



# *The Weather Wire*

**August 2016**

**Volume 23 Number 8**

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## **Thunderstorm Forecasting**

In Colorado forecasting thunderstorms can be quite tricky due to their random nature of development and many atmospheric variables. The most important ingredients are heat and moisture but here in Colorado there are many other factors at work. All storms need moisture, an unstable air mass, and lift to develop.

**Heat:** The heating of the lower atmosphere is crucial for thunderstorm formation as hot air rises, providing needed lift. The warm air near the surface becomes warmer than surrounding air and then rises to form clouds. If enough moisture is present a thunderstorm can develop by daytime heating alone. Without daytime heating from the sun, the cool air will remain in place and pool in low lying areas creating a stable environment. Even if there is plentiful moisture available in the atmosphere if temperatures do not warm sufficiently to provide lift then the air will not rise and condense to form clouds and eventually thunderstorms to precipitate the water out of the air. When moisture levels are high it typically does not take as much heating to produce storms and when moisture levels are low daytime heating can generate storms that contain little rainfall but gusty winds. Daytime heating is not the only lifting mechanism of air and often times the combination of geographic features, winds and upper air disturbances along with daytime heating are needed to produce thunderstorms. The strength of thunderstorms depends upon how all these variables come together including moisture...

**Moisture:** Without moisture even if the air rises due to heat it will not produce clouds and therefore thunderstorms. Many times in Colorado we have a lot of daytime heating but limited moisture which results in high cloud bases (distance from bottom of the cloud to the ground) and relatively weak storms that produce more wind than rain but can still contain lightning. As moisture increases typically less daytime heating is needed and with lower cloud bases there is less evaporation of moisture from cloud base to the surface increasing the chances for heavier rains. Moisture in the summer time is provided by both the Atlantic from the Gulf of Mexico and the Pacific from the Gulf of California. The North American Monsoon develops during the first week or two in July and continues through early September. Moisture from the Pacific works its way northward into Colorado and provides the moisture in the mid and upper levels needed for thunderstorms. Surface moisture is generally

provided from the Atlantic (Gulf of Mexico) as southerly winds draw moisture northward into the Great plains and can be pushed westward back into the Front Range mountains and foothills. When moisture at the surface and aloft are high the threat for heavy rainfall increases. What is a high moisture value? Well, in Denver anything over 1.0" of precipitable water is considered high. What is precipitable water you ask? It is the amount of water in a column of air if that would fall out as rain. The slower the upper level wind speeds are the slower the thunderstorms will move and be able to deposit higher rainfall amounts over a single location. Since storms are great recyclers of air, rainfall amounts may be much greater than actual precipitable water amounts. Storms of the same strength that move faster will produce less rain as it will be over the location for less time. Along with moisture storm motion plays a key role in forecasting potential rainfall amounts.

**Lift:** There can be many lifting mechanisms to generate thunderstorms beyond daytime heating alone. Sometimes when temperatures are at their peak the air just needs a little extra push to get storms going. One lifting mechanism in Colorado that is quite common is terrain (mountains). The mountains can provide lift from winds blowing air up the mountain itself "upslope" but also by differential heating. The southern slopes of the mountains warm faster than the north slopes and creates an area of air that is warmer than the surrounding air and will in turn begin to rise. (Remember: Warm is relative to the air around it and does not necessarily mean it is warm to the human body!) This is the main reason that thunderstorms first develop over the mountains and foothills earlier in the day. Lift can also be provided aloft. The air at the surface may not necessarily need to warm if air at the upper levels of the atmosphere is cooling. The air at the ground is becoming relatively warmer even though the temperature is not necessarily changing. This is why all these little disturbances become so important in forecasting thunderstorms. Even a few degree change in the upper levels can be enough to tilt the scales towards convection and thunderstorm activity. Winds play a large role in thunderstorm characteristics but let's focus on surface winds for just a minute. Fronts are areas of wind shift and convergence and are a common are of lift which we typically associate with winter storms as fronts are much stronger. In the summer fronts are weaker as the temperature difference is smaller between the air masses ahead of and behind the front. There are also smaller scale fronts that can be generated by thunderstorms such as gust fronts/outflow boundaries. The rain from a thunderstorm cools the air and when there is enough rain cooled air, the cooler air undercuts warmer air as it pushed outwards from the center of the storm. These mall scale gust fronts can create very strong winds and can generate new thunderstorm development. These gust fronts typically contain higher moisture behind it as well adding fuel to thunderstorms that it creates. One term that is used by local meteorologists in Denver is the "Denver Cyclone" and is caused by surface winds and their interaction with the Palmer Divide. Many cases when winds are from the S to SE over the eastern plains the winds literally wrap around the higher terrain of the Palmer Divide back into the Denver Metro area and create a convergence line (winds converging on a single location or line). The S to SE winds over the plains wrap counter clockwise around the Palmer Divide with winds over southern Denver suburbs from the S to SE but northern areas are often from the N to NW. These winds typically converge over northern Douglas County extending northeastward through Arapahoe and Adams County. Thunderstorms can initiate where the winds converge creating additional lift. Once these initial storms develop outflow typically generates now storms in and around the Denver Metro area. Once the thunderstorms create outflow the Denver Cyclone can wash out to set up again another day.

