North Dakota Climate Bulletin

Summer 2010

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In This Issue

NDSCO

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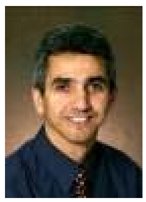
From the State Climatologist



The North Dakota Climate Bulletin is a digital quarterly publication of the North Dakota State Climate Office, the College of Agriculture, Food Systems and Natural Resources, North Dakota State University in Fargo, North Dakota.

Compared historically, North Dakota had a warmer and wetter summer following a warmer and wetter spring. Temperature-wise, this summer was the 37th warmest since 1895. Precipitation-wise, it was the 44th wettest winter since 1895. Although it is preliminary, a tornado outbreak in North Dakota on June 17 brought record number of tornadoes of 40 in a single day. CoCoRaHS network expanded into 29 counties with 135 volunteer observers.

The North Dakota total precipitation amounts as a percentage of the normal and average temperature departure from normal are shown on pages 6 through 8 (Season in-Graphics) followed by the time series of monthly total precipitation and average temperature of North Dakota for respective months of the season. This bulletin can be accessed at http://www.ndsu.edu/ndsco/. This website hosts other great resources for climate and weather information.

Photo by NWS Grand Forks Office

Adnan Akyüz, Ph.D.
North Dakota
State Climatologist

Weather Highlights

Seasonal Summary: by B. A. Mullins

June 2010

The state average precipitation was 3.69 inches which is above the 1971-2000 normal of 3.19 inches. June 2010 state average precipitation ranked 46th wettest in the last 116 years with a maximum of 7.21 inches in 2005 and a minimum of 1.14 inches in 1974.

Monthly precipitation totals ranged from about 2 to 6 inches. The highest amounts of 4 to 6 inches fell primarily in the north central, northeast, and southwest regions. The lowest amounts of 2 to 4 inches fell in the northwest and southeast regions. Percent of normal precipitation ranged from approximately 30% to 200%. The northwest and southeast regions had less than 100% of normal with greater than 100% elsewhere. Daily rainfall events were scattered throughout the month. According to the USDA, National Agricultural Statistics Service, ND Field Office, the wet conditions hampered fieldwork for much of the month. A severe storm on the 17th produced high winds, hail, and tornadoes. Approximately 20 tornadoes were reported across the eastern part of North Dakota and northwestern Minnesota. The tornadoes reported from Holmes ND, Wadena MN, and Almora MN were rated EF4 (166 to 200 mph) by the National Weather Service (NWS). There were three fatalities in MN from the June 17th tornadoes that struck at Almora, Mentor, and Albert Lea.

The National Weather Service (NWS) reported record rainfall on the 17th at Fargo with 1.89 inches, Grand Forks airport with 1.67 inches, and Minot with 3.75 inches.

The US Drought Monitor July 13, 2010 report had no drought conditions reported in the state.

The USDA, National Agricultural Statistics Service, North Dakota Field Office reported a topsoil moisture of 1% very short, 16% short, 75% adequate, and 8% surplus with a subsoil moisture reported as 1% very short, 5% short, 85% adequate, and 9% surplus (Weekly Weather and Crop Bulletin Vol. 97, No. 28).

According to the preliminary reports of the National Weather Service’s Storm Prediction Center (SPC), severe weather reports for June had 59 reports of high wind, 56 hail reports, and 41 reported tornadoes. The greatest majority of the events happened on the 17th.

The top five June daily maximum wind speeds recorded from NDAWN were Bowman on the 30th with 59.8 mph, Plaza on the 25th with 56.2 mph, Minot on the 17th with 55.5 mph, Bowman on the 21st with 55.1 mph, and Perley MN on the 17th with 53.3 mph. NDAWN wind speeds are measured at a height of 10 feet (3 m).

The state average air temperature was 63.0 °F which is below the 1971-2000 normal of 63.73 °F. June 2010 state average air temperature ranked 49th warmest in the past 116 years with a maximum of 74.2 °F in 1988 and a minimum of 56.2 °F in 1915.

June average air temperatures ranged from 60 °F to 67 °F with the lower temperatures in the north and higher temperatures in the southeast. June average temperatures were near normal across the state. Departure from normal average air temperatures ranged of -3 °F to 2 °F. The temperatures that were slightly above normal fell in the southeast. Temperatures that were 3 °F below normal fell in the northeast.

The National Weather Service (NWS) reported a record high minimum temperature of 73°F on the 30^{th} at Williston.

NDAWN's highest recorded daily air temperature for June was 94.5 °F at Hettinger on the 30^{th}. The lowest recorded daily air temperature was 36.1°F at Cavalier on the 2^{nd}.

July 2010

The state average precipitation was 2.81 inches which is above to the 1971-2000 normal state average of 2.75 inches. July 2010 state average precipitation ranked the 44^{th} wettest in the past 116 years with a maximum of 7.88 inches in 1993 and a minimum of 0.62 inches in 1936.

Monthly precipitation totals ranged from about 1 to 7 inches. The highest amounts of 4 to 7 inches fell primarily in the southeast with 1 to 4 inches elsewhere. Percent of normal precipitation ranged from approximately 40% to 200%. Areas of the east, southeast, southwest and the far northeast corner had greater than 100% of normal precipitation with less than 100% elsewhere. Daily rainfall events were scattered throughout the month. Most of the Storm Prediction Center's (SPC) reports of high winds, hail, and tornadoes fell on the 13^{th}, 20^{th}, and 26^{th}. The SPC had 87 reported hail events in July. A record setting hailstone was recorded near Vivan, SD on the 23^{rd}. The hailstone was 8 inches in diameter with a circumference of 18.625 inches and weighed 1.9375 lbs.

The National Weather Service (NWS) reported record rainfall of 1.24 inches at Jamestown on the 13^{th}, 1.61 inches at Williston on the 23^{rd}, and 1.82 inches at Fargo on the 27^{th}.

The US Drought Monitor August 3, 2010 report had no drought conditions reported in the state.

The USDA, National Agricultural Statistics Service, North Dakota Field Office reported a topsoil moisture of 0% very short, 15% short, 77% adequate, and 8% surplus with a subsoil moisture reported as 1% very short, 12% short, 79% adequate, and 8% surplus (Weekly Weather and Crop Bulletin Vol. 97, No. 31).

According to the preliminary reports of the National Weather Service's Storm Prediction Center (SPC), severe weather reports for July had 53 reports of high wind, 87 hail reports, and 9 reported tornadoes.

The top five July daily maximum wind speeds recorded from NDAWN were Streeter on the 13^{th} with 67.0 mph, Leonard on the 14^{th} with 61.9 mph, Lisbon on the 14^{th} with 58.4 mph, Leonard on the 27^{th} with 57.3 mph, and Dazey on the 26^{th} with 56.2 mph. NDAWN wind speeds are measured at a height of 10 feet (3 m).

The state average air temperature was 68.6 °F which is nearly the same as the 1971-2000 normal of 68.7 °F. July 2010 state average air temperature ranked the 53^{rd} coolest in the past 116 years with a maximum of 79.7 °F in 1936 and a minimum of 61.8 °F in 1992.

July average air temperatures ranged from 65 °F to 73 °F with the lower temperatures in the north and higher temperatures in the southeast. July average temperatures were close to normal across the state with western region being slightly below normal and the eastern regions being slightly above normal. Departure from normal average air temperatures ranged from -2.2 °F to 3.4 °F. July's warm temperatures promoted good crop development throughout most of the month according to the USDA, National Agricultural Statistics Service, North Dakota Field Office.

The National Weather Service (NWS) reported record temperatures set in the first three days of July. On the 1st Grand Forks airport had a record high temperature of 94 °F and a record high minimum temperature of 70 °F. On the 2nd Grand Forks airport had a record high minimum temperature of 72 °F. On the 3rd Grand Forks airport had a record high minimum temperature of 75 °F and Fargo had a record high minimum temperature of 73 °F.

NDAWN's highest recorded daily air temperature for July was 98.7 °F at Britton SD on the 17th. The lowest recorded daily air temperature was 42.4 °F at Roseau MN on the 12th.

August 2010

The state average precipitation was 2.30 inches which is above the 1971-2000 normal of 2.10 inches. August 2010 state average precipitation ranked 41st wettest in the past 116 years with a maximum of 5.02 inches in 1900 and a minimum of 0.72 inches in 1961.

