NORTH DAKOTA STATE CLIMATE OFFICE ndsco

North Dakota Climate Bulletin

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In This Issue

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Graphics
NCEI, NDSCO, NDAWN, NOAA, CPC, USDM

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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, College of Agriculture, Food Systems, and Natural Resources, North Dakota State University, Fargo.

The overall summer temperature was 1.4 degrees warmer than average, and it was the 21st warmest on record. Precipitationwise, it was the 39th wettest summer on record since 1895 in North Dakota. Overall, 94 high and 62 low daily temperature records were broken or tied. In addition, 53 daily precipitation records were broken or tied. A total of 209 records, including temperature- and precipitation-related occurrences across the state, were tied or broken.

Drought conditions improved towards the middle, but worsened towards the end of the season. By the end of the season, the northern half of the state was still experiencing at least a moderate drought. Warmer than normal temperatures pushed the crops ahead of their normal developmental stages. While the July moisture was plenty, August precipitation did not satisfy the plant water use, leading to a drought stress on certain crops. The Science Bits section in this bulletin explains the 2018 drought stress in corn in North Dakota.

Detailed monthly climate summaries for June, July and August, along with several other local resources for climate and weather information, can be accessed at www.ndsu.edu/ndsco/.

Prairie Wind, Valley City (Vern Whitten Photography)

Adnan Akyüz, Ph.D., North Dakota State Climatologist

Weather Highlights

Seasonal Weather Summary: By Adnan Akyüz

Precipitation

Using analysis from the National Centers for Environmental Information (NCEI), the average North Dakota precipitation for the summer season (June 1 through Aug. 31, 2018) was 8.91 inches, which was 5.19 inches more than the last season (spring 2018) and 2.68 inches more than last summer (summer 2017) and 0.61 inch greater than the 1981-2010 average summer precipitation. It also was the wettest summer since 2016 (Table 1). This would rank summer 2018 as the 39th wettest summer since such records began in 1895. The state's highest seasonal accumulation of precipitation was 16 inches, which fell in Litchville, Barnes County. Figure 1 shows the percent of normal precipitation distribution geographically. Based on historical records, the state average summer precipitation showed a positive long-term trend of 0.16 inch per century during this period of record since 1895. The highest and lowest seasonal summer average precipitation for the state ranged from 15.54 inches in 1993 to 3.32 inches in 1929. The "Historical Summer Precipitation for North Dakota" time series on Page 5 shows a graphical depiction of these statistics.

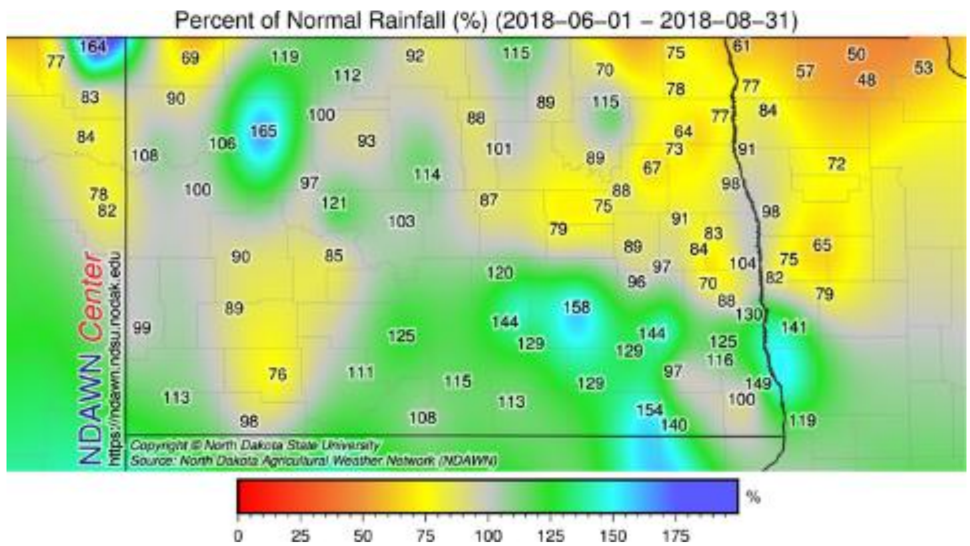


Figure 1. Precipitation percent of normal in summer 2018 for North Dakota. (North Dakota Agricultural Weather Network, NDSU)

Table 1. North Dakota Summer Precipitation Ranking Table.

