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North Dakota Climate Bulletin

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In This Issue

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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 in the College of Agriculture, Food Systems, and Natural Resources, North Dakota State University, Fargo, N.D.

The overall summer average temperature was 3.9 degrees warmer than average, which would make it the third warmest summer on record. Precipitation-wise, the statewide accumulation was 2.47 inches drier than average, which would make it the 16th driest summer on record. Conditions prior to summer also were dry. North Dakota experienced the sixth driest nine-month (December 2020 through August 2021) period on record since 1895. The exceptional drought conditions (D4) have continued 18 weeks in a row since May 18, 2021, which is already the longest-lasting D4 on record since 2000. The 2021 drought also broke the largest extent of D4, D3, D2 and D1, putting the entire population in drought for 11 weeks.

Overall, 339 records, including temperature- and precipitation-related occurrences across the state, were tied or broken. Three hundred sixty-two significant storms also were reported, including 16 tornadoes.

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

Rainbow above the Rain Gauge. (F.A. Akyüz)

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 August 31, 2021) was 6.15 inches, which was 3.26 inches more than the last season (spring 2021), but 2.35 inches less than last summer (summer 2020) and 2.47 inches less than the 1991-2020 average summer precipitation (Table 1). This would rank the summer of 2021 as the 16th driest summer since such records began in 1895.

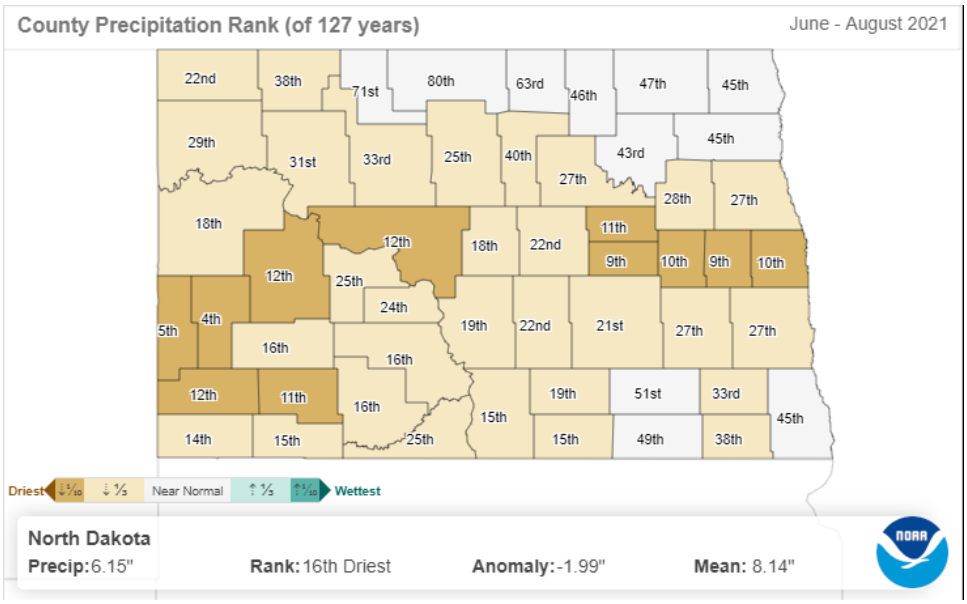


Figure 1. Precipitation rankings in summer of 2021 for North Dakota. (National Centers for Environmental Information, NOAA)

The counties shaded in brown in Figure 1 indicate drier-than-average conditions in February 2021. White shadings indicate near-average conditions. The numbers inside the counties are the precipitation rankings, with 1 being the lowest ranking (driest) and 127 being the highest ranking (the wettest)

The greatest seasonal precipitation accumulation of the season was 12.24 inches, recorded in Montpelier, Stutsman County. The greatest seasonal snowfall accumulation was “Trace,” recorded in multiple locations.

Based on historical records, the state average summer precipitation showed a positive long-term trend of 0.13 inches per century during this period of record since 1895. The state’s highest and lowest seasonal summer average precipitation ranged from 3.32 inches in 1929 to 15.65 inches in 1993. The “Historical Summer Precipitation for North Dakota” time series (Figure 2) shows a graphical depiction of these statistics.