**Winds:** Winds at the surface can cause convergence and lift but winds in the upper atmosphere have a different effect on thunderstorms. Not only do they steer where storms will move but they separate updrafts and downdrafts allowing storms to sustain themselves

over a longer period of time. The greater the difference in wind speed and direction with height is called wind shear. There are two types of winds shear, speed shear and directional shear. Storms with high wind shear values have the potential to spin and become “super cell” thunderstorms capable of producing severe weather and tornadoes. Typically winds shear is highest in the spring and early summer when severe weather season is at its peak. In the later summer months upper level winds are typically lighter and have less directional shear which results in slower moving thunderstorm cells and a lower threat for severe weather with heavy rainfall being the primary threat.

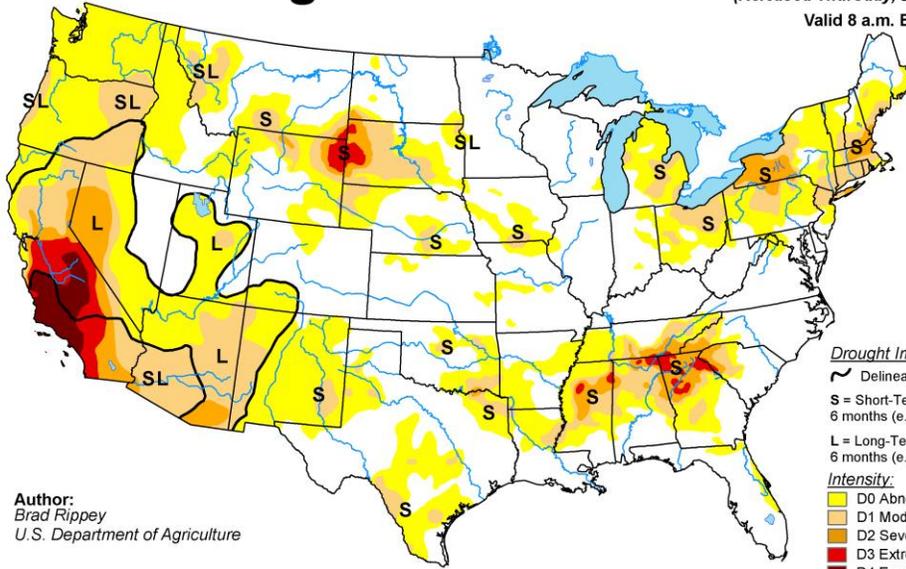
**Unstable Air Mass:** In simplest terms, Instability is simply the tendency for air to continue to rise once it has a lifting mechanism. This occurs is the air is warmer than the surrounding air, and relates to the temperature profile of the atmosphere. If air does not continue to rise (that is, its cooler than the surrounding air) the air is stable, and storms will not form, even if ample moisture and a lifting mechanism are present. Now that we know a little more about the variables that need to be taken into account to forecast thunderstorms it is no wonder that forecasting storms in Colorado can be difficult. If all of the little variables weren’t enough the weather models we base our forecasts on can also have small errors. It all boils down to the fact that we can usually nail down days with high risk but cannot say exactly where the strongest storms of the day will be due to the randomness of where the prime conditions will exist.