Period	Value	Normal	Anomaly	Rank	Wettest/Driest Since
Summer 2018	8.91"	8.3"	+0.61	86th driest 39th wettest	Driest since 2017 Wettest since 2016

Temperature

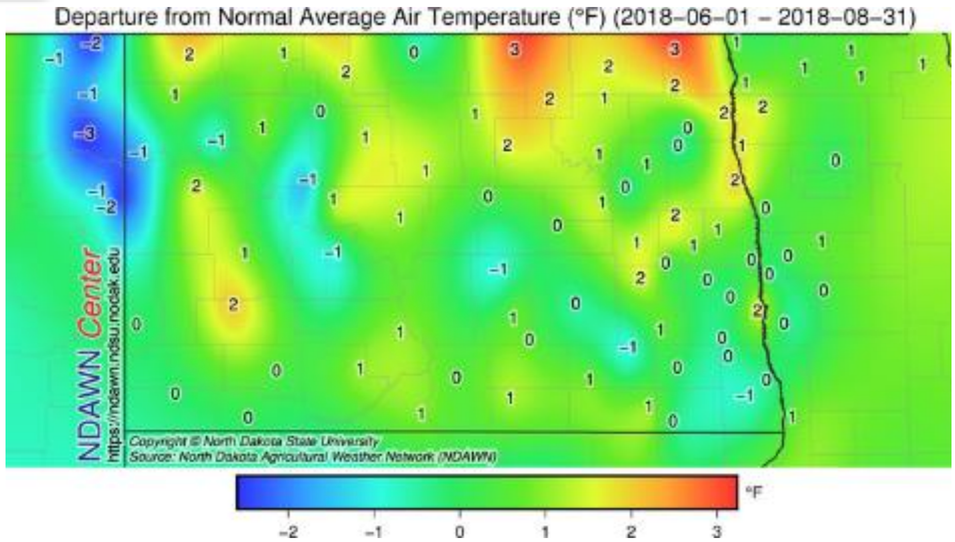


Figure 2. Temperature departure from normal in summer 2018 for North Dakota. (NDAWN)

The average North Dakota temperature for the season (June 1 through Aug. 31, 2018) was 68.1 F, which was 28.1 F warmer than the last season (spring 2018), 0.7 F warmer than last summer (2017) and 1.4 F warmer than the 1981-2010 average summer temperature. It also was the warmest summer since 2012. This would rank summer 2018 as the 21st warmest summer since such records began in 1895 (Table 2). Figure 2 shows the departure from normal temperature distribution geographically. Based on historical records, the average summer temperature showed a positive trend of 0.15 F per decade since 1895. The highest and lowest seasonal summer average temperatures for North Dakota ranged from 72 F in 1936 to 61.2 F in 1915. The "Historical Summer Temperature for North Dakota" time series on Page 6 shows a graphical depiction of these statistics.

Table 2. North Dakota Summer Temperature Ranking Table.

Period	Value	Normal	Anomaly	Rank	Warmest/Coolest Since
Summer 2018	68.1	66.7	+1.4	104th coolest 21st warmest	Coolest since 2017 Warmest since 2012

Drought: Despite the wetter than normal overall seasonal precipitation accumulations, warmer-than-normal conditions created an evaporative stress, causing the loss into the atmosphere of valuable water that could be used by the plants. In addition to the accumulating effect since the 2017 growing season, drought conditions made a complicated turn throughout the season, with improvement in the beginning of the season and worsening conditions toward the end (Figure 4). By the end of the season, 26 percent of the state still was experiencing drought (a 26 percent reduction in coverage, compared with the beginning of the season), only 3 percent of which was in the severe category. Figure 3 below shows the drought conditions in the beginning and the end of the summer (Figure 3).

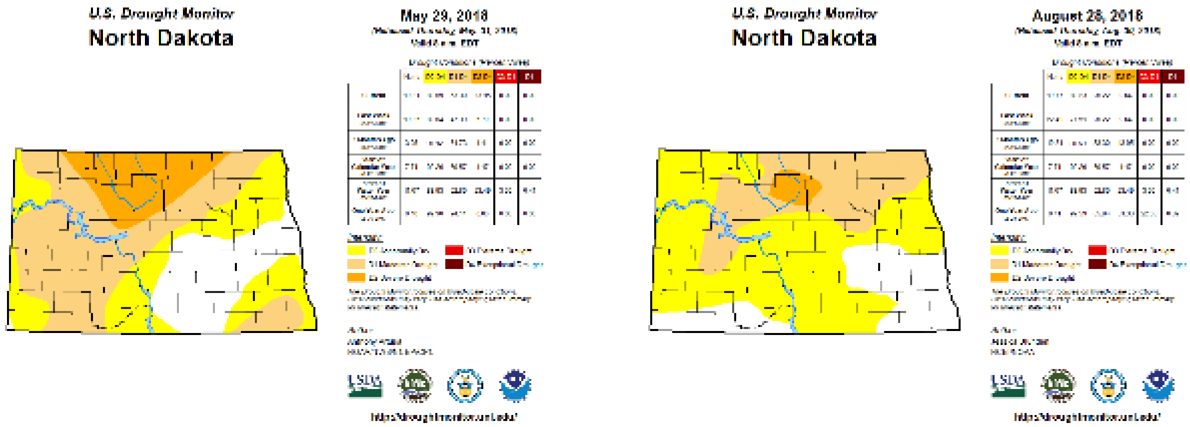


Figure 3. Drought Monitor map comparison for North Dakota in the beginning (on the left) and at the end (on the right) of summer 2018. (U.S. Drought Monitor)

Figure 4 below shows the statewide drought coverage in percentage and intensity (DO, D1, etc.) in time scale representing the state from the beginning to the end of the month, with a one-week resolution.

