North Dakota Climate Bulletin

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Produced by
Adnan Akyüz, Ph.D.
State Climatologist

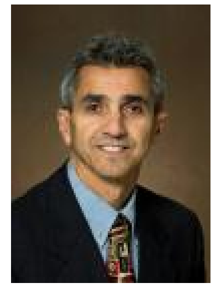
Graphics
NCEI, SPC, NOAA, USDM

Contributing Writers
R. Kupec
A. Schlag
G. Gust

North Dakota State Climate Office
www.ndsu.edu/ndsco

North Dakota State University

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, N.D.

The overall spring average temperature was 2.4 degrees warmer than average, which would make it the 22nd warmest spring on record. Precipitationwise, the statewide accumulation was 1.44 inches drier than average, which would make it the 14th driest spring on record. Conditions prior to spring also were dry. North Dakota experienced the second driest nine-month (September through May) period on record since 1895. An exceptional drought category (D4) appeared in central North Dakota in mid-May. It was the third time on record North Dakota experienced D4, but it was the first time a D4 was introduced this early in the growing season.

Overall, 211 records, including temperature- and precipitation-related occurrences across the state, were tied or broken. Three significant storms also were reported in May, including a tornado.

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.

Variety of cirroform clouds overhead in Fargo, N.D. (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 spring season (March 1 through May 31, 2021) was 2.67 inches, which was 2.03 inches more than the last season (winter 2020-21), 0.25 inch more than last spring (spring 2020) but 1.44 inches less than the 1991-2020 average spring precipitation (Table 1). This would rank the spring of 2021 as the 14th driest spring since such records began in 1895.

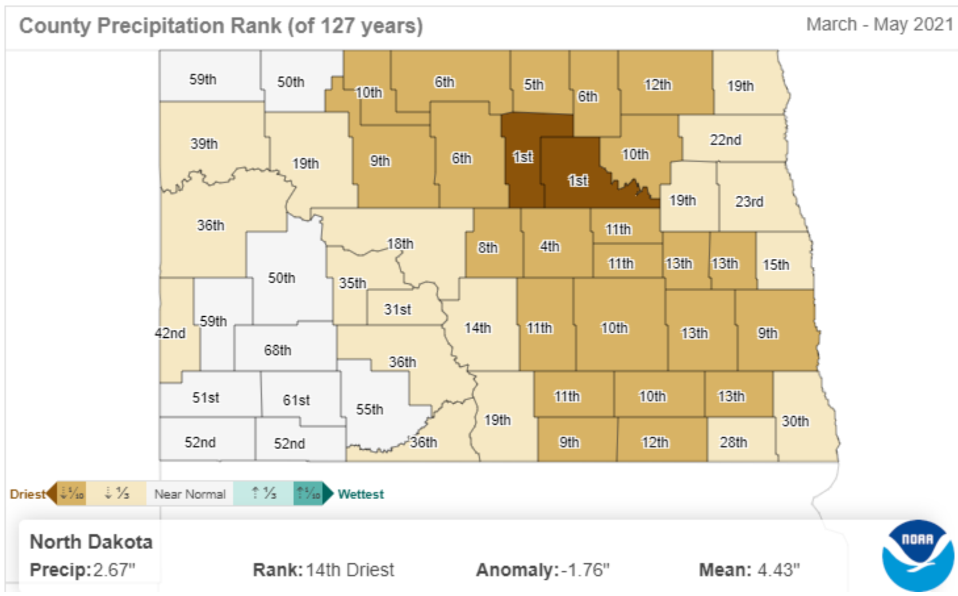


Figure 1. Precipitation percent of normal in spring of 2021 for North Dakota. (National Centers for Environmental Information, NOAA)

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 5.58 inches, recorded in Dickinson, Stark County. The greatest seasonal snowfall accumulation was 9.5 inches, recorded in Kenmare, Ward County.

Based on historical records, the state average spring precipitation showed a positive long-term trend of 0.17 inch per century during this period of record since 1895. The highest and lowest seasonal spring average precipitation for the state ranged from 1.3 inches in 1934 to 9.64 inches in 1896. The "Historical Spring Precipitation for North Dakota" time series (Figure 2) shows a graphical depiction of these statistics.