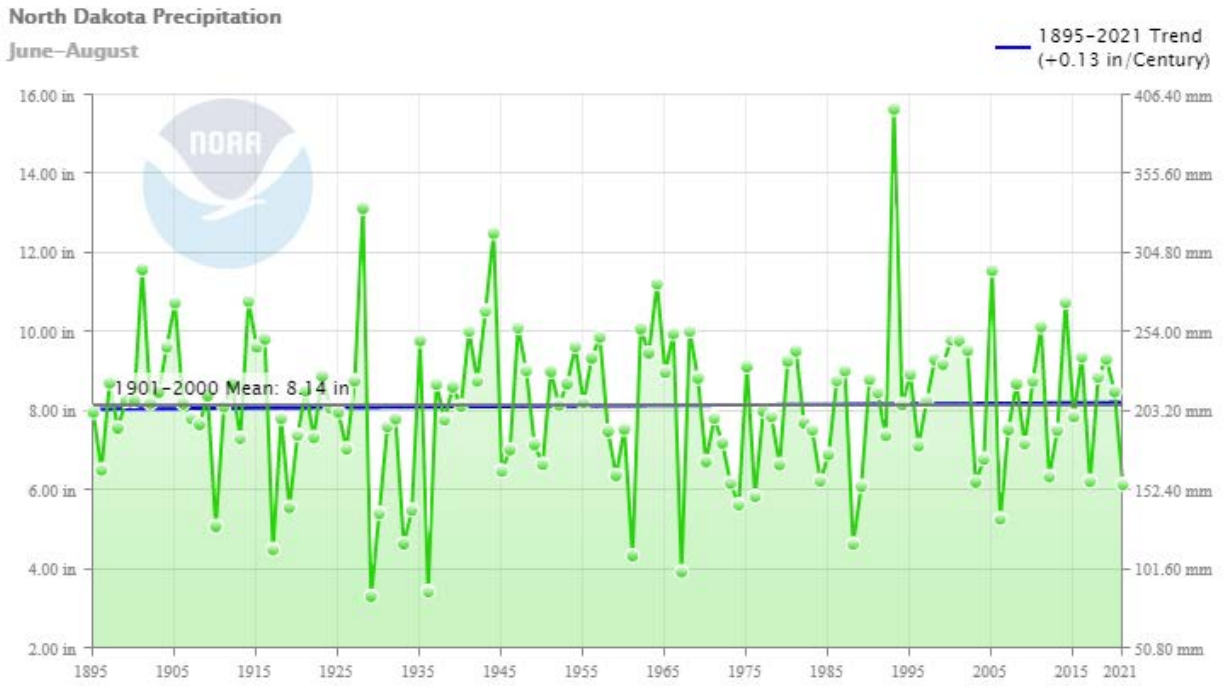


Figure 2. Historical summer precipitation time series for North Dakota.

Table 1. North Dakota Summer Precipitation Ranking Table[1].

Period	Value	Normal	Anomaly	Rank	Wettest/Driest Since	Record Year
Summer 2021	6.15”	8.62”	- 2.47”	16th driest 112th wettest	Driest since 2006 Wettest since 2020	3.32” (1929) 15.65” (1993)

[1] NOAA National Centers for Environmental Information, Climate at a Glance: Statewide Time Series: www.ncdc.noaa.gov/cag.

Temperature

The average North Dakota temperature for the season (June 1 through August 31, 2021) was 70.6 F, which was 27.6 degrees warmer than the last season (spring 2021), and 1.8 degrees warmer than last summer (summer 2020). It was 3.9 degrees warmer than the 1991-2020 average summer temperature, which would rank summer 2021 as the 33rd warmest summer since such records began in 1895 (Table 2).

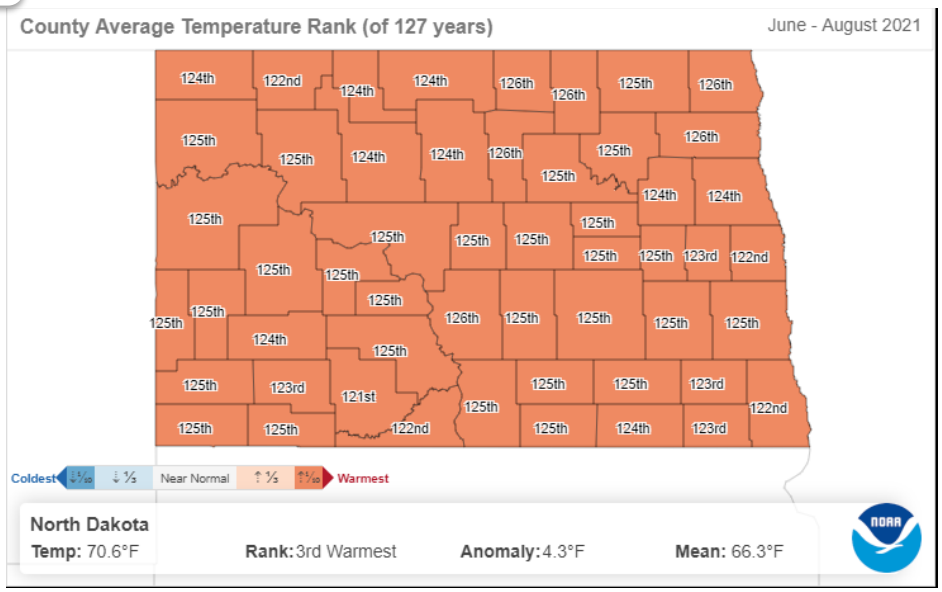


Figure 3. Temperature rankings in summer of 2021 for North Dakota. (National Centers for Environmental Information, NOAA).

The counties shaded in pink and brown in Figure 3 indicate warmer-than-average conditions. The numbers inside the counties are the temperature rankings, with one being the lowest ranking (coldest) and 127 being the highest ranking (the warmest).

Based on historical records, the average summer temperature showed a positive trend of 1.6 degrees per century since 1895. The state's highest and lowest seasonal summer average temperatures ranged from 61.2 F in 1915 to 72 F in 1936. The "Historical Summer Temperature for North Dakota" time series (Figure 4) shows a graphical depiction of these statistics.