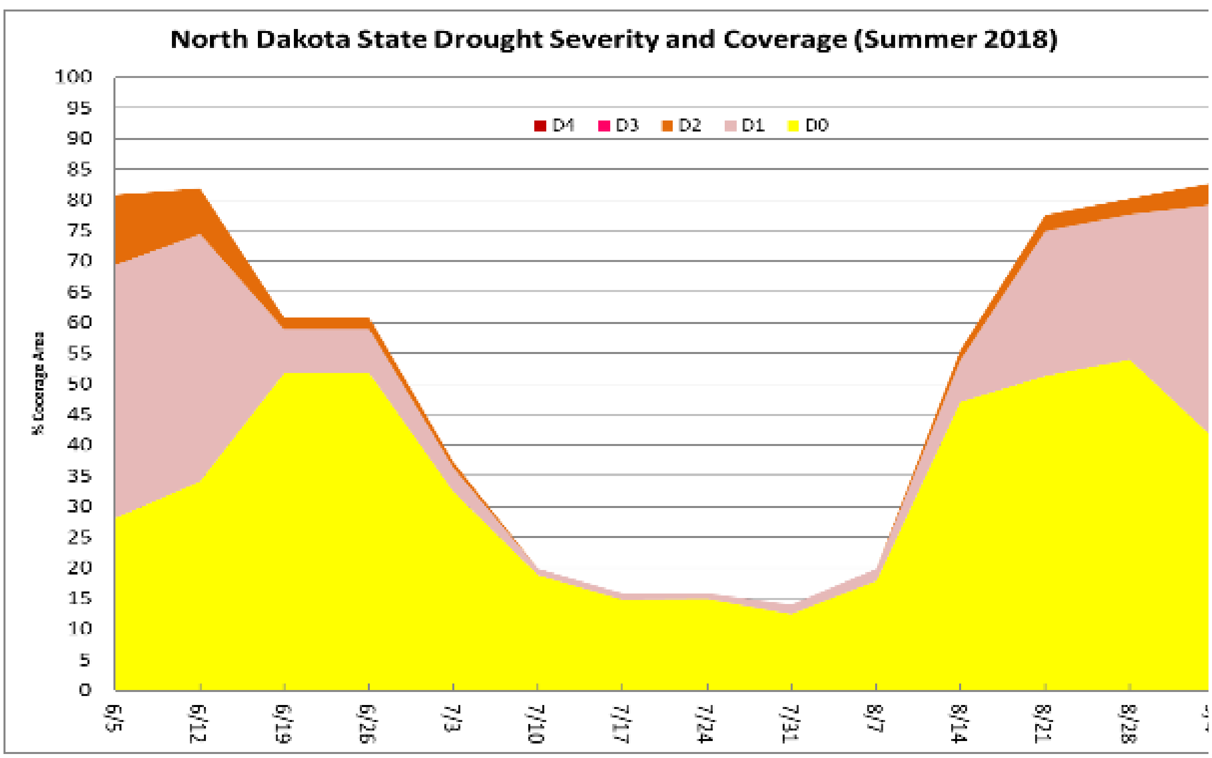
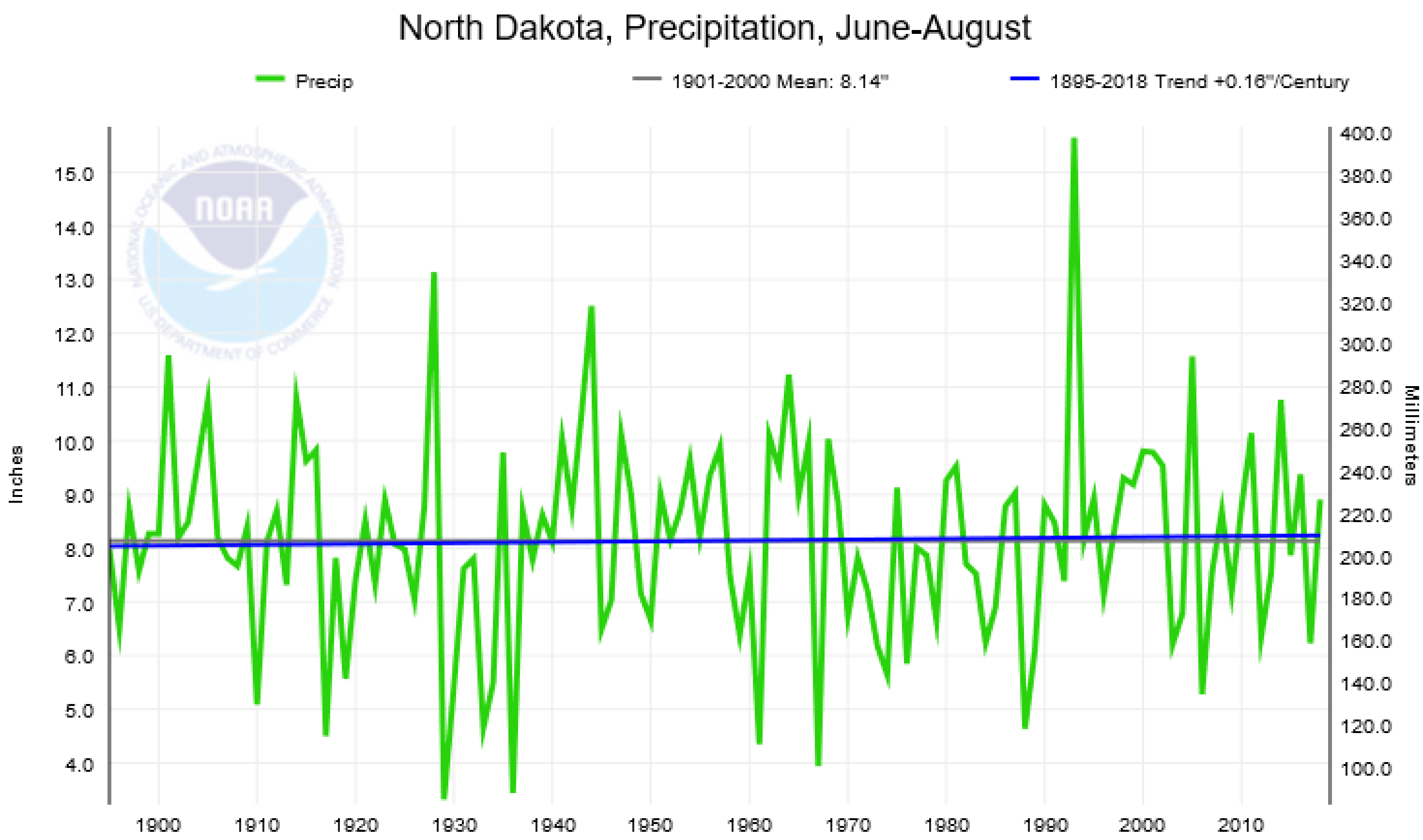