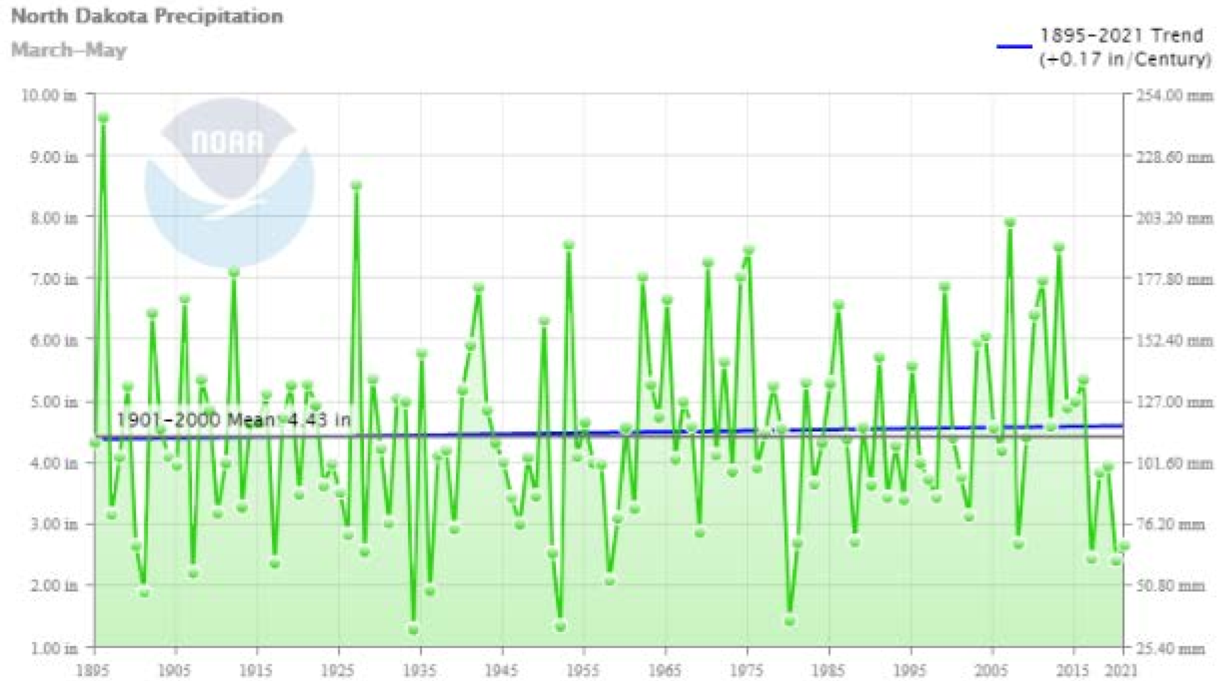


Figure 2. Historical spring precipitation time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Wettest/Driest Since	Record Year
Spring 2021	**2.67"**	**4.11"**	- 1.44"	**14rd driest** **114th wettest**	**Driest since 2020** **Wettest since 2019**	**1.3" (1934)** **9.64" (1896)**

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

Temperature

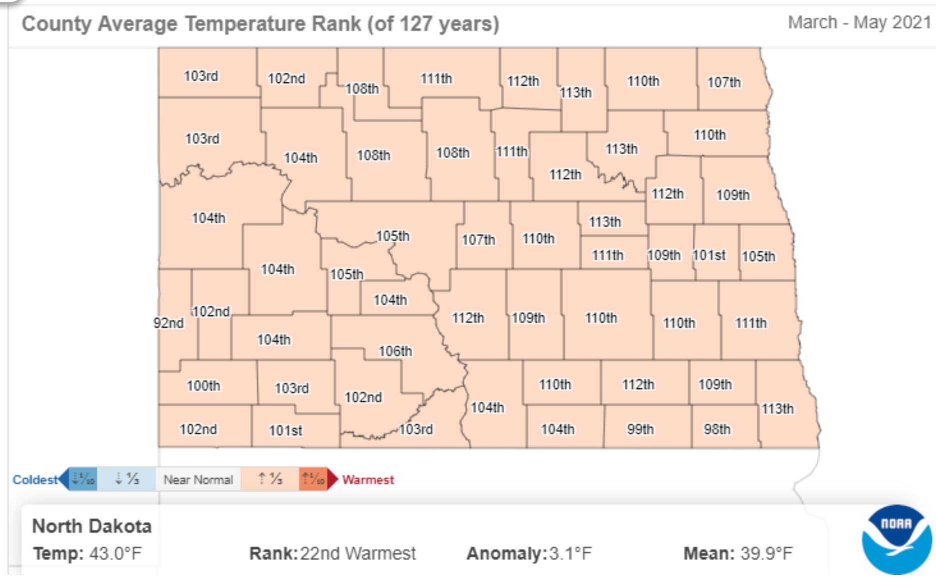


Figure 3. Temperature departure from normal in spring of 2021 for North Dakota. (National Centers for Environmental Information, NOAA).

