. Drought looks to persist or intensify over the West Coast inland through the Great Basin.



June Summary

June of 2015 was above normal in both temperature and precipitation. Average highs for the month were 82.9 degrees which was only 0.5 degrees above the normal of 82.4. Average lows for the month were 56.1 degrees which was 3.8 degrees above the normal of 52.3. The monthly mean temperature was 69.5 degrees, 2.1 degrees above the normal of 67.4, mainly due to the much warmer than average overnight low temperatures. The high temperature for June was 94 degrees on the 30th. There were 6 days with temperatures reaching or exceeding 90 degrees which was 2 days below normal. Precipitation was above normal at DIA but the airport reported about half as much rain as other locations in the Metro area. DIA reported 2.53" for the month compared to 1.98" on average with a surplus of 0.55". For the year to date 11.36" of moisture has been collected at DIA which is 3.85" above the normal of 7.51". I think it is safe to say that 2015 will be a very "wet" year for Denver standards. For the month of June there were 13 days with measureable precipitation and 16 days with thunderstorms. These values are low compared to the majority of the Denver Metro area. Of the 16 days with thunderstorms 3 days produced hail. There was only one day with dense fog of ¼ mile visibility or less. Cloud cover for the month produced 6 sunny to mostly sunny days and 22 partly to mostly cloudy days and 2 days considered cloudy. Average relative humidity was 61% indicative of a moist air mass in place for most of the month.

June Stats

TEMPERATURE (IN DEGREES F)

AVERAGE MAX	82.9	NORMAL	82.4	DEPARTURE	0.5
AVERAGE MIN	56.1	NORMAL	52.3	DEPARTURE	3.8
MONTHLY MEAN	69.5	NORMAL	67.4	DEPARTURE	2.1
HIGHEST	94 on 6/30				
LOWEST	51 on 6/3				

DAYS WITH MAX 90 OR ABOVE	6	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

No temperature records tied or broken

HEATING DEGREE DAYS

MONTHLY TOTAL	11	NORMAL	62	DEPARTURE	-51
SEASONAL TOTAL	5583	NORMAL	6058	DEPARTURE	-475

COOLING DEGREE DAYS

MONTHLY TOTAL	154	NORMAL	133	DEPARTURE	21
YEARLY TOTAL	158	NORMAL	155	DEPARTURE	3

PRECIPITATION (IN INCHES)

MONTHLY TOTAL	2.53	NORMAL	1.98	DEPARTURE	0.55
YEARLY TOTAL	11.36	NORMAL	7.51	DEPARTURE	3.85
GREATEST IN 24 HOURS		0.99” On 6/5			
DAYS WITH MEASURABLE PRECIP.			13		

SNOWFALL (IN INCHES)

MONTHLY TOTAL	0.0	NORMAL	0.0	DEPARTURE	0.0
SEASONAL TOTAL	0.0	NORMAL	0.0	DEPARTURE	0.0
GREATEST IN 24 HOURS		NA			
GREATEST DEPTH		NA			

WIND (IN MILES PER HOUR)

AVERAGE SPEED	9.0mph
PEAK WIND GUST	47mph from the SSE

MISCELLANEOUS WEATHER

NUMBER OF DAYS WITH THUNDERSTORM	16	NORMAL	10
NUMBER OF DAYS WITH HEAVY FOG	1	NORMAL	<1
NUMBER OF DAYS WITH HAIL	3		
NUMBER OF SUNNY DAYS	6		
NUMBER OF PARTLY CLOUDY DAYS	22		
NUMBER OF CLOUDY DAYS	2		
AVERAGE RELATIVE HUMIDITY	61%		

July Preview

July is the warmest month of the year on average in the Denver Metro area with average highs just shy of 90 degrees at 89.4. Average lows are in the upper 50s at 58.9 degrees. The highs and lows combine for a monthly mean of 74.2 degrees. Usually just over half of the days during the month reach or exceed 90 degrees. For July of 2015 temperatures are expected to be near normal to slightly below normal. Precipitation increases from July as the North American monsoon season kicks into gear. Average July precipitation is 2.16". Thunderstorms are possible nearly every afternoon within eye sight during the month more numerous over the foothills but on average there are 11 thunderstorm days with 8 days with measureable precipitation. Moisture levels can be high at times during the month with just one or two storms capable of producing an entire month worth of rain. Severe storms are less likely in July as compared to May and June but there can still be bouts of severe weather usually in the form of large hail but tornadoes cannot be ruled out! Precipitation for July of 2015 is expected to be above normal as well as the amount of thunderstorm days and days with measureable rain. The overall "wetter than normal" pattern we have been in since spring will continue.

DENVER'S JULY CLIMATOLOGICALLY NORMAL
(NORMAL PERIOD 1981-2010 DIA Data)

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	0
PERCENT OF SUNSHINE POSSIBLE	71%

EXTREMES

RECORD HIGH	105 on 7/20/2015
RECORD LOW	42 on 7/4/1903

WARMEST	78.9 in 2012
COLDEST	67.4 in 1895
WETTEST	6.41” in 1965
DRIEST	0.01” In 1901
SNOWIEST	0.0”
LEAST SNOWIEST	0.0"

Rainfall

May 2015 to October 2015

City	May	June	July	Aug	Sept	Oct	Total
Aurora (Central)	6.85	3.35					10.20
Brighton	5.20	1.14					6.34
Broomfield	6.54	3.39					9.93
Castle Rock	4.72	5.08					9.80
Colo Sprgs Airport	8.13	5.72					13.21
Denver DIA	3.76	2.53					6.29
Denver Downtown	5.87	4.92					10.79
Golden	6.93	2.60					9.53
Fort Collins	6.09	1.96					8.05
Highlands Ranch	5.31	3.46					8.77
Lakewood	5.59	4.33					9.92
Littleton	6.18	4.06					10.24
Parker	4.17	5.12					9.29
Sedalia - Hwy 67	5.51	3.58					9.09
Thornton	4.96	2.72					7.68
Westminster	6.34	4.09					10.43
Wheat Ridge	5.89	4.81					10.70

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