Figure 4. Statewide drought coverage (%) and intensity (Dx) in summer 2018. (USDM)

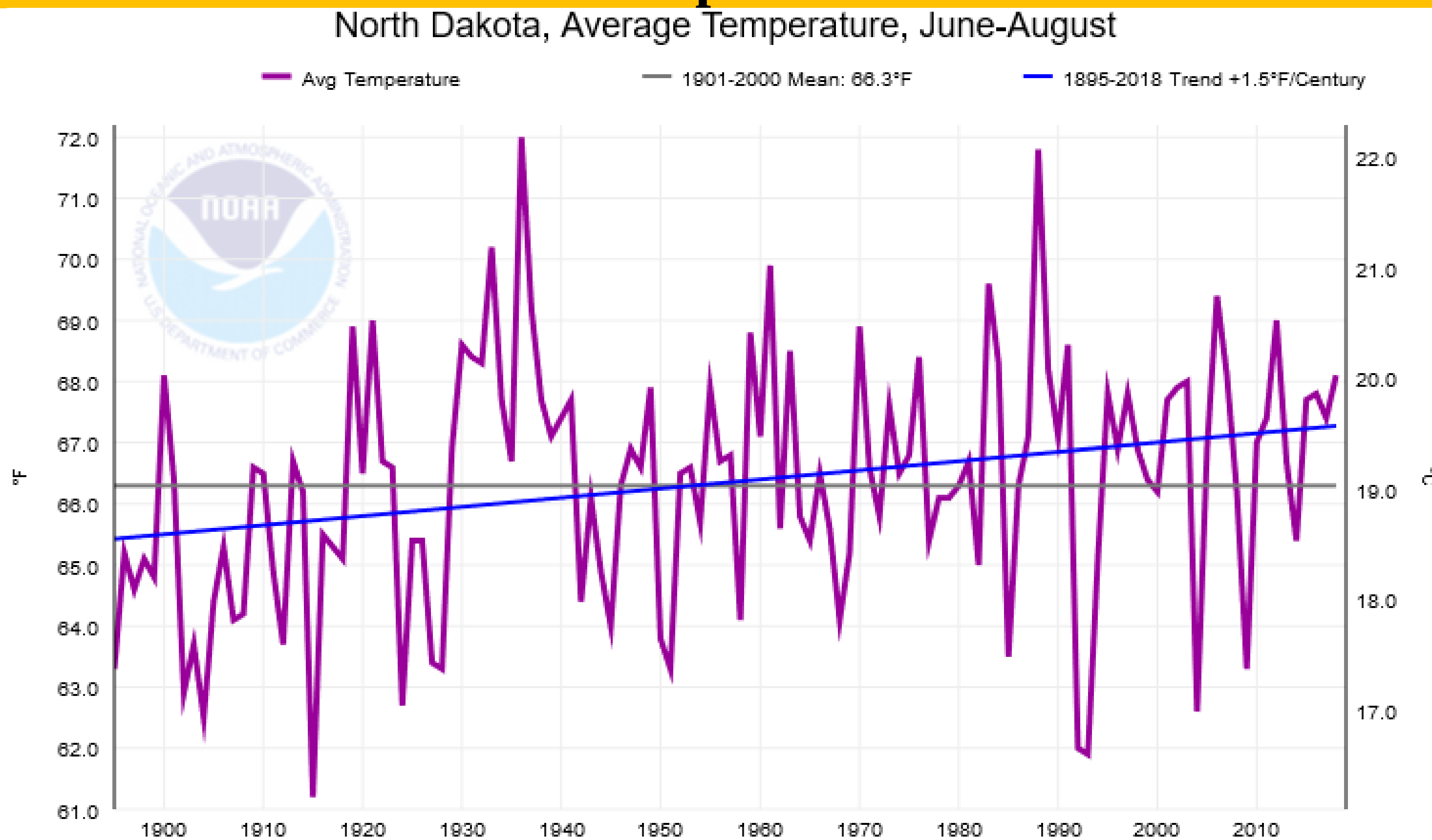
Historical Summer Precipitation for North Dakota