The North Dakota Agricultural Weather Network (NDAWN) August precipitation totals ranged from approximately 0.5 to 6.5 inches with the higher amounts of greater than 3 inches falling in the northwestern, north central, and southeast regions. NDAWN's percent of normal precipitation ranged from about 30% to 250%. Areas in the northwest, north central, southeast, and southwest edge had greater than 100% of normal with less than 100% falling elsewhere. Most of the daily rainfall events happened on the 1st and 2nd, 7th through the 13th, and the 30th. The National Weather Service (NWS) Storm Prediction Center reported 14 tornadoes in August. According to the NWS, on the 7th an EF3 (Enhanced Fujita Scale) tornado touched down about 10 miles south of Wahpeton, ND and tracked northwestward for approximately 5 miles, increasing in intensity to a low end EF4, and ended 7 miles south southeast of Breckenridge, MN. On the 12th the NWS reported an EF3 tornado near Bowbells that destroyed one home and damaged a second. The tornado also threw a car 200 yards resulting in one injury and one fatality.

The National Weather Service (NWS) reported one record rainfall in August of 2.36 inches on the 10th at the Grand Forks airport.

The US Drought Monitor August 31, 2010 report had abnormally dry conditions in the southwest and three counties in the central east. The remainder of the state had no drought conditions.

The USDA, National Agricultural Statistics Service, North Dakota Field Office reported a topsoil moisture of 1% very short, 31% short, 65% adequate, and 3% surplus with a subsoil moisture reported as 1% very short, 24% short, 70% adequate, and 5% surplus (Weekly Weather and Crop Bulletin Vol. 97, No. 35).

According to the preliminary reports of the National Weather Service's Storm Prediction Center (SPC), severe weather reports for August had 31 reports of high wind, 36 hail reports, and 14 reported tornadoes.

The top five August daily maximum wind speeds recorded from NDAWN were Hettinger on the 12th with 67.7 mph, Mott on the 12th with 65.9 mph, Williston on the 1st with 64.8 mph, Linton on the 12th with 63.7 mph, and Watford City on the 9th with 53.0 mph. NDAWN wind speeds are measured at a height of 10 feet (3 m).

The state average air temperature was 68.6 °F which is above the 1971-2000 normal of 67.23 °F. August 2010 state average air temperature ranked the 34th warmest in the past 116 years with a maximum of 73.6 °F in 1983 and a minimum of 60.9 °F in 1977.

NDAWN's August average air temperatures ranged from 65 °F to 73 °F. The eastern part of the state had above normal temperatures and the western part had near normal to below normal average air temperatures. NDAWN departure from normal air temperatures ranged from -1 °F to 4 °F. According to the USDA, National Agricultural Statistics Service, North Dakota Field Office much of August had warm, dry weather which allowed good progress for small grain harvest. High winds, especially around the middle of the month, caused damage to some crops. NDAWN on the 12th recorded a maximum wind speed of 68 mph at Hettinger, 66 mph at Mott, 64 mph at Linton and 50 mph at Bowbells. NDAWN wind speeds are measured at a height of 10 feet (3 m).

The National Weather Service (NWS) reported breaking two temperature records in August. The first was a record high temperature of 95 °F on the 9th at the Grand Forks airport. The second was a record high minimum temperature of 70 °F on the 22nd at Williston.

NDAWN's highest recorded daily air temperature for August was 102.8 °F at Linton on the 22nd. The lowest recorded daily air temperature was 36.5 °F at Bottineau on the 25th.

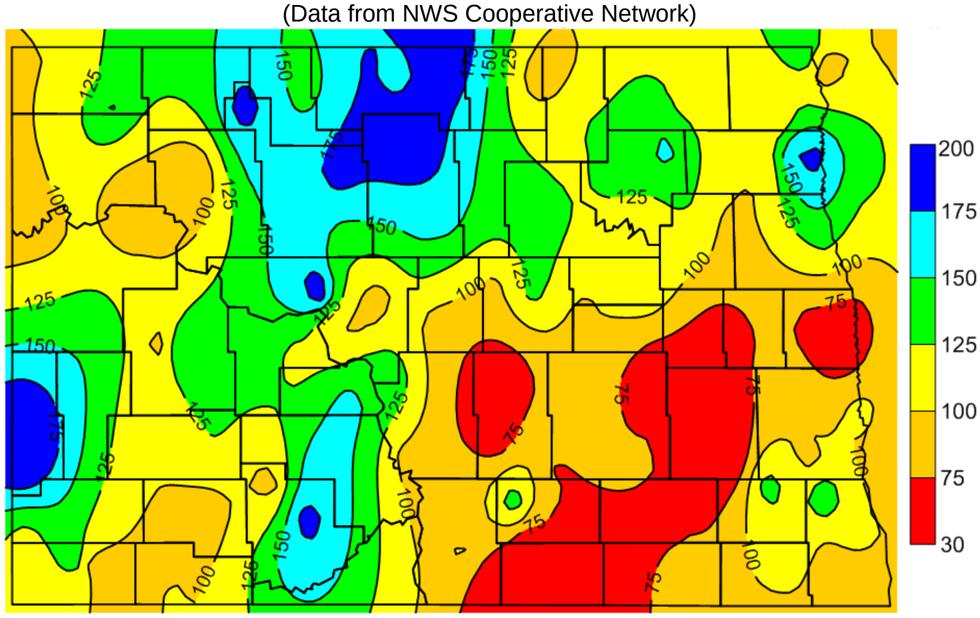
Season in Graphics

June 2010

Summer 2010 Weather in North Dakota:

Total Precipitation percent of mean (1971-2000)

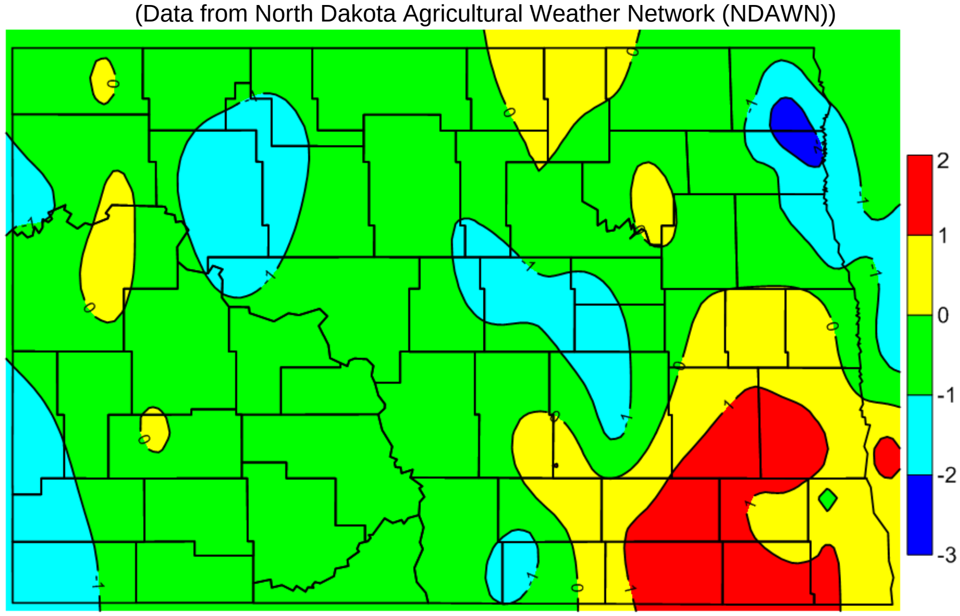
Precipitation Percent of Normal
(Data from NWS Cooperative Network)

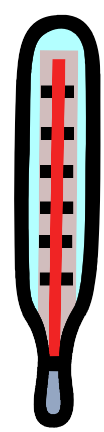


North Dakota State Climate Office

Average Temperature (°F) Deviation from Mean (1971-2000)

Departure From Normal Monthly
Average Air Temperature in degrees F
(Data from North Dakota Agricultural Weather Network (NDAWN))