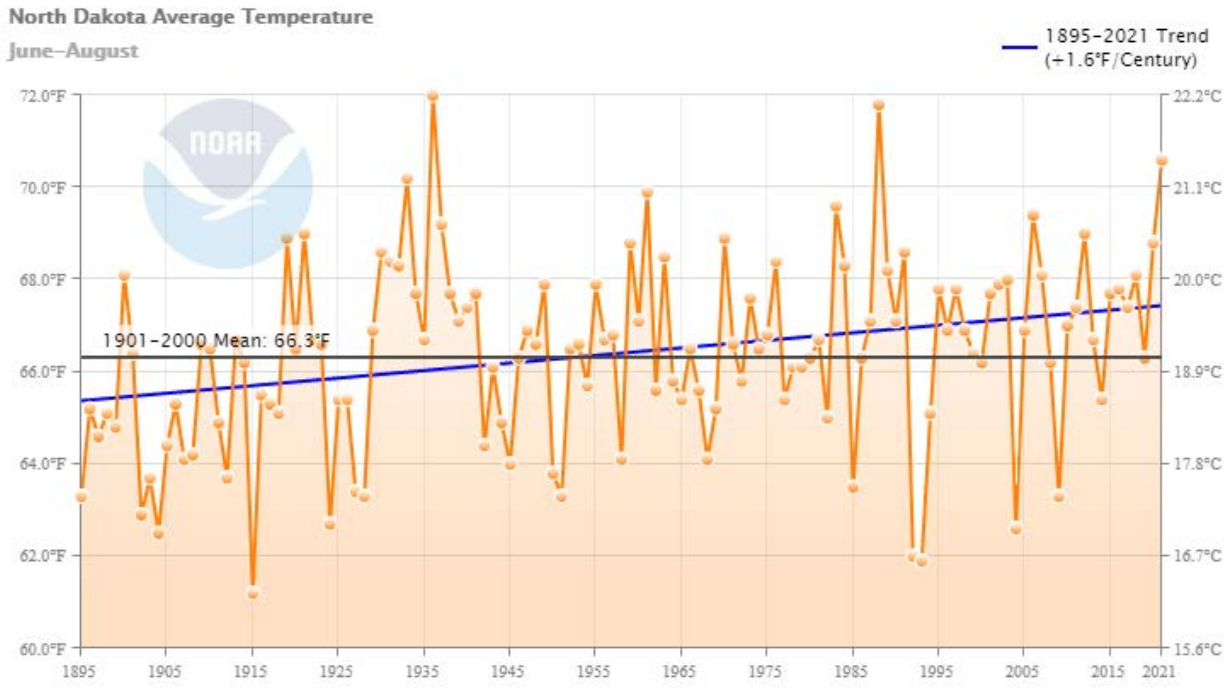


Figure 4. Historical summer temperature time series for North Dakota.

Table 2. North Dakota Summer Temperature Ranking Table[2].

Period	Value	Normal	Anomaly	Rank	Warmest/Coolest Since	Record Year
Summer 2021	70.6 F	66.7 F	3.9 F	125th coolest 3rd warmest	Coolest since 2020 Warmest since 1988	61.2 F (1915) 72 F (1936)

[2] NOAA National Centers for Environmental Information, Climate at a Glance: Statewide Time Series: www.ncdc.noaa.gov/cag.

Drought: The D4 (exceptional drought) category shrunk from 18% in the beginning of the season to 6% by the end of the season to account for late-season precipitation. However, the timing of the rains had very small benefit to agricultural communities. Extreme heat during this period somewhat annulled the impact of rainfall also. By the end of the season, 65% of the state was in the D3 (extreme drought) category. Ninety-five percent of the state was in at least severe drought category, and 100% of the state was in drought by the end of the season. Figure 5 below shows the drought conditions at the beginning and the end of summer. Figure 6 shows the drought intensity and coverage on a time scale. Both of the figures show drought conditions spatially and temporally.

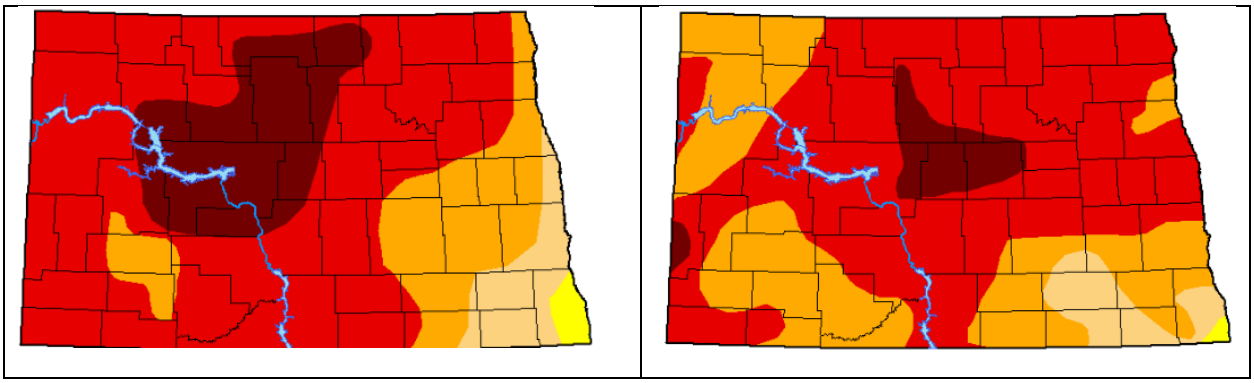


Figure 5. Drought Monitor map comparison for North Dakota in the beginning (on the left) and at the end (on the right) of summer 2021. (U.S. Drought Monitor)