The average North Dakota temperature for the season (March 1 through May 31, 2021) was 43 F, which was 26.2 degrees warmer than the last season (winter 2020-21), and 3 degrees warmer than last spring (spring 2020). It was 2.4 degrees warmer than the 1991-2020 average spring temperature, which would rank spring 2021 as the 22nd warmest spring since such records began in 1895 (Table 2).

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 1 being the lowest ranking (coldest) and 127 being the highest ranking (the warmest).

Based on historical records, the average spring temperature showed a positive trend of 0.2 degree per decade since 1895. The highest and lowest seasonal spring average temperatures for North Dakota ranged from 31.5 F in 1899 to 48.1 F in 1977. The "Historical Spring Temperature for North Dakota" time series (Figure 4) shows a graphical depiction of these statistics.

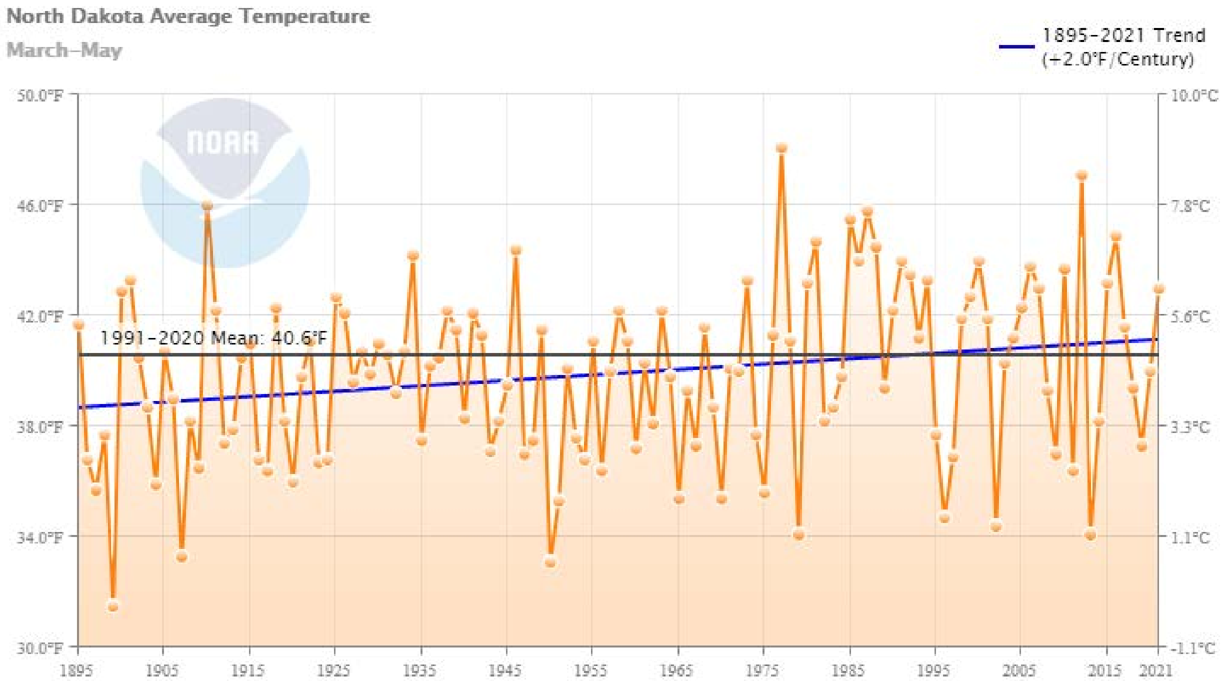


Figure 4. Historical spring temperature time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Warmest/Coolest Since	Record Year
Spring 2021	**43 F**	**40.6 F**	**2.4 F**	**106th coolest** **22nd warmest**	**Coolest since 2020** **Warmest since 2016**	**31.5 F (1899)** **48.1 F (1977)**