North Dakota State Climate Office

Season in Graphics

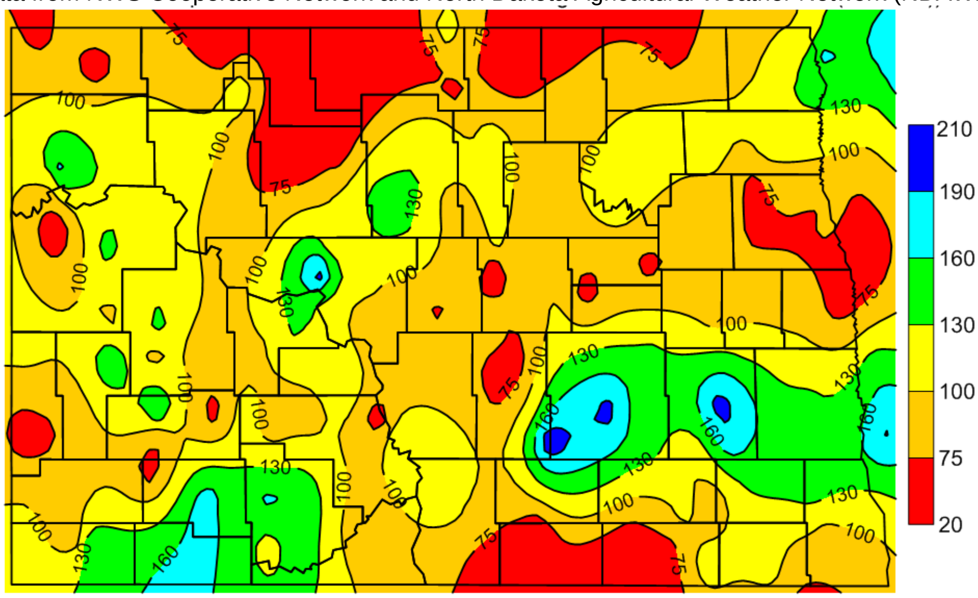
July 2010

Summer 2010 Weather in North Dakota:

Total Precipitation percent of mean (1971-2000)

Precipitation Percent of Normal

(Data from NWS Cooperative Network and North Dakota Agricultural Weather Network (NDAWN))

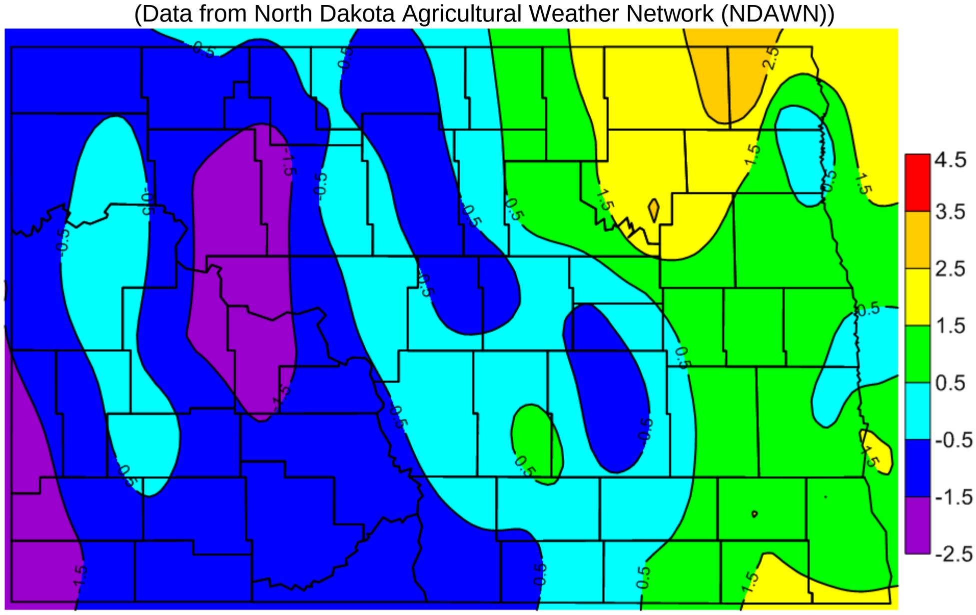


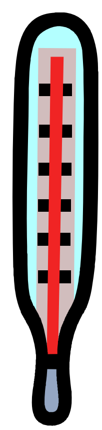
North Dakota State Climate Office

Average Temperature (°F) Deviation from Mean (1971-2000)

Departure From Normal Monthly
Average Air Temperature in degrees F

(Data from North Dakota Agricultural Weather Network (NDAWN))





North Dakota State Climate Office

Season in Graphics

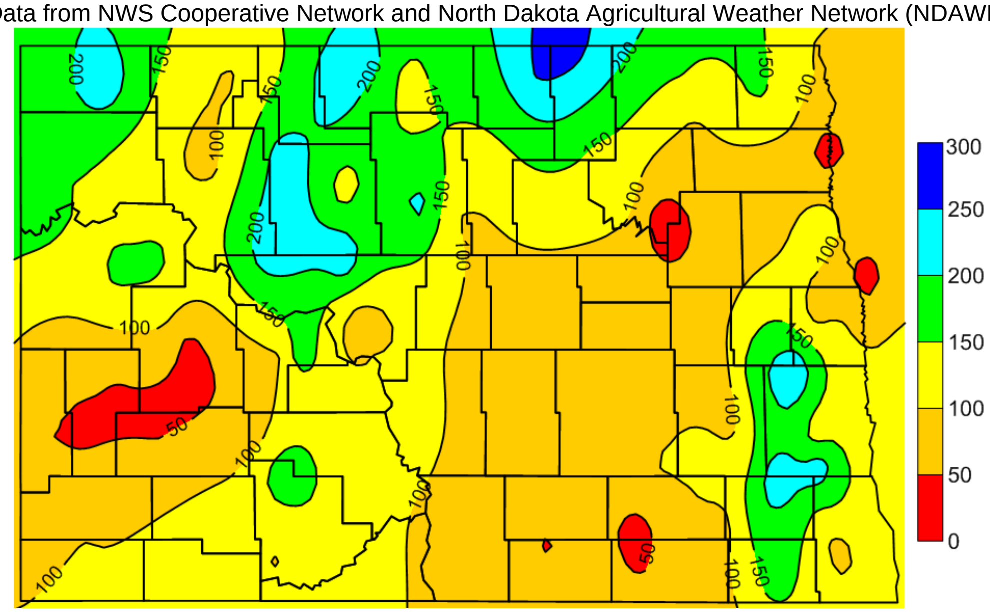
Summer 2010 Weather in North Dakota:

August 2010

Total Precipitation percent of mean (1971-2000)

Precipitation Percent of Normal

(Data from NWS Cooperative Network and North Dakota Agricultural Weather Network (NDAWN))

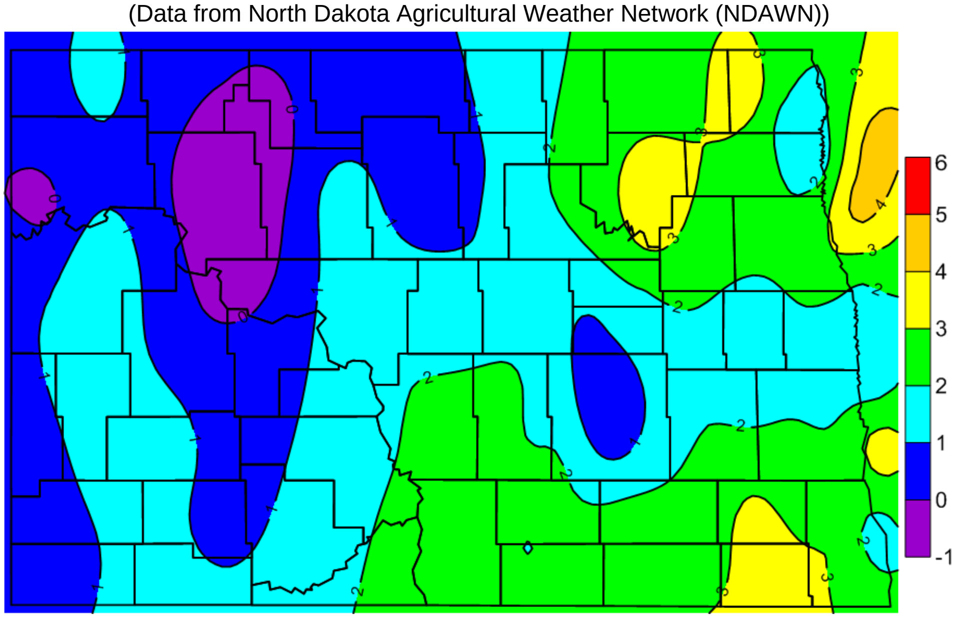


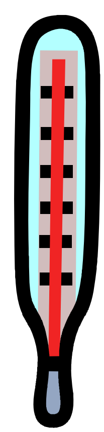
North Dakota State Climate Office

Average Temperature (°F) Deviation from Mean (1971-2000)