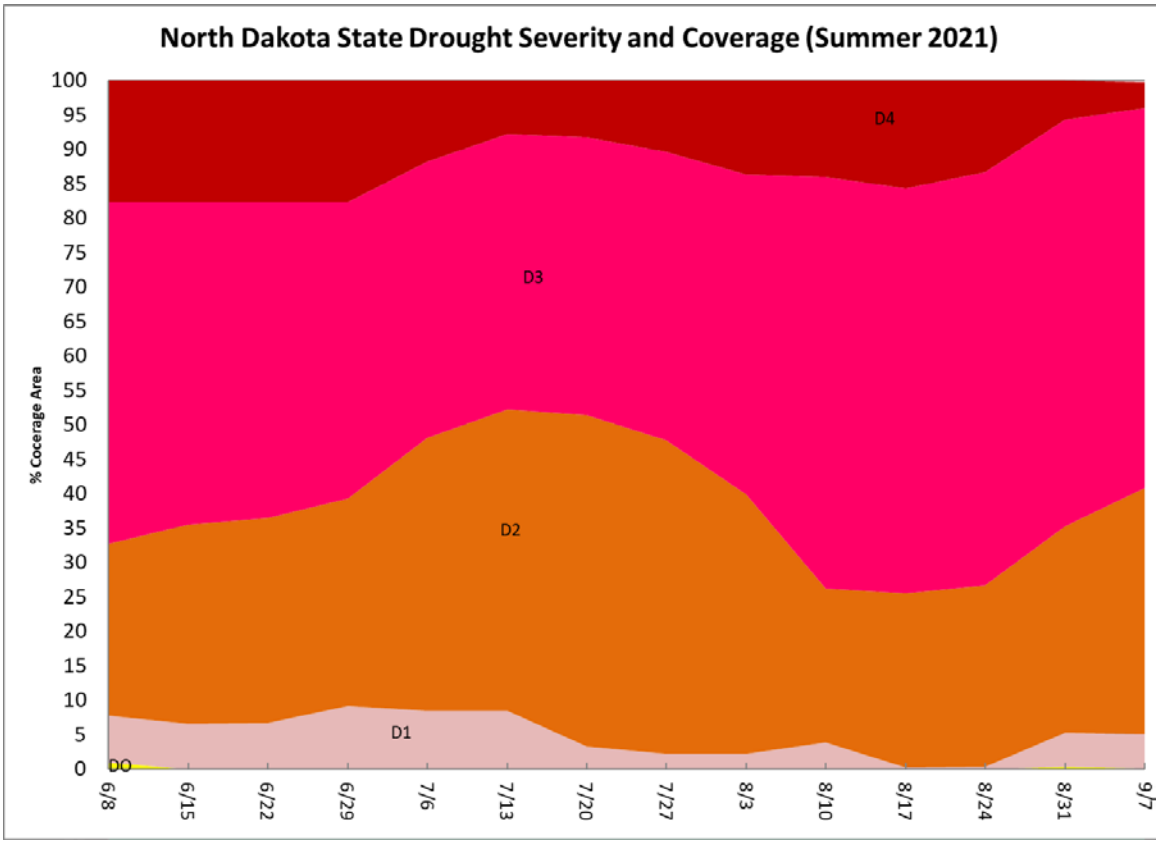


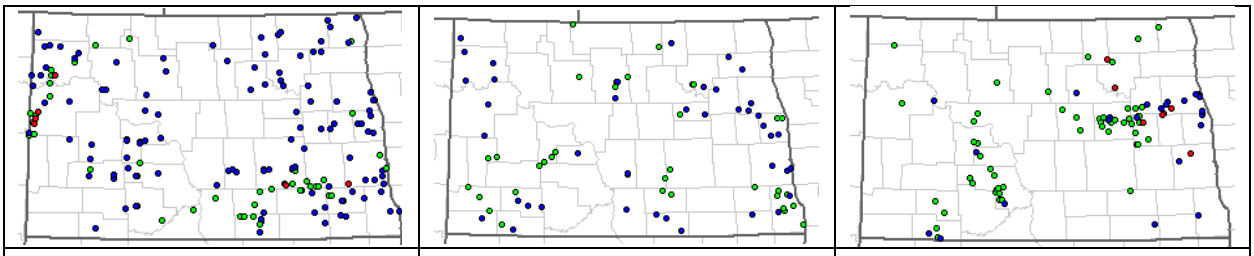
Figure 6. Statewide drought coverage in percentage and intensity (D.O. through D4) in a time scale representing the state from the beginning to the end of the season, with a one-week resolution in Summer 2021.

Storms and Record Events

State Tornado, Hail and Wind Events for Summer 2021

Table 3. The numbers in the table below represent the number of tornados and hail and wind events accumulated monthly and seasonally.

	June 2021	July 2021	August 2021	Seasonal Total
Tornado	6	0	10	**16**
Hail	55	34	58	**147**
Wind	126	50	24	**200**
Total	**187**	**84**	**92**	**362**



June 2021 North Dakota Storm Events | July 2021 North Dakota Storm Events | August 2021 North Dakota Storm Events

Figure 7. 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).