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

Drought: A D4 (exceptional) drought category was introduced for the first time since 2017 (and third time since 2000) in North Dakota to account for progressive dryness and unseasonably warm temperatures that exacerbated the conditions inherited from the prior season. By the end of the season, 18% of the state was in the D4 (exceptional drought) category, which is the largest extent North Dakota ever experienced since the inception of the Drought Monitor practice in the U.S. Seventy-seven percent of the state was in at least extreme drought, which is also the largest extent in this category that North Dakota ever experienced since 2000. Figure 5 below shows the drought conditions at the beginning and the end of spring. Figure 6 shows the drought intensity and coverage on a time scale. Both of the figures show no drought conditions spatially and temporally.

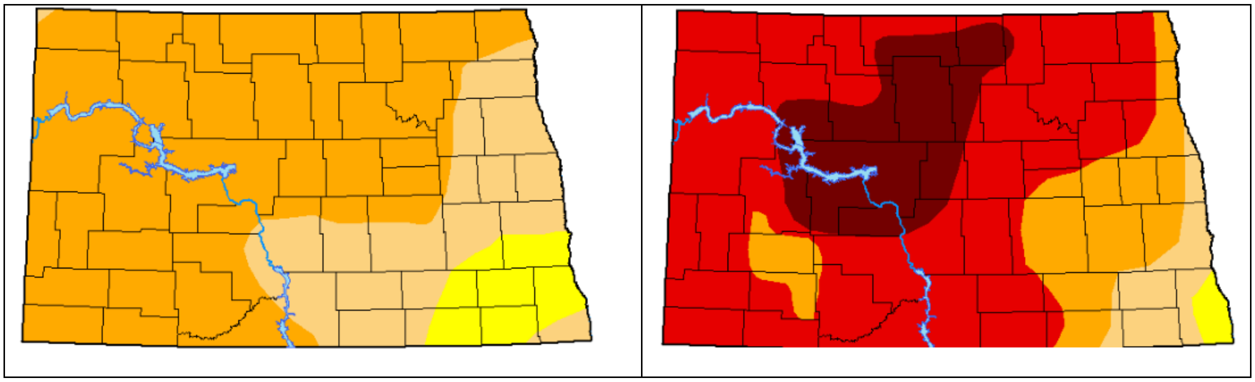


Figure 5. Drought Monitor map comparison for North Dakota in the beginning (on the left) and at the end (on the right) of spring 2021. (U.S. Drought Monitor)