Departure From Normal Monthly
Average Air Temperature in degrees F

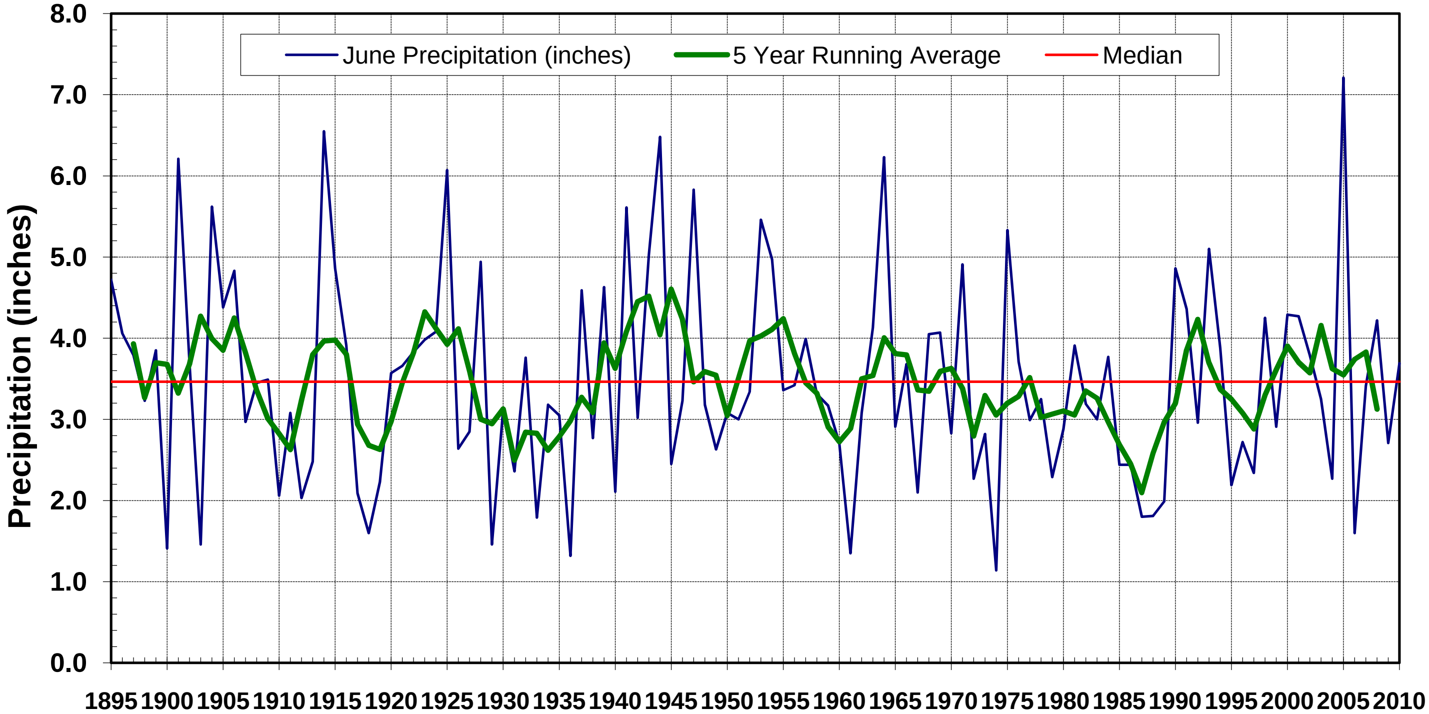
(Data from North Dakota Agricultural Weather Network (NDAWN))





North Dakota State Climate Office

Historical June Precipitation for North Dakota

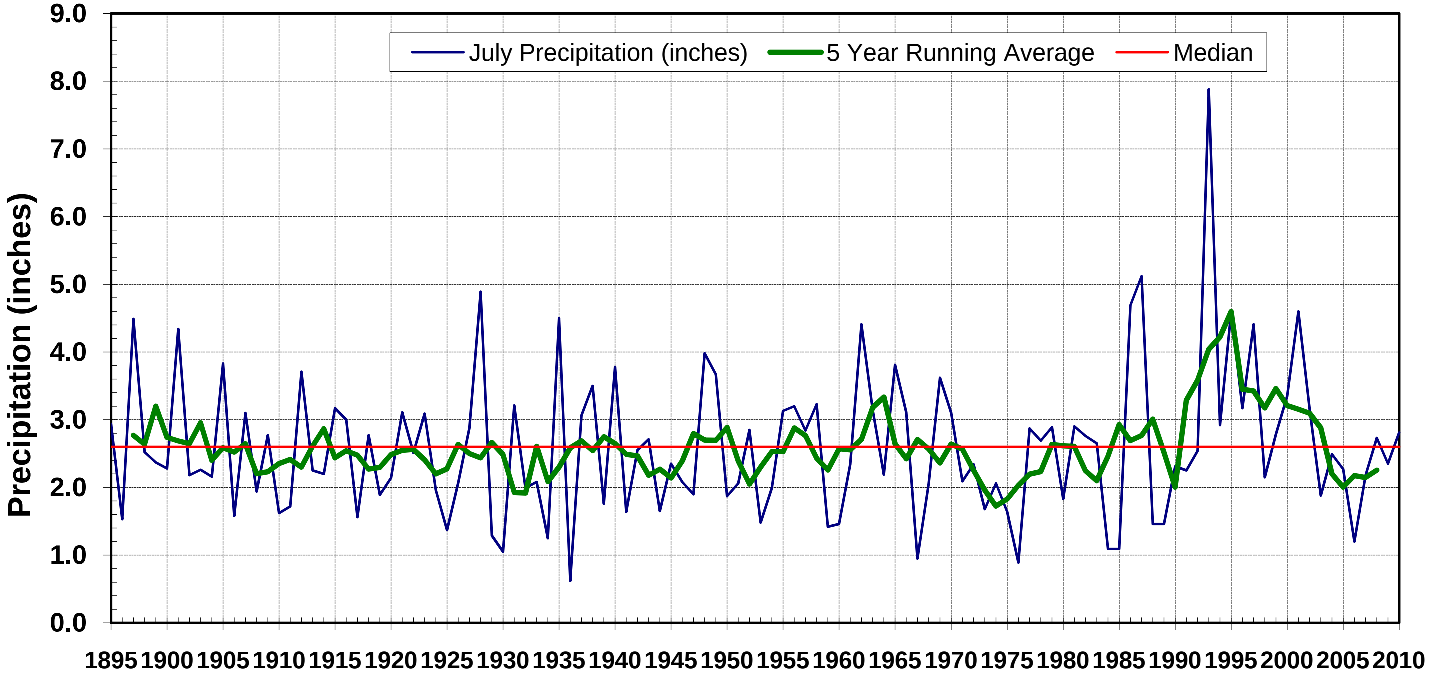


June Precipitation Statistics

2010 Amount: **3.69 inches**
Maximum: 7.21 inches in 2005
State Normal: 3.19" (1971-2000)

Monthly Ranking: 46th Wettest in 116 years
Minimum: 1.14 inches in 1974
Years in Record: 116