Record high value: 15.54 inches in 1993
Record low value: 3.32 inches in 1929
Seasonal trend: 0.16 inch per century

Summer 2018 value: 8.91 inches
1981-2010 average: 8.3 inches
Seasonal ranking: 39th wettest summer
Record length: 124 years

Historical Summer Temperature for North Dakota



Record high value: 72 F in 1936
Record low value: 61.2 F in 1915
Seasonal trend: 0.15 F per decade

Summer 2018 value: 68.1 F
1981-2010 average: 66.7 F
Seasonal ranking: 21st warmest summer
Record length: 124 years

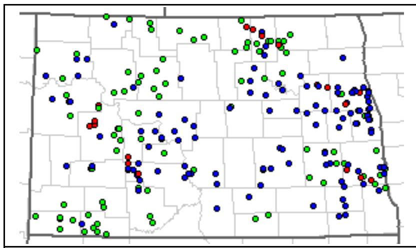
Storms and Record Events

State Tornado, Hail and Wind Events for Summer 2018

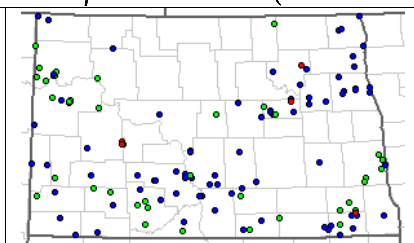
Table 3. Numbers in the table below represent the number of tornado, hail and wind events accumulated monthly and seasonally.

Month	Tornado	Hail	Wind	Total
June total	21	103	125	**249**
July total	7	42	85	**134**
August total	0	21	12	**33**
Seasonal total	**28**	**166**	**222**	**416**

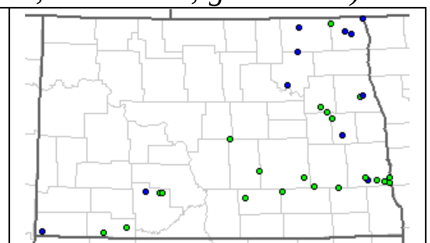
The graphics below show the geographical distribution of the storm events in the table above in each month. The dots are color-coded for each event (red: tornado; blue: wind; green: hail).



June 2018
North Dakota Storm Events



July 2018
North Dakota Storm Events



August 2018
North Dakota Storm Events

State Record Events for Summer 2018

Table 4. Numbers in the table below represent the number of select state record events (records broken or tied) accumulated monthly and seasonally.

Category	June	July	August	Seasonal Total
Highest daily max. temp.	6	0	39	**45**
Highest daily min. temp.	18	22	9	**49**
Lowest daily max. temp.	2	4	49	**55**
Lowest daily min. temp.	0	1	6	**7**
Highest daily precipitation	19	23	11	**53**
Highest daily snowfall	0	0	0	**0**
Total	**45**	**50**	**114**	**209**

Seasonal Outlook

Fall 2018 Outlook

By R. Kupec[1]

Summer 2018 started warm and wet across North Dakota and ended slightly cool and dry. The summer outlook called for near normal precipitation and slightly above-average temperatures. When all the summer numbers were combined, that is exactly how summer 2018 will go in the record books. The summer outlook also mentioned that northeastern North Dakota tended to be a little drier in the prevailing weather pattern, and that scenario also was true. The neutral phase of the La Niña/El Niño in the southern Pacific remains in place, with a turn to El Niño conditions expected by the winter. In many ways, this is analogous to conditions in the fall of 2015. That autumn started warm and dry in September and October, then turned sharply colder in November, but the dry conditions continued. I would expect a similar scenario this fall, with the turn to cold in November not being quite as dramatic. Winter 2015/16 saw a strong El Niño develop. The forecast for the expected El Niño this winter is not so extreme. In some falls with a developing El Niño, the onset of cooling can start earlier in western portions of North Dakota.