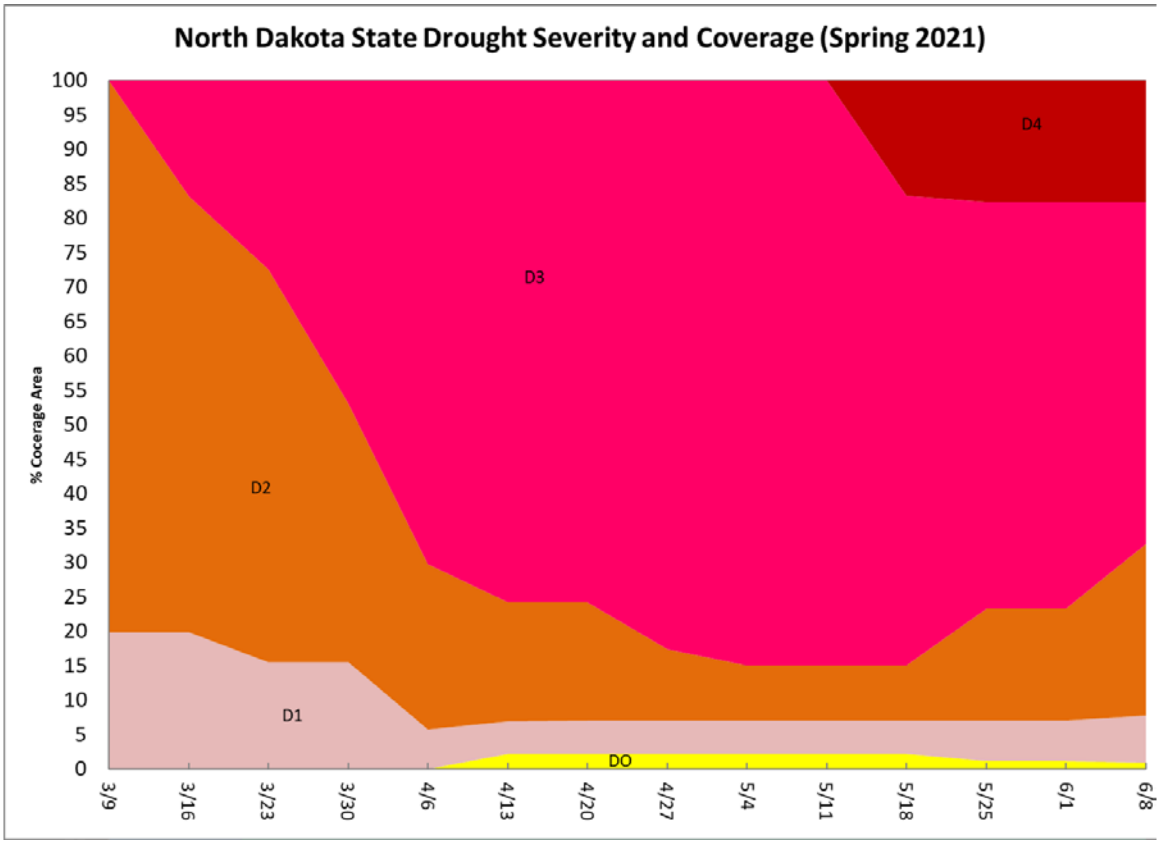


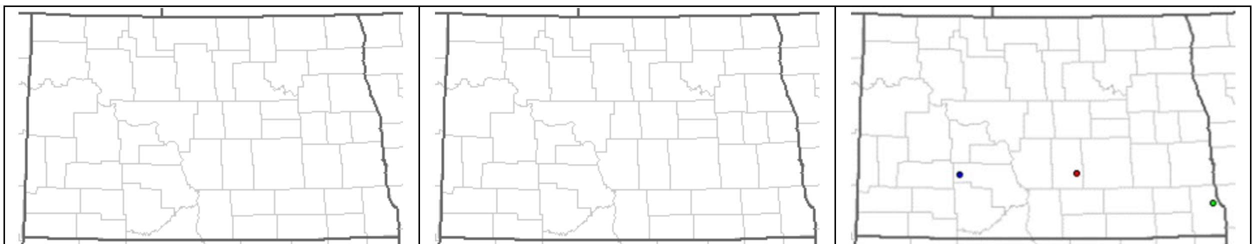
Figure 6. Statewide drought coverage in percentage and intensity (D.O., D1, etc.) in a time scale representing the state from the beginning to the end of the season, with a one-week resolution.

Storms and Record Events

State Tornado, Hail and Wind Events for Spring 2020-21

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

	March 2021	April 2021	May 2021	Seasonal Total
Tornado	0	0	1	**1**
Hail	0	0	1	**1**
Wind	0	0	1	**1**
Total	**0**	**0**	**3**	**3**



March 2021 North Dakota Storm Events	April 2021 North Dakota Storm Events	May 2021 North Dakota Storm Events

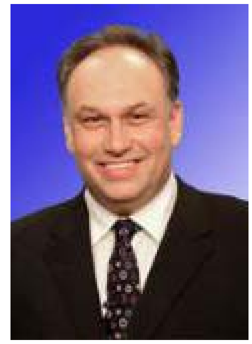
Figure 7. Geographical distribution of the storm events in the table above in each month. The dots are color-coded for each event (red: tornado; blue: wind; green: hail).

State Record Events for Spring 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	March	April	May	Seasonal Total
Highest daily max. temp.	75	23	4	**102**
Highest daily min. temp.	27	2	8	**37**
Lowest daily max. temp.	0	6	16	**22**
Lowest daily min. temp.	0	11	12	**23**
Highest daily precipitation	1	9	7	**17**
Highest daily snowfall	2	6	2	**10**
Total	**105**	**57**	**49**	**211**

Seasonal Outlook



Summer 2021 Outlook **By R. Kupec[3]**

The Spring Climate Outlook called for near average temperatures and slightly below-average precipitation. Temperatures in April and May were 1 to 4 degrees below average across North Dakota. This brought the average spring temperature down, but the season ended 1 to 3 degrees above average due to the unusually warm March, which was 6 to 11 degrees above average. Precipitation was well below average for March and April. Some much-needed rain arrived in May, with large enough amounts in some pockets to end the season with above-average rainfall. Those pockets were primarily in the west, with one in Stutsman County near Jamestown. The remainder of the state had below-average rainfall. Even the spots that were above average did not have enough to break the drought that has continued since winter.