Historical July Precipitation for North Dakota

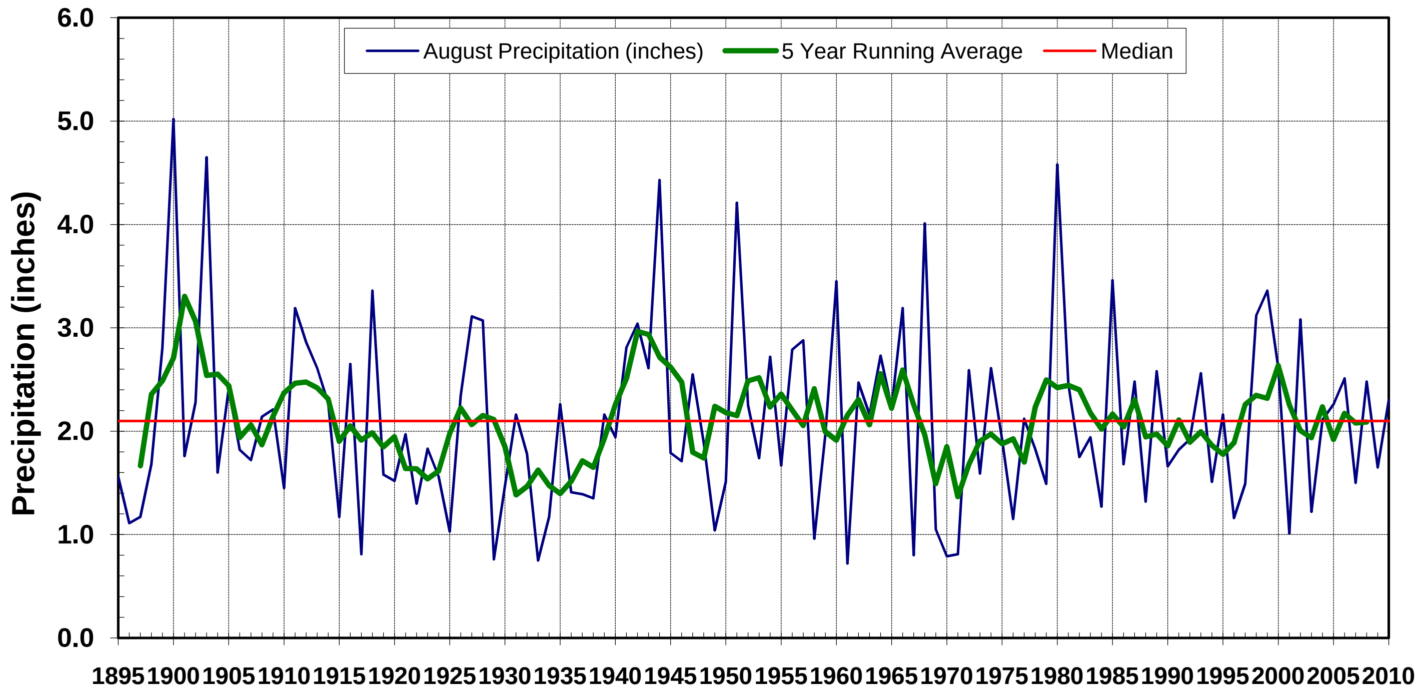


July Precipitation Statistics

2010 Amount: 2.81 inches
Maximum: 7.88 inches in 1993
State Normal: 2.75" (1971-2000)

Monthly Ranking: 44th wettest in 116 years
Minimum: 0.62 inches in 1936
Years in Record: 116

Historical August Precipitation for North Dakota

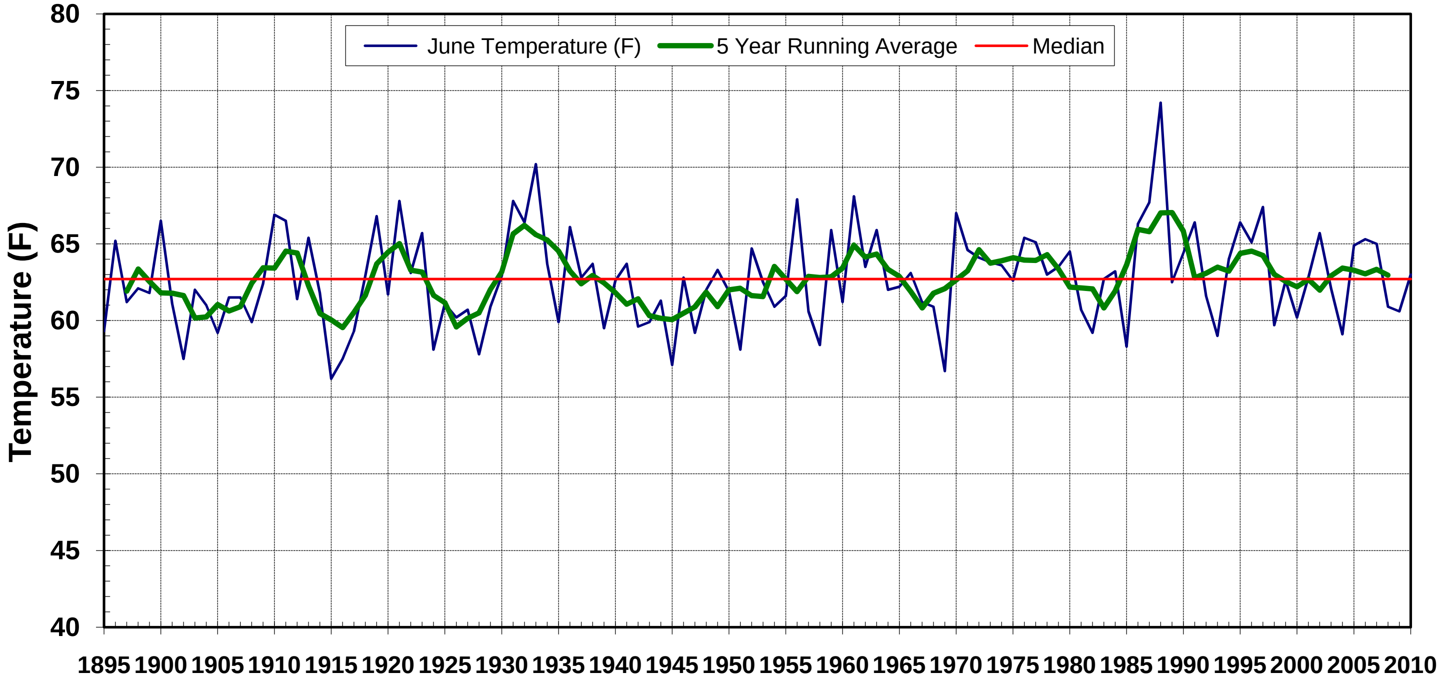


August Precipitation Statistics

2010 Amount: 2.30 **inches**
Maximum: 5.02 inches in 1900
State Normal: 2.10” (1971-2000)

Monthly Ranking: 41st wettest in 116 years
Minimum: 0.72 inches in 1961
Years in Record: 116

Historical June Temperature for North Dakota

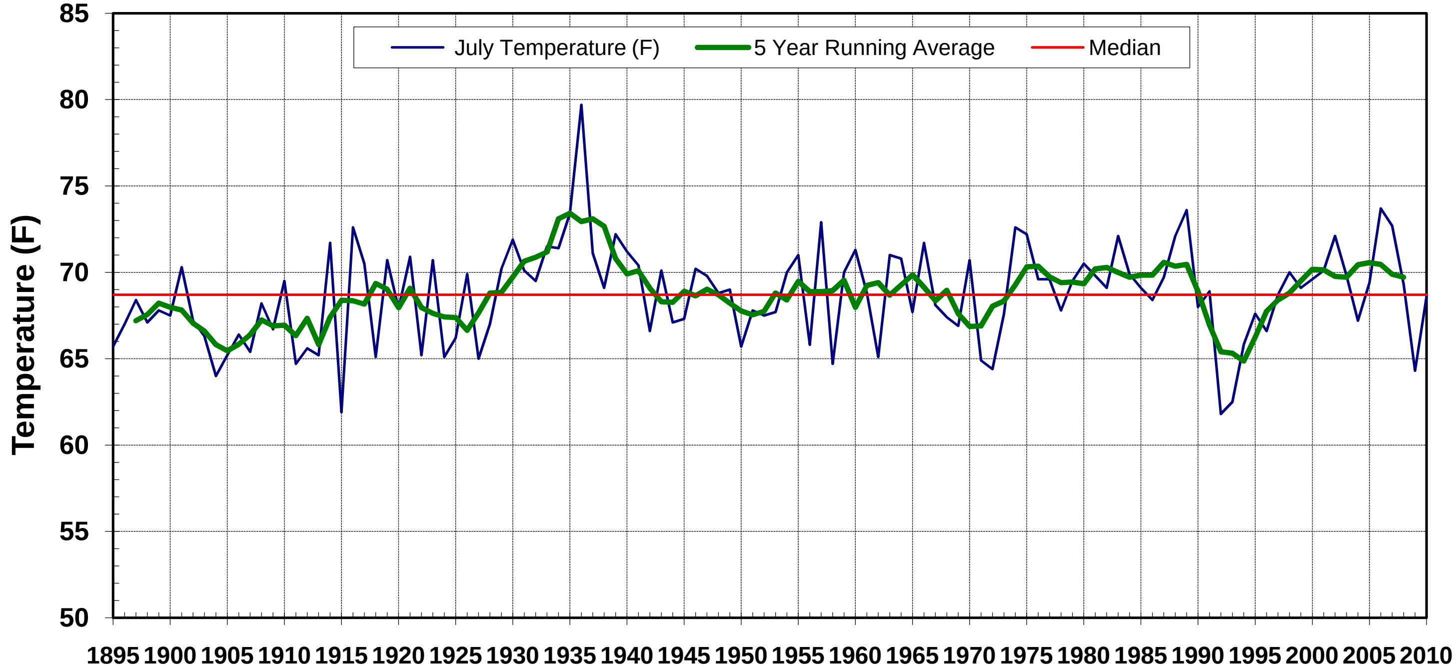


June Temperature Statistics

2010 Average: **63.0** °F
Maximum: 74.2 °F in 1988
State Normal: 63.73 °F (1971-2000)

Monthly Ranking: 49th Warmest in 116 years
Minimum: 56.2° F in 1915
Years in Record: 116