State Record Events for Summer 2021

Table 4. The 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.	88	42	32	**162**
Highest daily min. temp.	55	53	15	**123**
Lowest daily max. temp.	0	4	10	**14**
Lowest daily min. temp.	2	0	1	**3**
Highest daily precipitation	10	5	22	**37**
Highest daily snowfall	0	0	0	**0**
Total	**155**	**104**	**80**	**339**

Seasonal Outlook

Summer 2021 Outlook

By R. Kupec[3]

Summer 2021 is entering the record books as one of the top 10 driest in North Dakota. For many locations, it was the warmest summer since the drought year of 1988. In most of the state it will rank as one of the top five warmest summers. While most of the state was categorized as being in severe drought, late August rains bumped most locations out of the driest summer on record. Still, much of the state saw 50-75% of average summer rainfall. A few spots along the Canadian border and parts of Kidder, Logan and McIntosh counties actually received slightly above average precipitation. Overall, the Summer Outlook for 2021 was correct in its precipitations and temperature forecast.

It appears the warm and dry conditions of the summer will extend into the Autumn. Despite late August rains, the overall weather pattern over our area remains similar to what has been in place going back to spring. However, changing weather patterns in the Pacific Ocean should have an impact on the weather in North Dakota. The weak spring La Niña faded to neutral over the summer. La Niña conditions are expected to return this winter, which could mean cooler and wetter conditions in that season. Historically, fall weather tends to be drier and warmer, heading into a developing winter La Niña. In addition, the analogous warm water in the northern Pacific Ocean is showing signs of cooling, which should eventually lead to a pattern shift over North America.

While fall 2021 should be slightly warmer and drier than average overall, it will not likely be at the levels of heat and drought experienced over the summer. The current Climate Prediction Center (CPC) Fall Outlook has a similar forecast. It is calling for above-average temperatures for much of North Dakota, except in the northwest and along much of the Canadian border (see Figure 8a). The CPC is calling for below-average rainfall statewide (see Figure 8b).

The next 90-day outlook from the CPC is available at http://www.cpc.ncep.noaa.gov/products/predictions/90day .

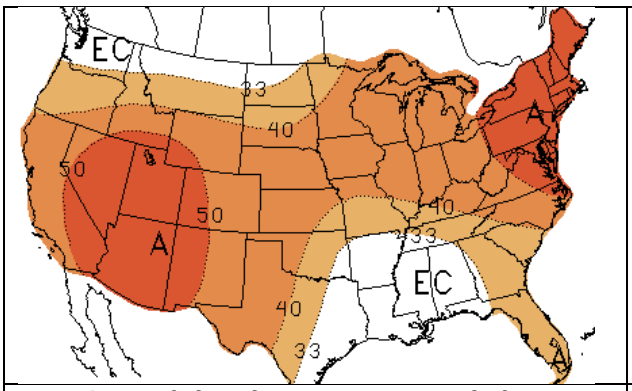


Figure 8a. March through May temperature outlook. (Climate Prediction Center, NOAA)

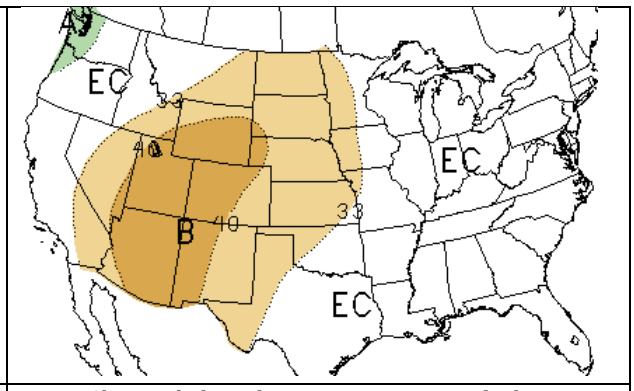


Figure 8b. March through May precipitation outlook. (Climate Prediction Center, NOAA)

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

Hydro-Talk

Drought Improves and Continues

By A. Schlag[4]

As a reminder, the current drought in North Dakota was first acknowledged in late March of 2020. Since then, the drought seems to have peaked around the middle of May 2021 based on the area of the state in D3-D4 drought (Figure 9). Since then, the presence of a D4 area in central North Dakota has been a mainstay even as its border has been tweaked almost weekly.

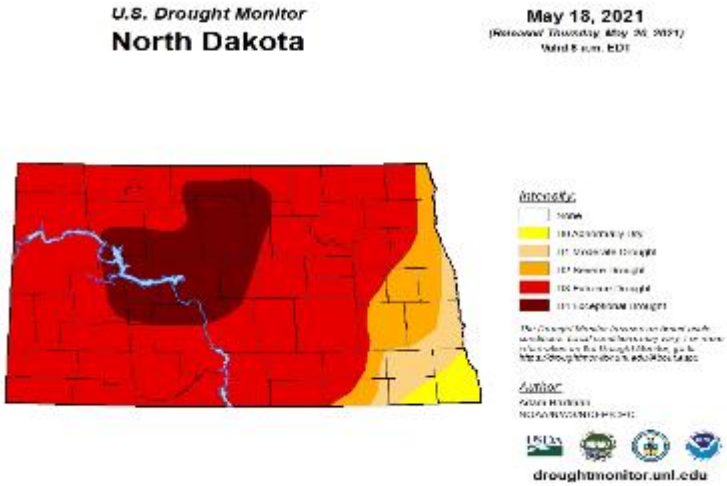


Figure 9. USDM Map at Maximum Extent.