As we look for some signals for what we can expect in summer 2021, we find the La Niña conditions in the Pacific Ocean are fading to neutral. In 2012, we had a very similar setup: a dry spring and a weak La Niña fading to neutral. Summer 2012 ranks in the top 20% of warmest summers in North Dakota. Rainfall tended to be closer to average or slightly below average across the state.

June is off to the warmest start on record, and the drought continues for most despite an increase in thunderstorm activity. With such a head start on temperatures, this summer should be warmer than average. I am hopeful that the precipitation pattern will follow 2012 and be closer to average or a little below. The current Climate Prediction Center (CPC) Summer Outlook has a similar forecast. It is calling for above-average temperatures for all of North Dakota (see Figure 8a). The CPC is calling for below-average rainfall in the western half of the state and an equal chance of above or below average precipitation in the east (see Figure 8b).

The next 90-day outlook from the CPC should be available on June 17 at www.cpc.ncep.noaa.gov/products/predictions/90day.

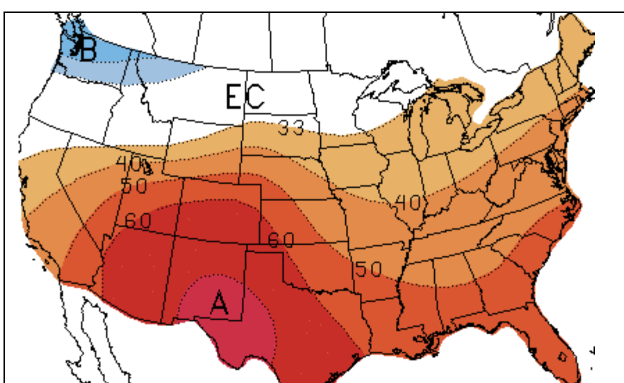


Figure 8a. March through May temperature outlook. (Climate Prediction Center, NOAA)

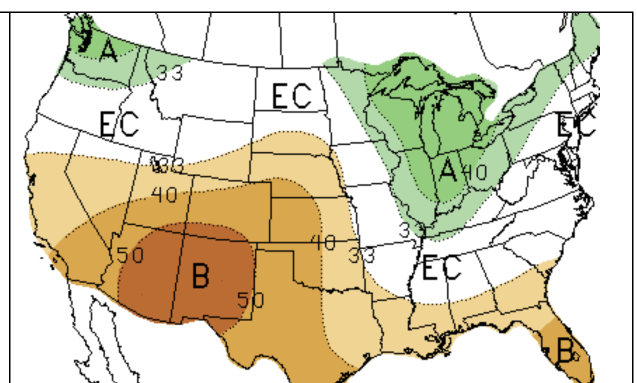


Figure 8b. March through May precipitation outlook. (Climate Prediction Center, NOAA)