## **Drought Update**

Colorado remains mostly drought-free, although some areas of moderate drought are beginning to creep into the extreme southwest corner of the state. Pockets of “abnormally dry” conditions also exist across portions of southwest and north central Colorado. Elsewhere, areas of severe to moderate drought remain across portions of California, Nevada, Oregon, and Arizona.

# U.S. Drought Monitor

July 26, 2016  
 (Released Thursday, Jul. 28, 2016)  
 Valid 8 a.m. EDT



Author:  
 Brad Rippey  
 U.S. Department of Agriculture

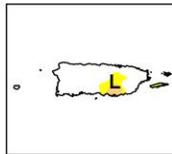
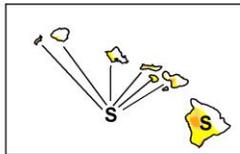
**Drought Impact Types:**

- ~ Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

**Intensity:**

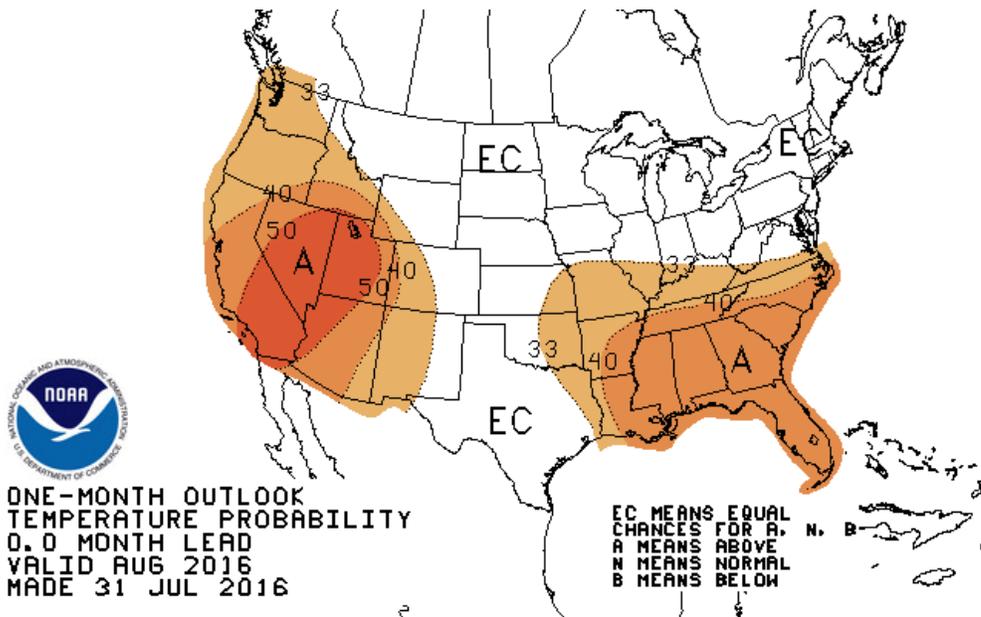
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