Historical July Temperature for North Dakota

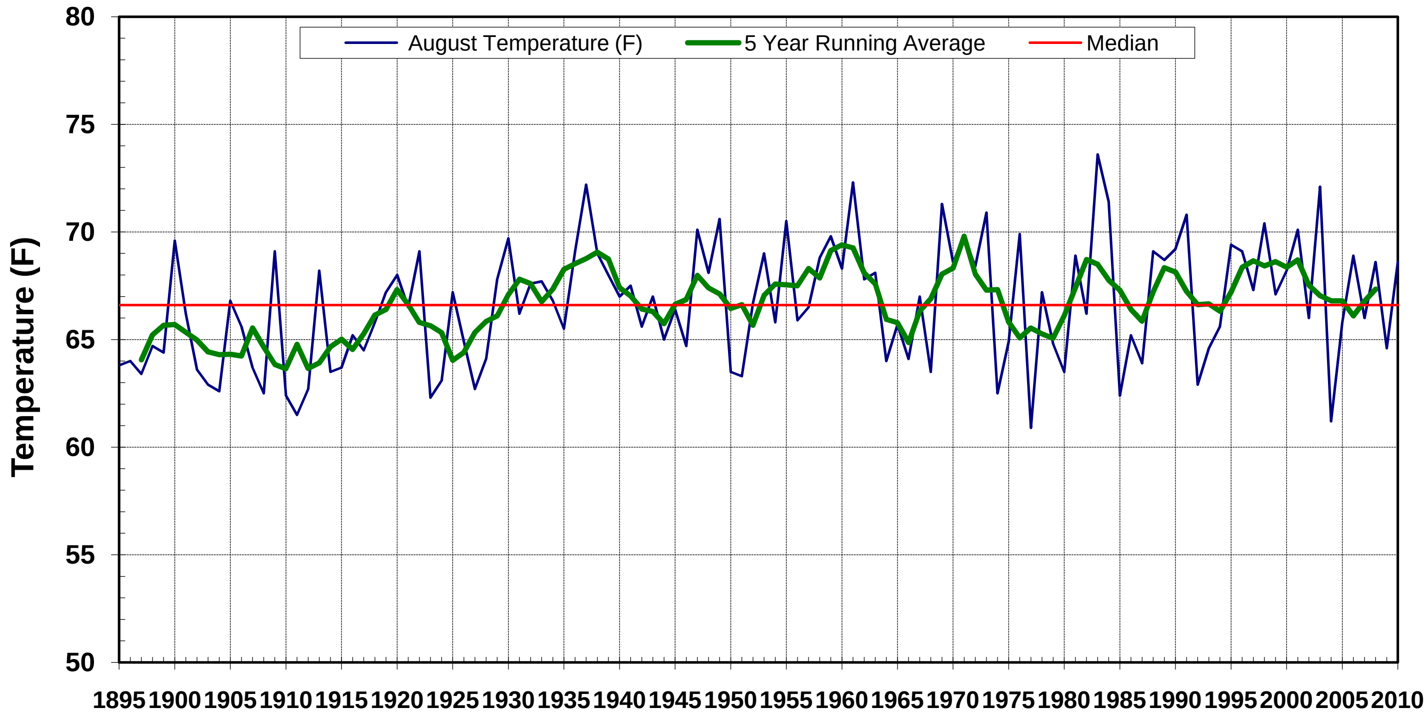


<u>July Temperature Statistics</u>

2010 Average: 68.6 °F
Maximum: 79.7 °F in 1936
State Normal: 68.7 °F (1971-2000)

Monthly Ranking: 53rd Coolest in 116 years
Minimum: 61.8 °F in 1992
Years in Record: 116

Historical August Temperature for North Dakota



<u>August Temperature Statistics</u>

2010 Average: **68.6 °F**
Maximum: 73.6 °F in 1983
State Normal: 67.23 °F (1971-2000)

Monthly Ranking: 34th Warmest in 116 years
Minimum: 60.9 °F in 1977
Years in Record: 116

Storms & Record Events

State Tornado, Hail, and Wind Reports for Summer 2010 by B. A. Mullins

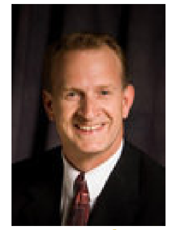
North Dakota 3 Month Total	Wind	Hail	Tornado
	143	179	64

Reports by Month			
Month	**Wind**	**Hail**	**Tornado**
Total June	59	56	41
Total July	53	87	9
Total August	31	36	14

North Dakota Record Event Reports for Summer 2010

Date	Location	Type of Record	Previous Record
06/17/10	Fargo	Rainfall of 1.89 inches	1.85 inches set in 1986
06/17/10	Grand Forks airport	Rainfall of 1.67 inches	1.50 inches set in 1992
06/17/10	Minot	Rainfall of 3.75 inches	2.12 inches set in 1957
06/30/10	Williston	High minimum temperature of 73°F	70 °F set in 1921
07/01/10	Grand Forks airport	High temperature of 94°F	93 °F set in 1974
07/01/10	Grand Forks airport	High minimum temperature of 70 °F	69 °F set in 1966
07/02/10	Grand Forks airport	High minimum temperature of 72 °F	68 °F set in 1990
07/03/10	Grand Forks airport	High minimum temperature of 75 °F	66 °F set in 1978
07/03/10	Fargo	High minimum temperature of 73 °F	71 °F set in 1975
07/13/10	Jamestown	Rainfall of 1.24 inches	0.62 inches set in 1981
07/23/10	Williston	Rainfall of 1.61 inches	1.33 inches set in 2007
07/27/10	Fargo	Rainfall of 1.82 inches	1.52 inches set in 1908
08/09/10	Grand Forks airport	High temperature of 95 °F	94 °F set in 1958 and 1947
08/10/10	Grand Forks airport	Rainfall of 2.36 inches	2.15 inches set in 1941
08/22/10	Williston	High minimum temperature of 70 °F	68 °F set in 1947
08/30/10	Williston	Low maximum temperature of 58 °F	Ties record set in 1956

Seasonal Outlook



Summer Climate Outlooks

by D. Ritchison[1]

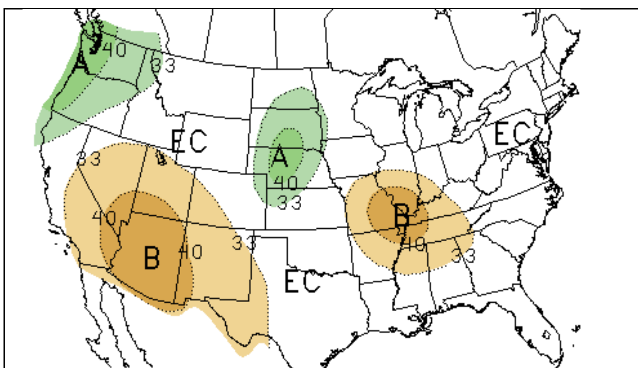
The summer of 2010 finished with both temperatures and precipitation finishing above average throughout much of North Dakota. So now the question is will this pattern continue or change as we move into autumn.

Many of you may have heard that a La Niña, the cold-water cousin to El Niño, has developed in the tropical Pacific Ocean. This oscillation of sea-surface temperatures and the correlating wind flow pattern changes, is often overused as a seasonally forecasting tool. There are numerous other signals, many of which are poorly understood, that influence the long-term weather patterns in North Dakota.

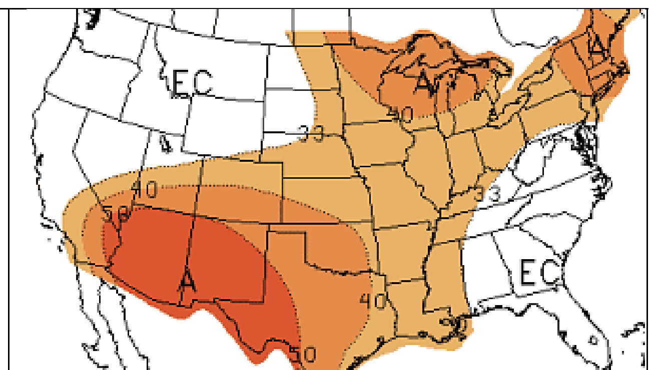
Having said that, historically, autumns with a La Niña pattern in the Pacific have been generally warmer than average with no good trend on rainfall. In other words, some have been wet, others being dry. My feelings are this autumn may differ from what we have seen in the past.