Precipitation this fall may not play out exactly as it did in 2015, which was fairly dry. Given current weather patterns and other conditions in the northern Pacific, I would expect the summer pattern of near- to slightly below-average precipitation to continue into the fall. While characteristically dry, some onset El Niño autumns are marked by an early snowfall. No telling if that will be the case this year, but that early snowfall usually is followed by a less-than-impressive amount of snow in the winter.

The current Climate Prediction Center (CPC) fall outlook gives nearly all of North Dakota a 33 percent chance of above-average temperatures for the season. A slightly higher chance is likely in the extreme southeastern corner of the state (see Figure 5a). The CPC outlook has an equal chance of above- or below-average precipitation (see Figure 5b).

The next 90-day outlook from the CPC should be available after Sept. 20 at [www.cpc.ncep.noaa.gov/products/predictions/90day.](http://www.cpc.ncep.noaa.gov/products/predictions/90day)

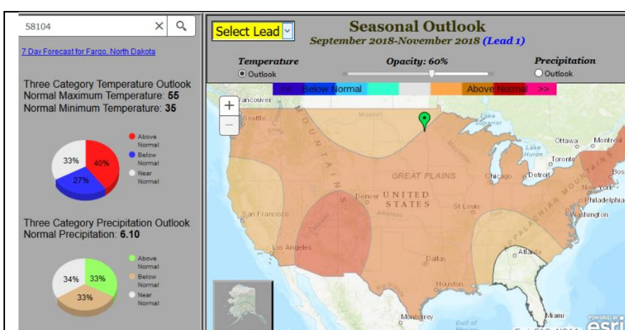


Figure 5a. September through November temperature outlook. (Climate Prediction Center, NOAA)

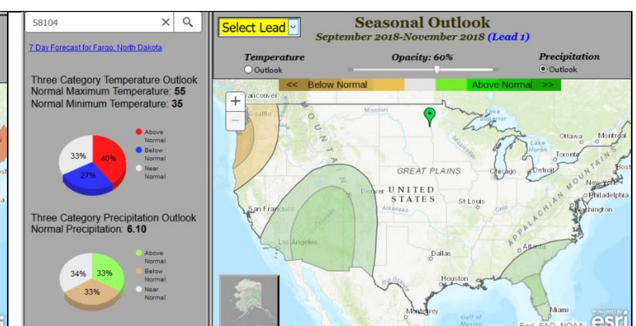


Figure 5b. September through November precipitation outlook. (Climate Prediction Center, NOAA)

[1] The corresponding author, Rob Kupec, is chief meteorologist at KVRR-TV in Fargo, N.D. Email: rkupec@kvrr.com

Hydro-Talk

Past, Present and Maybe Future Drought — By A. Schlag[2]

As we close in on the end of the growing season in North Dakota, drought persistence remains a concern for the state. Despite not having the widespread severity experienced in 2017, areas of North Dakota clearly have not healed from the dryness of 2017 or again have been short of moisture in 2018. A couple of the more common sources are the National Weather Service's Advanced Hydrological Prediction Services (AHPS) precipitation mapping program in Figure 6 and the High Plains Regional Climate Center's (HPRCC) ACIS map in Figure 7.

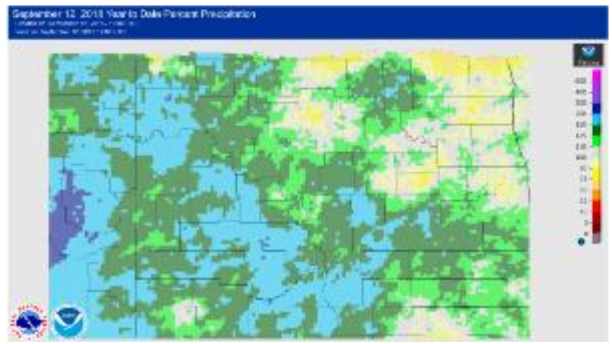


Figure 6. NWS precipitation mapping on AHPS.

The differences between Figures 7 and 8 are not trivial, even though the general pattern tends to have more similarities than differences. The main difference is that the AHPS image combines radar precipitation estimates with National Weather Service and cooperative observer data to produce a single estimate of spatial coverage, while the HPRCC image relies on the interpolation of discrete observations. Arguably, the strength of the AHPS image is its tendency to more accurately fill in areas where rain occurred, even if not caught in a rain gauge, but this can lead to an overestimate of total rainfall. The strength of the HPRCC program is its ability to capture areas where rain did not occur as evidenced by a lack of observation data, but its weakness is its failure to recognize when smaller, discrete storms zigzag their way through the observer network.