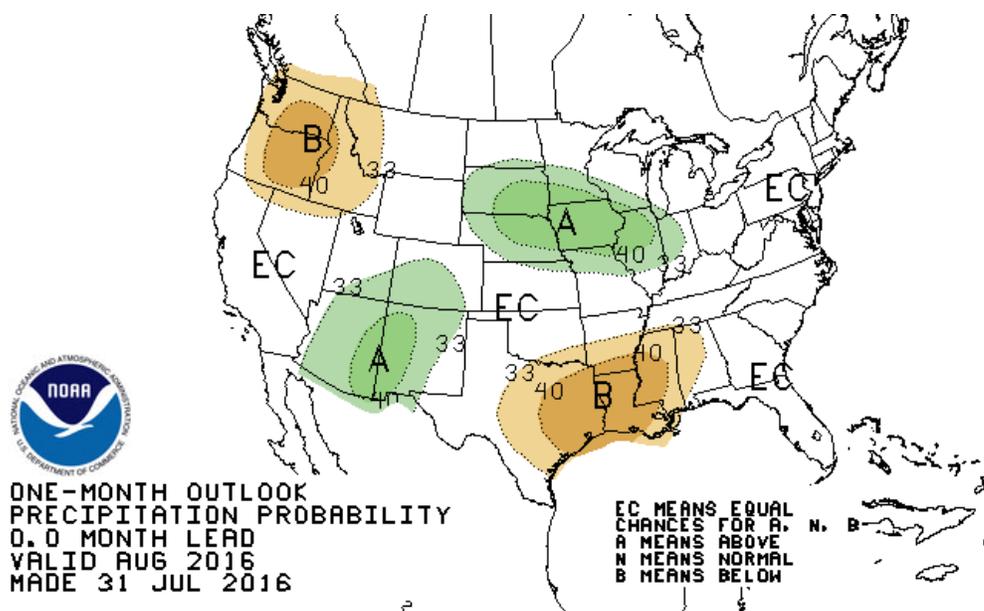


<http://droughtmonitor.unl.edu/>

The map below shows forecasted temperature deviances for August 2016. There is a slight bias toward above normal temperatures across the western half of Colorado, and equal chances for above or below normal temperatures for the rest of the state.



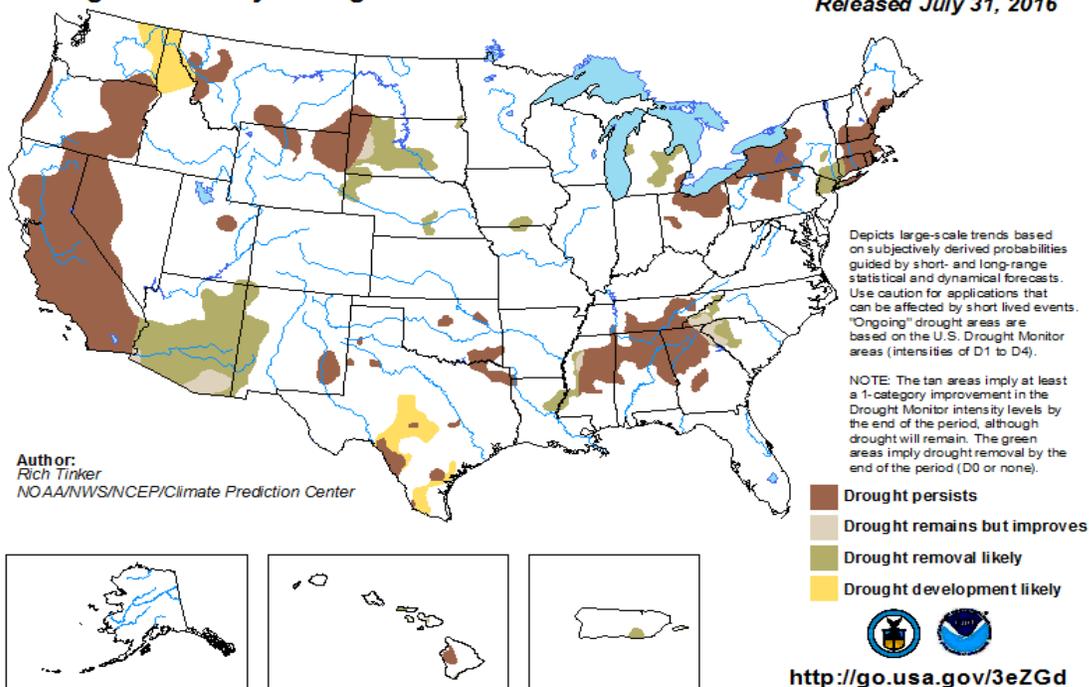
The map below shows forecasted precipitation deviances for August 2016. There is a slight bias toward above normal precipitation across southwest and south central Colorado, and equal chance for above or below normal precipitation across northern and eastern Colorado.



No drought is forecast for Colorado in the near term. No changes in drought conditions are anticipated across California, Nevada, and Eastern Oregon, while drought removal is likely across Arizona, and drought development is likely across Northern Idaho.