I am leaning toward our summer pattern continuing, especially during the first half of autumn. This will mean wetter than normal conditions throughout much of North Dakota this fall. This will correspondingly attribute to more cloudy days, probably keeping the overall temperature trend toward the long-term average.

Of course there is going to be the typical day-to-day *weather* that differs, but wetter than average conditions with near normal temperatures seem to be the trend for our fall season. This is reasonably close to what the Climate Prediction Center's autumn forecast for the area is that can be seen below.



September through November Precipitation Outlook



September through November Temperature Outlook

The North Dakota State climate Office has links to the National Weather Service's local 3-month temperature outlooks for the next 12-month period (updated monthly). Those outlooks can be found at:
http://www.ndsu.edu/ndsco/outlook/L3MTO.html

These outlooks are updated on the third Thursday of each month, with a final monthly outlook issued at the end of each month. These outlooks are available at http://www.cpc.ncep.noaa.gov/products/predictions/90day/

Also the readers will find the following National Weather Service office web sites very useful for shorter term weather forecasts:

Eastern North Dakota: http://www.crh.noaa.gov/fgf/
Western North Dakota: http://www.crh.noaa.gov/bis/

[1] The corresponding author: Daryl Ritchison is a broadcast meteorologist working at WDAY-TV Fargo, ND.
E-Mail: daryl@ritchison.com

Hydro-Talk

Transitioning into the Fall 2010 Hydrology

by A. Schlag[2]

As we exited the spring, not unscathed but certainly thankful it wasn't worse, we entered summer which is typically a fairly quiet time in terms of flooding across North Dakota. This was largely true this year although a single large storm pushed the Souris River downstream of Minot to flood stage for a number of days. But generally speaking, precipitation during the June to end of August timeframe was fairly normal to maybe slightly above normal for North Dakota. Normal, now there is an interesting word when it comes to describing the weather in North Dakota. Many people mistakenly define "normal" as something akin to a mathematical mean or "average" with regard to precipitation. Nothing could be further from the truth. Normal for North Dakota is actually a range of extremes, and sometimes opposite ends of those extremes can be witnessed in close proximity to each other. We all have seen where a heavy rain or hailstorm destroyed the crop on one side of the road but left the field on the other side literally unscathed. But to really put this into perspective I will use a precipitation map from the North Dakota Agricultural Weather Network (Figure 1).

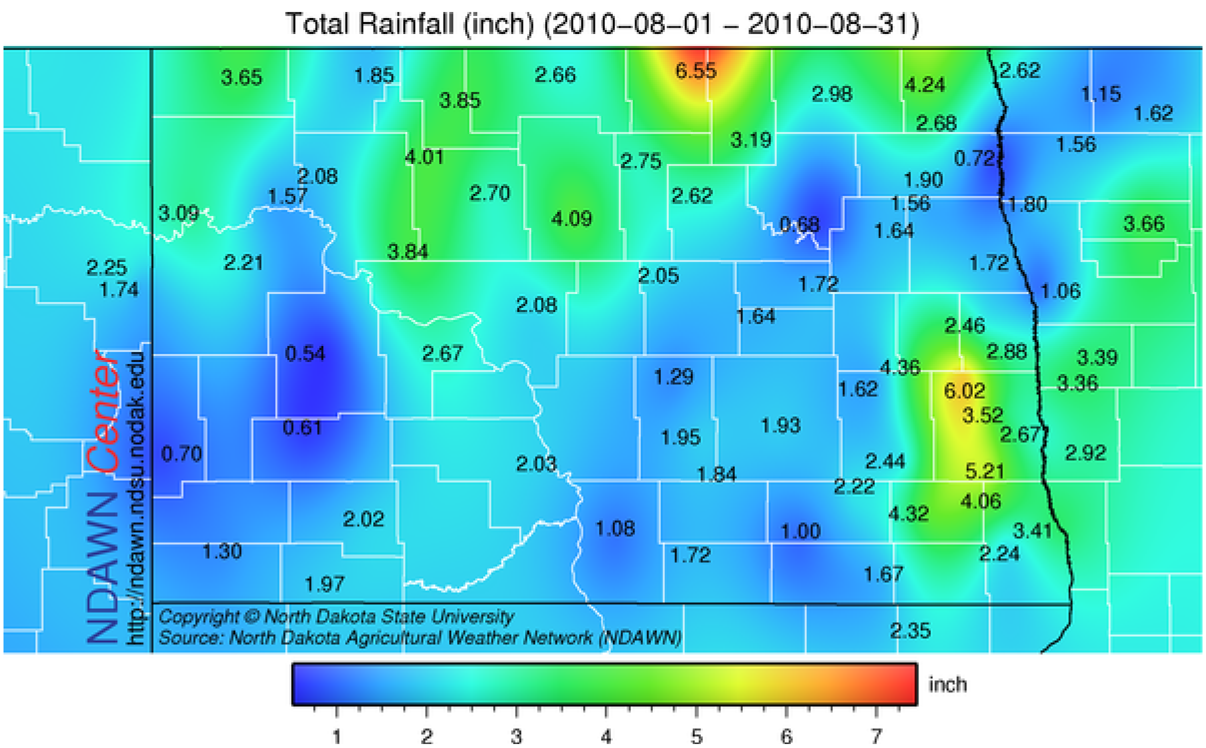


Figure 1. August precipitation map for North Dakota available at the North Dakota Agricultural Weather Network: http://ndawn.ndsu.nodak.edu/

As shown above in Figure 1, it is not unusual in a precipitation map to see well defined areas of high precipitation within as little as 15 miles from an area of very low precipitation. Some of

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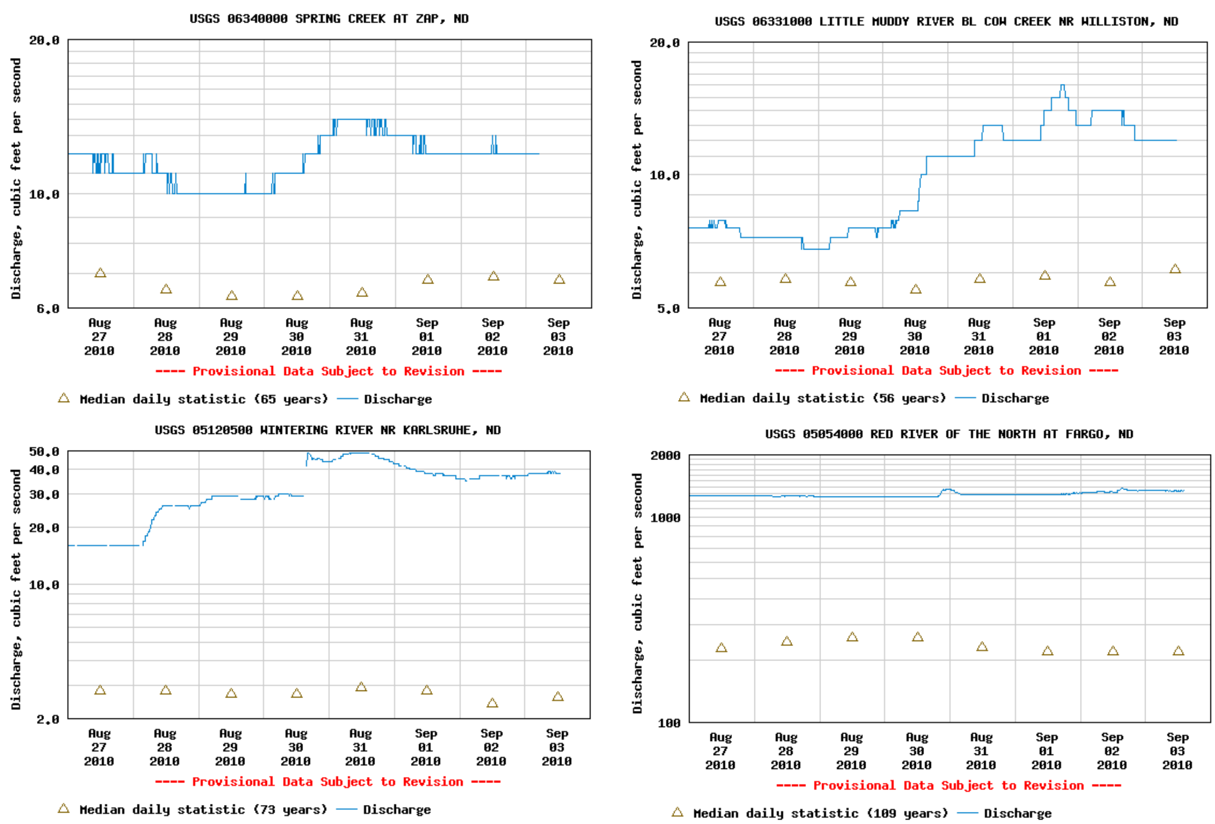
this is because of the distance between neighboring rain gauges, and some is the result of statistical programs used to generate the maps. Perhaps nowhere is the difference between the haves and have-nots in precipitation more easily observed than in North Dakota.