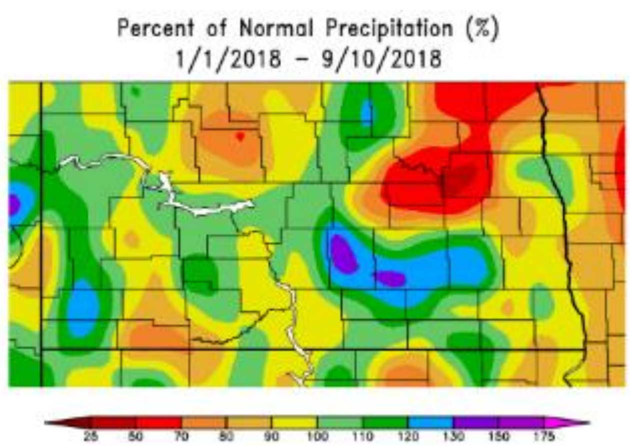


Figure 7. HPRCC precipitation mapping.

The reason these two images are so important to us in defining the current status of drought is that we need to have confidence that an area has been under an "abnormal" departure from its normal range at some timescale, and it must be representable on at least a state map. That latter portion also is very important in North Dakota because we commonly see very discrete thunderstorms that, through sheer luck of the draw, track over a given area while missing the next county or township. This can produce conflict in trying to ascertain the overall severity of impacts on a useable scale for the U.S. Drought Monitor

[2] The corresponding author, Allen Schlag, is the service hydrologist at the NOAA's National Weather Service in Bismarck, N.D. Email: Allen.Schlag@noaa.gov

(USDM). Outside of observed precipitation, a number of other indicators are used, a few of which are noted in the USDM's Drought Severity Classification shown in Table 5.

Table 5. USDM Drought Severity Classification (https://droughtmonitor.unl.edu/AboutUSDM/DroughtClassification.aspx).

			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

Areas of North Dakota have run the entire range of D0 (abnormally dry) all the way up to D4 (exceptional drought) during the past year. The first step of getting to abnormally dry is not necessarily very easy in North Dakota. In looking at long-term precipitation data for the Bismarck area, let's look at the numbers for the critical months of May-August in Table 6.

Table 6. Bismarck Precipitation Statistics.

	May	June	July	August
Mean	2.29	3.24	2.35	1.93
Median	2.01	2.93	2.08	1.58
30th percentile	1.26	2.15	1.48	1.03
20th percentile	1.03	1.77	1.13	0.70
10th percentile	0.72	1.23	0.77	0.44

One of the first things that stands out is the significant difference between the median and the mean. Every single month has a statistical mean that is somewhere between 0.27 and 0.35 inch of moisture above the median value. This demonstrates that in any given year, the chance that moisture for a given month will be below the often used "30-year normal" is greater than 50 percent.

Given this historical perspective of precip statistics, the prognosis for the current drought is not exceptionally encouraging. The Climate Prediction Center has put the chances of a weak to moderate El Nino at 60 percent through the fall of 2018 and at 70 percent for the winter. Local research suggests that during an El Nino-affected winter, the chance of near-normal to above-normal temperatures is 60 percent and the chance of December-February snowfall of being below normal is 70 percent. The exasperating problem with these numbers is that above-normal temperatures help remove the snow that could be limited but is a very valuable part of the moisture we will need to replenish already low soil moisture reserves.

Science Bits

2018 Drought Stress in Corn in North Dakota

Joel Ransom[3]

In mid-August, I wrote an article about water use in corn and used information to identify areas in North Dakota where corn likely would experience drought stress. Since then, many areas of the state have received rainfall and this stress has been reduced or alleviated. Nevertheless, I will excerpt part of that article because the principles regarding water use in corn and the impact of water deficits on corn yield still apply.

For much of this growing season, conditions were favorable for corn growth and up until mid-August, we looked like we had the potential to produce a record or near-record crop in North Dakota. However, for much of August, corn growth was impacted by water stress in some key regions of the state. Figure 8 shows the water deficit levels for the corn crop in various parts of the state through Aug. 13. Corn grown in red and orange zones were showing some symptoms of water stress at that time (see accompanying photo in Figure 9).

When water becomes limiting to plants, the stomata close, reducing the availability of carbon dioxide within the leaf. This increases the temperature of the leaf tissue and reduces photosynthesis, thereby slowing plant growth, although usually hastening crop development (meaning less biomass production and yield because of a lower rate, as well as a shorter duration of growth). The first symptoms of drought stress is leaf curling of the upper leaves. This will be followed by yellowing of lower leaves and firing of leaves along the edges. Green leaves can recover their productivity once stress has been alleviated, but desiccated leaves will not contribute to further growth.

The impact of drought on corn yield varies considerably, depending on its timing, severity and duration. Short periods of drought produce little impact on corn growth during early vegetative stages, while the greatest losses occur during pollination (Table 7). Much of the corn that was impacted by water stress in August probably was in the milk to dough stages. Crops in these stages are somewhat less sensitive to drought than crops during pollination. Nevertheless, yield losses can be substantial if drought persists for any length of time. Newer hybrids may be somewhat more productive when stressed than indicated in the table.