While the critically important months of May and June were generally dry, the month of July was particularly brutal to crops and livestock forage as the dry conditions shown in Figure 10 were exasperated by exceptionally warm temperatures. Since August, though, improvements across the state have outweighed degradation to where we are now at least holding our own. Indeed, recent wildfires have been challenging wooded areas. However, over the past few weeks, the fires have been much easier to extinguish as they get out of the drier wood-based fuels and encounter fresh green grass. While agricultural interests may not benefit as much as one would hope from this greening of the countryside in September, at least for now, it would appear to be warding off an early entry into the severe fire weather season that often accompanies fall in North Dakota.

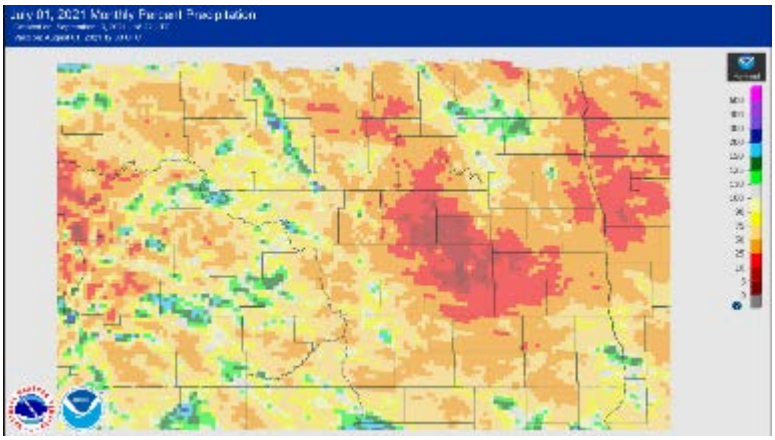


Figure 10. Percent of Normal Precipitation for July, 2021.

Overall, this change in fortune for North Dakota is due to a fairly wet pattern observed in August (see Figure 11).

This wet pattern in August has provided the vast majority of relief observed this summer and has the state going into Autumn with a drought map as seen in Figure 12.

[4] 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

One's first impression when looking at the August precipitation totals and the USDM maps is that they aren't necessarily in alignment. While this is true, the reason for this apparent disconnect is that it takes more than just precipitation deficits to create a drought. On the reverse side of the same coin, it often takes more than near-normal to above-normal precipitation alone to improve the drought designations. Despite the apparent surplus of rain in August, hydrologically, we have not yet seen a rebound in our surface waters, nor in our soil moisture content to warrant much improvement. Over the past several years, we have often seen non-growing season storms or series of storms such as that observed in the early fall of 2019, which would greatly impact the depiction of drought across North Dakota. However, these types of events are not that common, and the most likely of all scenarios is that the area would need to carry a normal to above-normal snowpack into the spring melt season to significantly alleviate the hydrologic and agricultural impacts associated with this most recent drought. Until then, we will most likely continue to see minor tweaks of the boundaries between the different levels of drought. Hopefully, in my next article, we will have some understanding of what winter 2021-22 will have in store for us.

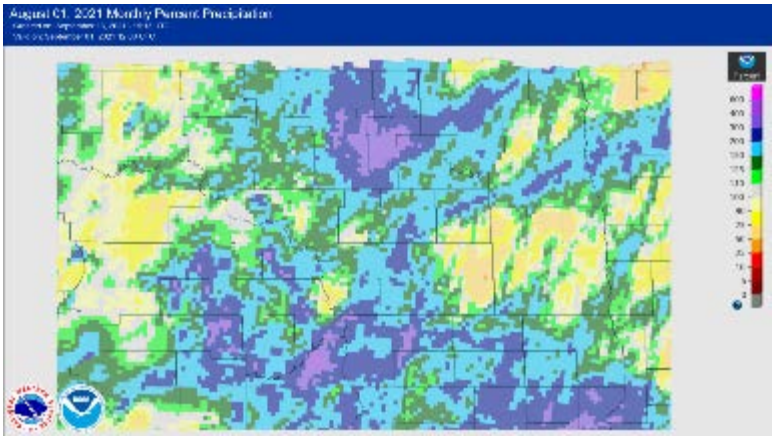


Figure 11. Percent of Normal Precipitation for August 2021.

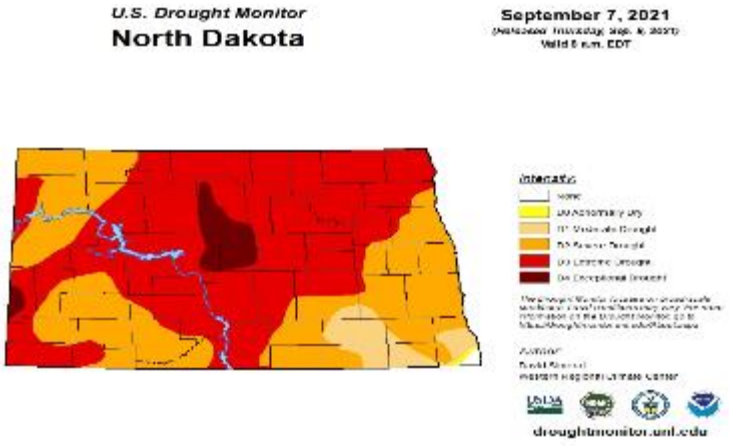


Figure 12. USDM Map of North Dakota After the First Week of September.