Few large watersheds ever receive a very high amount of precipitation across the entire basin during a given month. If we were to look even closer at a daily precipitation map of a significant event, we would note that only very small areas received greater than an inch or two during any given 24 hour period. This net result of small areas of haves and have-nots within the same watershed helps to minimize the likelihood of major flooding along streams and rivers in North Dakota.

What this pattern of precipitation can do is combine locally strong runoff from ephemeral streams with groundwater baseflow into the larger streams and result in very healthy streamflow overall.

In order to illustrate this point, I will use the some recent 7-day hydrographs available from the USGS' North Dakota Water Science Center webpage for somewhat randomly selected river gages across the major watersheds (Red, Souris, and Missouri) of North Dakota. (Note: I specifically avoided using sites immediately downstream of major dams). As depicted in the discharge hydrographs below, each site is well above the median daily value for that location. This strongly suggests that it has been a good, if not great, year for stream levels with little to no concern about low water levels this year.



Figures 3-6. Randomly selected USGS river gages across North Dakota from http://waterdata.usgs.gov/nd/nwis/current/?type=flow.

Along with the above rivers in the graphs above, reservoirs and lakes in North Dakota have also remained nearly full, and in some cases, above desired levels. Due to spring flooding, both the Jamestown Dam and Pipestem Creek reservoirs above Jamestown were used to hold back tremendous amounts of water which was then slowly let out over the course of the summer in order to alleviate downstream flooding. Similarly, Lakes Oahe and Sakakawea also were both above their normal operating pool levels for much of the summer. In fact both lakes spent considerable time in what is considered the exclusive flood control zone of >1850 MSL for Lake Sakakawea and >1817 MSL for Lake Oahe. The overall wet conditions leading to flooding in downstream states along the Missouri River helped keep these reservoirs at unusually high levels as releases from the Missouri River dams were restricted in order to not cause unnecessary problems.

Every corner of North Dakota would seem to be included with the abundance of surface water this year. Numerous areas of the prairie pothole region are still brimming with water even in the wetlands that historically tend to go dry during the summer. Even the state's largest natural lake, known as Devils Lake, retained a very high profile by setting yet another modern day record of 1,452.05 ft MSL in late June. Perhaps the most troubling aspect as we head into fall and winter of all these bodies of water is that few, if any, are on track to lose as much as is normal from its high point for the year as is historically the norm. This observation is notable given the need in many areas for these wetlands to be able to absorb or temper runoff during next spring's snowmelt.

Ah, snowmelt. While it may be a little early to speak of the white stuff, the current long-term outlook is discussing expectations for another La Niña fall and winter. Not that this is a 100% indicator of what is in store for North Dakota over the winter of 2010-11, but more often than not, La Niña means wetter than normal winters for North Dakota.

Science Bits

Ingredients for a Severe Storm Recipe:

by F. A. Akyüz[3]

Heat, Moisture and North Dakota

Cool and moist conditions normally go hand-by-hand. When the soil is moist, more evaporation takes place into the atmosphere than if it were dry. Six hundred calories of heat energy is necessary to evaporate each gram of water. Atmosphere supplies the necessary heat to evaporate as much water as air can hold, depending on the air temperature. Therefore, the more evaporation that takes place, the more heat (energy) is taken away from the atmosphere, causing air to cool. This process is called latent heat exchange.

Most places in North Dakota were wet this summer. Then why were they not cool? There is also a process where radiant heat (directly from the sun through the space), conductive heat (from the soil into the air immediately above it through the molecules), and convective heat (mass displacement of heated layer of air just above the soil upward) occurs during the course of a day. This process is called sensible heat exchange. Sensible heat and latent heat exchange continually occur simultaneously to form an energy budget that dictates air temperature. However, this is only half of the story that explains the local changes. The second half is the "advection", mass transport of air horizontally and/or vertically, from one place to another. Each of these variables and their role in local weather can be discussed in a semester-long course. In short, there are many factors in determining local temperature variation.

Why is heat a factor in the development of a severe storm? Positive heat budget increases the temperature of the air which is more buoyant (less dense) than the surrounding air. Therefore warmer air rises. This is called "convection." The role of convection is also discussed below.

Why is moisture a factor in the development of a severe storm? It is a factor in two aspects

1. Moist air is lighter than dry air at the same temperature. Therefore moist air will rise in the presence of dryer air. Again the convection begins.
2. When the moist air rises, pressure of the surrounding air decreases with height. This causes the volume of the rising moist air to expand. Expansion of the air causes the temperature to fall. It is an internal process and requires no heat exchange between the rising air and the air that surrounds it. It is called "adiabatic cooling". Adiabatic cooling cause water vapor, which the rising moist air holds, to change phase from vapor to liquid, also known as "condensation." Because at lower temperatures, air can hold less water vapor. Any additional water will be in the form of liquid water. During the condensation process, six hundred calories of heat for each gram of water is released back to atmosphere. (Remember, the 600 calories of heat was taken away from the air at the ground level to evaporate the water). This is an important process by which the heat is transported into the atmosphere from the lower atmosphere to upper atmosphere (and from lower latitudes to higher latitudes). At the same time, this energy can be used to fuel severe storms including hail, tornadoes and hurricanes. Storms utilize the energy that is released into the middle atmosphere to sustain upward motion or convection.

Why is convection a factor in the development of a severe storm? Where the air rises vertically, there must be a horizontal motion towards the rising air at the surface from every direction to fill the mass that is displaced vertically by rising air. We call this "surface convergence". Air converges into a region of low pressure (air moves from high pressure to low pressure) then rises. However, air does not rush into a low pressure center in a direct line. Because of the Earth's rotation, the motion of the air is deflected to its right (also known as Coriolis deflection) causing a counterclockwise rotation around the low pressure center. The lower the pressure inside the low center, the greater the pressure gradient becomes. The greater the pressure gradient force, the faster the air rushes into the low pressure center, causing a stronger convection. This process yields deep clouds that persist long enough to produce severe weather, including hail and tornado.

Even though the rotation of the tornadoes are independent from the Coriolis force as it occurs in too small scale to be impacted by it, most often tornadoes do rotate counterclockwise just like the low pressure centers and associated parent clouds they are imbedded in.

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The summer of 2010 was wet and hot in most places in North Dakota which provided favorable conditions for severe weather. This summer, North Dakota experienced well above normal severe storm activities with 64 tornadoes, 179 hail events and 143 high wind events (based on preliminary numbers).

North Dakota averages 23 tornadoes per year based on tornado climatology between 1950 and 2009. A record number of tornadoes occurred in 1999 with 65 reported tornadoes based on the National Climatic Data Center's (NCDC) data, costing $6,382,000 in property and crop damage to the citizens of North Dakota. Tornadoes cause nearly an average of $3.5 million in damage annually in North Dakota. 2007 was among the costliest years, with $60 million tornado-related property and crop damage.

On the average, most tornadoes in North Dakota occur in July. As most tornadoes occur during the afternoon when the solar heat energy is at its peak, the North Dakota tornadoes occurred most frequently between 3:00 and 4:00 PM. Cass County reported the most tornadoes since 1950 because it has the greatest population density in the State, meaning few tornadoes have gone unnoticed in Cass County.

North Dakota ranks nineteenth in the number of tornadoes that occur annually in the United States. When divided by population, North Dakota ranks 3rd in the nation in terms of population-weighted average. The risk of death in North Dakota is one out of 1,263,665 ranking 26th in the risk of death by tornadoes list in the nation. The cost of damage per person in the state per year is $5 ranking North Dakota 15th in the nation.

Heat and moisture do not always cause severe storms. The atmospheric process is so complex, predicting its next move skillfully is nearly impossible.

Remaining of an automobile thrown into a sugarbeet field in Richland County ND after an EF3 tornado (which became an EF4 as it entered into Wilkin County, MN) on August 7, 2010 showing the damage capabilities of tornadoes (Photo courtesy of National Weather Service Grand Forks Office).

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