Corn is a very water-use-efficient crop, but it also is a heavy water user. Depending on where in the state, estimated corn crop water use (using NDAWN data) in August averaged about 1.5 inches per week. Soils have the capacity to hold up to 10 inches of available moisture in the top 4 feet, although most will hold less (Table 8). Unfortunately, by mid-August, most of the stored moisture had been depleted, as noted by the negative water balances exceeding what can be stored in the soil (Figure 8). Obviously, water stress in these parts of the state during this period significantly impacted corn yield potential. The recent rains in much of the state have relieved this stress and will moderate losses that might have occurred had the stress continued.

During grain filling, plants under stress are able to translocate carbohydrates stored in the stem and leaf tissue to the grain. This helps increase grain yield beyond what might otherwise be

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expected. Because of the movement of carbohydrates from stalks, plants stressed during grain filling commonly have weak stalks. For drought-stressed fields, this may be a consideration when deciding when to harvest and which fields to harvest first.

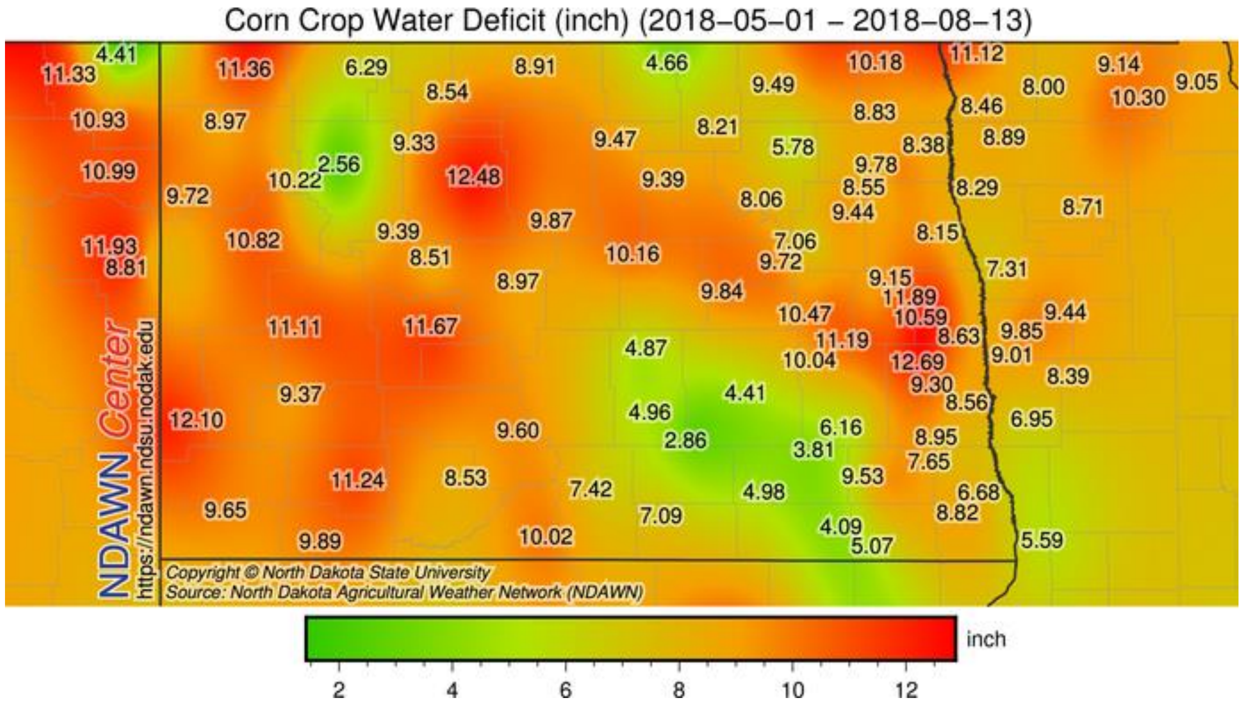

Figure 8. Water deficit for this year's corn crop, assuming a May 1 planting. (NDAWN)

Table 7. Estimated potential water use and effect of water stress on corn of differing growth stages.

Growth stage	Water use (inches per day)	Average % yield loss per day of stress
4-leaf to 8-leaf	0.10	---
8-leaf to 12-leaf	0.18	---
12-leaf to 16-leaf	0.21	3.0
16 -leaf to tasseling	0.33	3.2
Pollination (R1)	0.33	6.8
Blister (R2)	0.33	4.2
Milk (R3)	0.26	4.2
Dough (R4)	0.26	4.0
Dent (R5)	0.26	3.0
Adapted from Lauer, 2006, (http://corn.agronomy.wisc.edu/AA/A042.aspx).		

Table 8. Range of water-holding capacity for different soil types (inches of water per foot of soil depth).

Coarse sand	0.25-0.75
Loamy sand	1.10-1.20
Fine sandy loam	1.50-2.00
Silt loam	2.00-2.50
Silty clay loam	1.80-2.00
Silty clay	1.50-1.70
Clay	1.20-1.50

Figure 9. Corn in Cass County with desiccated lower leaves because of drought during grain filling. (NDSU)

Contacting the North Dakota State Climate Office

Please contact us if you have any inquiries or comments, or would like to know how to contribute to this quarterly bulletin.

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