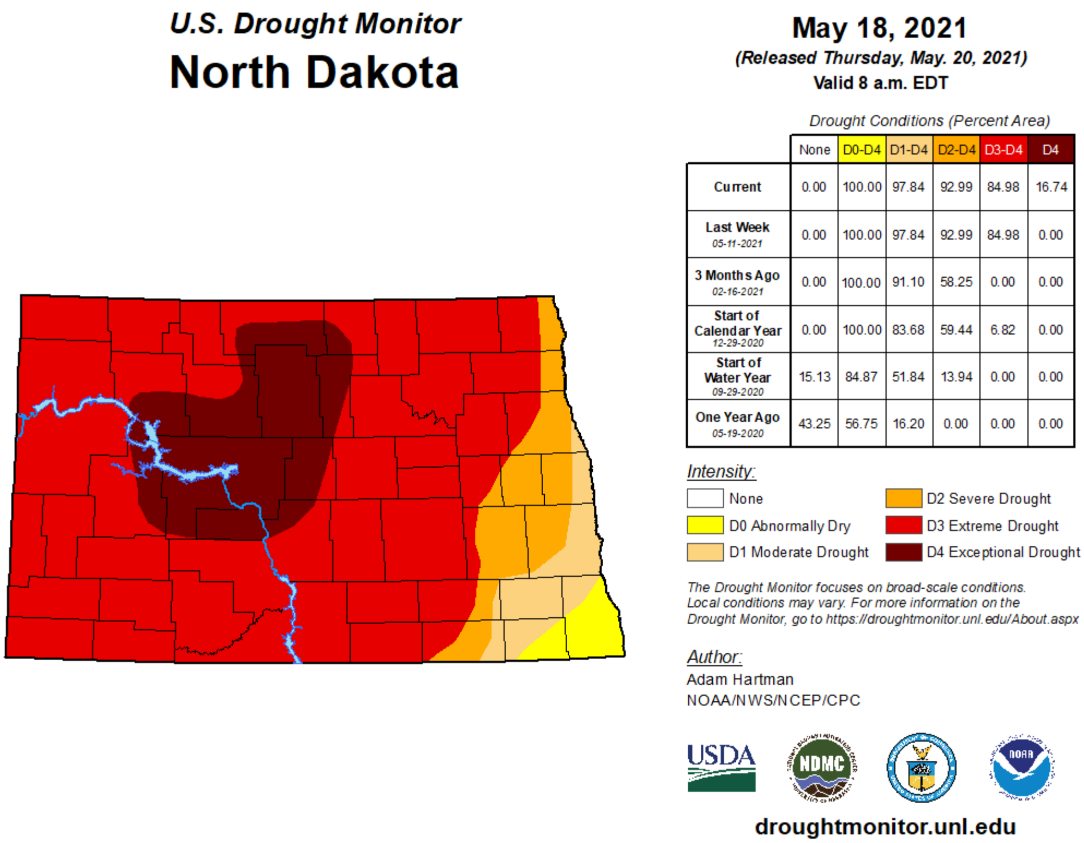
[3] The corresponding author, Rob Kupec, is chief meteorologist at KVRR-TV in Fargo, N.D. Email: rkupec@kvrr.com

Hydro-Talk

Drought Improvement?

By A. Schlag[4]

The drought in North Dakota has dragged on since late March 2020. At least for now, the severity and extent would appear to have reached their maximum around the middle of May 2021, as depicted in Figure 9. Since then, the state has received a couple of rounds of significant moisture. May 8-24 was in particular a wet period for southwestern North Dakota, which saw Stark and Dunn counties receive above-normal rainfall. The rapid turnaround in meteorological drought can be seen in the 180-day percent of normal, dated April 15, June 8 and June 11 in Figures 10, 11 and 12, respectively.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	97.84	92.99	84.98	16.74
Last Week 05-11-2021	0.00	100.00	97.84	92.99	84.98	0.00
3 Months Ago 02-16-2021	0.00	100.00	91.10	58.25	0.00	0.00
Start of Calendar Year 12-29-2020	0.00	100.00	83.68	59.44	6.82	0.00
Start of Water Year 09-29-2020	15.13	84.87	51.84	13.94	0.00	0.00
One Year Ago 05-19-2020	43.25	56.75	16.20	0.00	0.00	0.00

Figure 9. U.S. Drought Monitor map at maximum extent.

As shown in Figure 10 (the April image), widespread deficits were readily apparent. Then by the same measure of time, on June 8 (Figure 11) a couple of notable areas were above normal for precipitation, all due to just a couple of storms! And again, just another three days later, the same 180-day measuring stick on June 11 (Figure 12) showed an even larger part of the state was now well above average for

[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

precipitation. This improvement came largely from a single storm front that moved across the state on June 8 and 9. This one storm produced enough rain to leave several counties well above normal for precipitation.

Meteorologically, it is tough not to recognize this change in fortune on the U.S. Drought Monitor. Despite a lack of widespread improvement with regard to impacts, improvements have been reflected in the U.S. Drought Monitor maps. Nonetheless, we are now far enough along in the growing season to where some impacts are now set in stone for the year. Pastures and native hay are unlikely to rebound to anywhere near normal productivity, nor are some of the early planted small grains, but later planted row crops in these areas are likely to benefit. Similarly, rebounds in streamflow did take place but look likely to once again fall down to worrisome levels.