**U.S. Monthly Drought Outlook**  
Drought Tendency During the Valid Period

Valid for August 2016  
Released July 31, 2016



## July Summary

July 2016 was hotter and drier than average, featuring 22 days with temperatures exceeding 90 degrees and a monthly high of 102 on the 10<sup>th</sup>, which was also a daily record high. The average high for the month was 92.0, which is 2.6 degrees above normal, and the average low for the month was 60.5, which is 1.6 degrees above normal. The month also featured a 12-day streak of 90 degree temperatures from the 16<sup>th</sup> through the 27<sup>th</sup>. The wettest day of the month at DIA occurred on the 1<sup>st</sup> when 0.61" was recorded, but the next couple of weeks were much drier than usual across the area as high pressure dominated the pattern. The southwest monsoon finally developed over the last two weeks of the month, resulting in more active weather, but even so drier than average conditions prevailed. A total of 12 thunderstorm days were officially recorded at DIA, which is actually about average, but most of these storms produced little rainfall. A strong gust front from thunderstorm activity did manage to produce an impressive 74mph wind gust at DIA on the 24<sup>th</sup>, though. While most of the Denver metro area experienced below average precipitation and relatively little severe weather, portions of the Colorado Springs area saw a wetter July due to some heavy rainfall producing thunderstorms that occurred over the final week of the month, including a massive hail storm that occurred over eastern parts of the city on the 29<sup>th</sup>. During the first half of the month, the dry weather resulted in several notable wildfires across Colorado, such as the Cold Springs Fire near Nederland and the Hayden Pass Fire south of Salida.

## July Stats

### TEMPERATURE (IN DEGREES F)

AVERAGE MAX	92.0	NORMAL 89.4	DEPARTURE 2.6
AVERAGE MIN	60.5	NORMAL 58.9	DEPARTURE 1.6
MONTHLY MEAN	76.2	NORMAL 74.2	DEPARTURE 2.0
HIGHEST	102 on 7/10		
LOWEST	51 on 7/12		

DAYS WITH MAX 90 OR ABOVE	22	NORMAL	16.0
DAYS WITH MAX 32 OR BELOW	0	NORMAL	0.0
DAYS WITH MIN 32 OR BELOW	0	NORMAL	0.0
DAYS WITH MIN ZERO OR BELOW	0	NORMAL	0.0

### TEMPERATURE RECORDS

7/10 – record high of 102 set, 7/23 – record high minimum of 70 set

### HEATING DEGREE DAYS

MONTHLY TOTAL	0	NORMAL 6	DEPARTURE -6
SEASONAL TOTAL	0	NORMAL 6	DEPARTURE -6

**COOLING DEGREE DAYS**

MONTHLY TOTAL	356	NORMAL 289	DEPARTURE 67
YEARLY TOTAL	544	NORMAL 444	DEPARTURE 100

**PRECIPITATION (IN INCHES)**

MONTHLY TOTAL	1.07	NORMAL 2.16	DEPARTURE -1.09
YEARLY TOTAL	9.79*	NORMAL 9.67	DEPARTURE 0.12*
GREATEST IN 24 HOURS	0.61 on 7/1		
DAYS WITH MEASURABLE PRECIP.	6		

\*Error on 3/23 due to under catch from snow

**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	0		
GREATEST DEPTH	0		

**WIND (IN MILES PER HOUR)**

AVERAGE SPEED	10.2 mph
PEAK WIND GUST	74 mph from the NNW on 7/24

**MISCELLANEOUS WEATHER**

NUMBER OF DAYS WITH THUNDERSTORM	12	NORMAL	11
NUMBER OF DAYS WITH HEAVY FOG	0	NORMAL	<1
NUMBER OF DAYS WITH HAIL	0		
NUMBER OF SUNNY DAYS	10		
NUMBER OF PARTLY CLOUDY DAYS	19		
NUMBER OF CLOUDY DAYS	2		
AVERAGE RELATIVE HUMIDITY	46%		