Science Bits

An Examination of Tornadic Supercell Types

By G. Gust[5]

Severe/Tornadic Thunderstorms in Wet vs. Dry Years: Part 2

We left off last quarter with a brief treatise on what it takes to produce our typical spring-summer convective weather (See Volume 15, Number 2 - Part 1: The 10-11 June 2021 Outbreak). Now, after our abnormally dry fall, winter and spring seasons have persisted as a mainly dry summer, we can see how these accumulated conditions have impacted our overall "Tornado Production" for the season.

The 2021 Tornado Count is Down: As of the end of August, the total number of distinct tornados in the state for the 2021 convective season stood at just 13, well below our past 30-year average of around 30 tornados per year. Keep in mind that the 1990-2020 climate period was overall wetter than any of the previous 30-year climate periods, as recalibrated every 10 years since such record-keeping began in the state back in the late 1800s. This year's tornado count, though relatively low, is similar in size to other noted dry years or multi-year dry periods in our history looking back to 1950 (Figure 13).

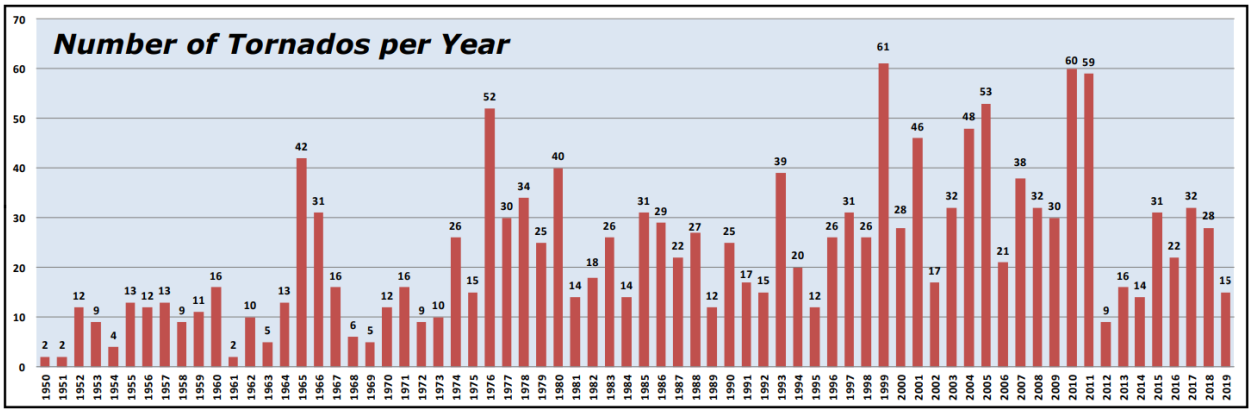


Figure 13. Annual number of tornados in North Dakota, 1950 through 2019. Graphic courtesy of Nathan Heinert, NWS Bismarck, N.D. [https://www.weather.gov/bis/ndtorhistory]

2021 Growing/Convective Season Moisture Was Low: The spring-summer convective season largely coincides with the spring-summer growing season. Looking back from May 1 through Aug. 31, most of the state received 60-80% of normal precipitation (Figure 13). When combined with underlying dry soil conditions, this limited the available moisture for evapotranspiration, the movement of local moisture from lakes, soils and plants into the air.

Last quarter's article discussed the processes by which a near-surface moist layer is able to advect into the state and provide fuel for widespread thunderstorm activity. However, persistently dry soils and crops in and around our immediate area act to reduce the overall moisture availability needed to initiate and sustain such deep convection. As a result, overall storm size, duration and effective precipitation footprint are all likely to be reduced. And it's said, "Wet begets wet, *and dry begets dry*."

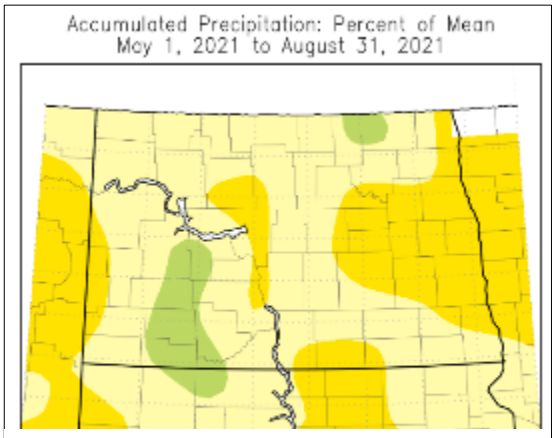


Figure 13. Accumulated precipitation percent of normal from May 1 to Aug. 31 (Midwest Regional Climate Center)

[5] The corresponding author, Greg Gust, is the warning coordination meteorologist at the National Weather Service, Grand Forks, N.D. Email: gregory.gust@noaa.gov

The secret to severe weather is to take layer of warm, moist air, near the surface to lift it, cool and thus to condense the moisture. And the faster we can lift it, and the deeper the layer of the atmosphere we can lift it through, the bigger the storms will be and the higher the likelihood we'll have severe weather (G.G.).