## August Preview

Monsoon season typically peaks during the first week of August, before dropping off over the second half of the month with thunderstorms becoming weaker and a little less frequent than what is typical during July. Average precipitation during August is 1.69" and there an average of eight thunderstorm days at DIA during the month. Although it happens on occasion, severe weather is less likely in August compared to May, June, and July, due to typically weaker winds aloft and warmer air at the mid to upper levels of the atmosphere (this has a stabilizing effect) compared to early summer. However, the weaker upper level winds also favor slower-moving storms, so heavy rainfall is a common threat during active monsoonal periods. August is the second hottest month on average in Denver, just a little cooler than July with an average high of 87.2 and an average low of 57.9. The month often starts out hot, but temperatures do start to trend downward over the second half of the month with Canadian cold fronts occasionally bringing brief tastes of fall. The all-time record high in August is 105, set in 1878, and the all-time record low is 40, which has occurred on multiple dates in 1910. For August 2015, we are generally expecting both temperatures and precipitation to be near average, with a bias toward wetter conditions over the first half of the month and drier conditions over the second half of the month. There will likely be some hot days from time to time, but overall temperatures shouldn't be quite as hot as what we experienced in July.

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

#### TEMPERATURE

AVERAGE HIGH	87.2
AVERAGE LOW	57.9
MONTHLY MEAN	72.5
DAYS WITH HIGH 90 OR ABOVE	12
DAYS WITH HIGH 32 OR BELOW	0
DAYS WITH LOW 32 OR BELOW	0
DAYS WITH LOWS ZERO OR BELOW	0

#### PRECIPITATION

MONTHLY MEAN	1.69"
DAYS WITH MEASURABLE PRECIPITATION	9
AVERAGE SNOWFALL IN INCHES	0.0"
DAYS WITH 1.0 INCH OF SNOW OR MORE	0

#### MISCELLANEOUS AVERAGES

HEATING DEGREE DAYS	10
COOLING DEGREE DAYS	244
WIND SPEED (MPH)	8.0mph
WIND DIRECTION	South
DAYS WITH THUNDERSTORMS	8
DAYS WITH DENSE FOG	1
PERCENT OF SUNSHINE POSSIBLE	71%

## EXTREMES

RECORD HIGH	105 on 8/18/1878
RECORD LOW	40 on multiple dates
WARMEST	77.0 in 2011
COLDEST	66.5 in 1915
WETTEST	5.85" in 1979
DRIEST	0.02" in 1924
SNOWIEST	0.0"
LEAST SNOWIEST	0.0"

## Rainfall

### May 2016 to October 2016

City	May	Jun	Jul	Aug	Sep	Oct	Total
Aurora (Central)	2.64"	1.42"	2.09"				6.15"
Brighton	2.52"	1.57"	0.59"				4.68"
Broomfield	1.42"	0.35"	0.12"				1.89"
Castle Rock	2.64"	2.95"	0.59"				6.18"
Colo Sprgs Airport	2.38"	1.04"	3.04"				6.46"
Denver DIA	2.38"	1.62"	1.07"				5.07"
Denver Downtown	1.54"	2.83"	0.51"				4.88"
Golden	1.26"	1.00"	1.20"				3.46"
Fort Collins	2.05"	0.22"	0.94"				3.21"
Highlands Ranch	0.79"	2.20"	0.47"				2.99"
Lakewood	0.98"	2.68"	0.94"				4.60"
Littleton	0.94"	1.06"	2.01"				4.01"
Parker	2.32"	2.72"	0.98"				6.02"
Sedalia - Hwy 67	2.32"	2.48"	0.32"				5.12"
Thornton	1.26"	0.39"	0.12"				1.77"
Westminster	0.83"	1.50"	0.63"				2.95"
Wheat Ridge	1.02"	2.09"	0.24"				3.35"

Skyview Weather  
2350 N Rocky View Rd  
Castle Rock, CO 80108

Phone: (303) 688-9175  
Fax: (303) 380-3338

E-mail: [Tim@SkyviewWeather.com](mailto:Tim@SkyviewWeather.com)  
On the web at [www.SkyviewWeather.com](http://www.SkyviewWeather.com)

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