Tornadic Supercell Types: Supercell thunderstorms are responsible for the longer-lasting and most destructive tornados we see across the Northern Plains states. The amount of available low-level moisture affects the type of supercell we see in a couple of ways. First, the relative amount of low-level moisture in the air will determine the height Above-Ground-Level (AGL) where that water vapor will start to condense and form a cloud base. This is called the Lifted Condensation Level (LCL). Second, the relative amount of low-level heat and moisture determines atmospheric instability and the resulting height to which the thunderstorm cloud (Cumulonimbus) can ultimately grow.

Supercell thunderstorm types are generally divided into three types: the Classic Supercell, the Low-Precipitation Supercell, and the High-Precipitation Supercell.

Classic Supercell: The Classic Supercell thunderstorm is the variety most commonly seen across the Central and Northern Plains, including North Dakota. In the schematic below (Figure 14), a supercell thunderstorm is viewed from the east looking west. The storm is feeding on low-level moisture moving in from the south, rising, cooling and condensing to form the huge cumulonimbus cloud, and both raindrops and hailstones formed within the cloud will likely fall out of the storm as precipitation.

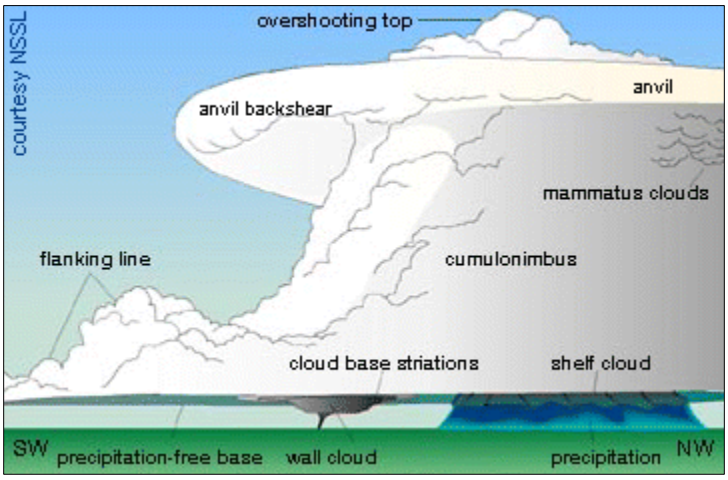


Figure 14. Idealized view of a classic supercell as viewed from the east looking west (The National Severe Storm Laboratory).

With the Classic Supercell in North Dakota, the LCL or cloud base is usually between one and two thousand feet AGL, while the overall storm may rise to a height of eight to 10 miles high, punching well into the stratosphere. The updraft area of the storm may produce a tornado that is relatively near the rain footprint, usually within a mile or two of the precipitation and downdraft portion of the storm.

Low Precipitation (L.P.) Supercell: L.P. Supercells occur more often under the drier conditions of the western Dakotas, with lower overall dewpoints. In North Dakota, the LCL or cloud base of an L.P. supercell can range from two to five thousand feet AGL, while the overall storm may still rise to a height of eight to 10 miles high. As its name suggests, a low-precipitation supercell has a smaller rain footprint, in part because the shallower cloud carries less overall rain mass and in part because the higher cloud base allows for more evaporation of rainfall below the cloud base, and thus less rainfall actually reaching the surface.

In addition, when an L.P. Supercell is able to produce a tornado, that tornado has a longer path to "stretch" or reach between the surface and the cloud base and may more easily break its suction vortex and dissipate. Often the longer, rope-like tornado of the L.P. Supercell is more removed from the rain area, sometimes by several miles. Like this tornado photographed near Highway 32, west of Park River, N.D., on June 27, 2015 (Figure 15. Photo from the west looking east, courtesy of Aaron Kennedy).

Figure 15. June 27, 2015 Tornado in North Dakota. Photo courtesy of A. Kennedy.

High Precipitation (H.P.) Supercell: H.P. Supercells can occur across the state but occur more often under the more humid conditions of the eastern Dakotas, with higher overall dewpoints. In North Dakota, the LCL or cloud base of an H.P. Supercell can range from a few hundred to around a thousand feet AGL, again with overall storm reaching a height of eight to 10 miles high. As its name suggests, a high-precipitation supercell is bigger and wetter overall, and this large rain footprint can start to wrap around the updraft of the storm, often hiding the tornado from view.

It is possible for a supercell to change from an L.P. storm to a classic, or from a classic to an H.P., as it moves from county to county and responds to changing atmospheric conditions and local moisture sourcing. In Figure 16, a large tornado formed near the border of Rolette and Towner Counties, N.D., became a large wedge-shaped tornado and eventually became wrapped in very heavy rain as it passed just north of Bisbee on Aug. 3, 2016. Photo from the south, looking north, courtesy of Brandon Copic and Alex Haworth.

Figure 16. August 3, 2016 Tornado near the border of Rolette and Towner Counties, N.D. (Photo courtesy of B. Copic and A. Haworth)

Go back and check the tornado photos linked to the online Event Review produced by the NWS Bismarck and covering the June 10, 2021 Episode for more examples:

Widespread Severe Weather in Western and Central North Dakota on June 10, 2021
https://www.weather.gov/bis/SevereWx06102021

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[6].

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[6] *This work is supported by the USDA National Institute of Food and Agriculture, Hatch/Multi State project ND1005365.*