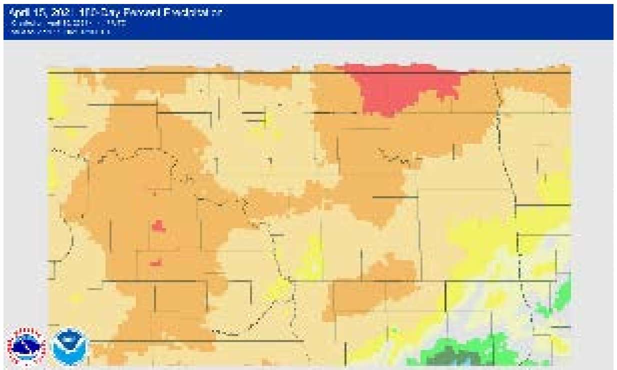


Figure 10. April 15 180-day percent of normal precipitation.

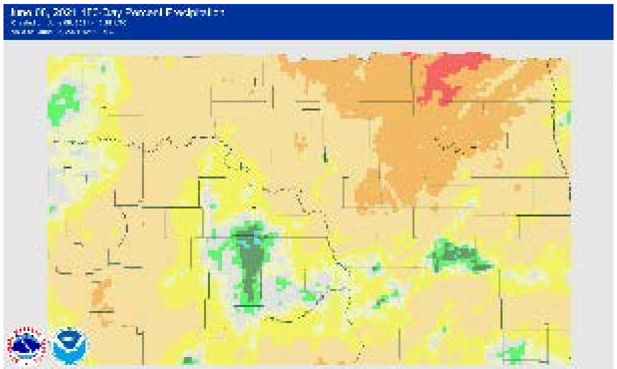


Figure 11. June 8 180-day percent of normal precipitation.

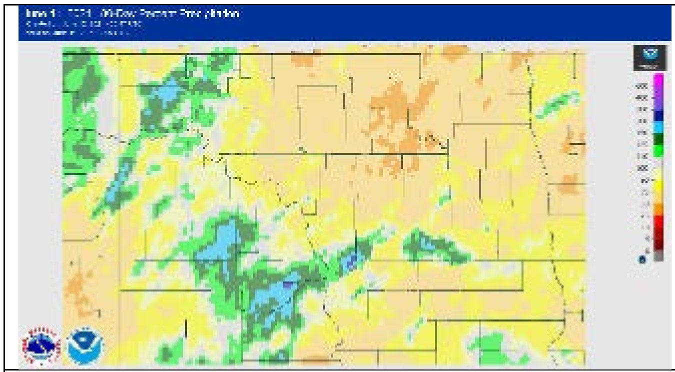
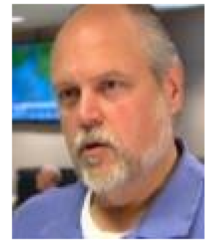


Figure 12. June 11 180-day percent of normal precipitation.

Science Bits



June 10-11 2021, Severe Storm Outbreak

By G. Gust[5]

Low-level Moisture, Storm Size and Severe/Tornadic Thunderstorms in Wet vs. Dry Years

As a dry fall, then winter, turned into a dry spring and potentially dry summer, more than a few folks have questioned whether we would ever have a spring-summer severe weather season. And as of this writing, in early June 2021, we can say unequivocally: Yes!

Keep in mind that a number of factors conspire to produce our typical spring-summer convective weather, and this **Part 1** article can only touch lightly on a few.

The (westerly) jet stream(s): On a large scale, the mid to upper atmospheric jet stream is what brings large-scale organization to our weather, and its day-to-day location constitutes the general west-to-east storm track across the northern Plains region. This jet stream changes amplitude and intensity and can branch or merge very dynamically during periods of several hours to many days. The jet stream generally will keep a seasonally steady number of storm systems moving into and across the northern Plains region, although sometimes tracking them a bit further north or south of any one area. Earlier this spring, for instance, South Dakota, Nebraska and Iowa were quite a bit stormier and wetter, while from late May into early June, the storm track has shifted back over North Dakota and Minnesota.

The image below (Figure 13) depicts the jet stream (500 MB level) at roughly 1 a.m. CDT (06 UTC) on June 11, 2021. The highest wind core of the jet stream (shaded blue) is pushing into eastern Wyoming, then arching sharply northward along the Montana/North Dakota border, producing what is called a diffluent flow aloft over much of the state and providing a large scale upward "pull" on developing storms.

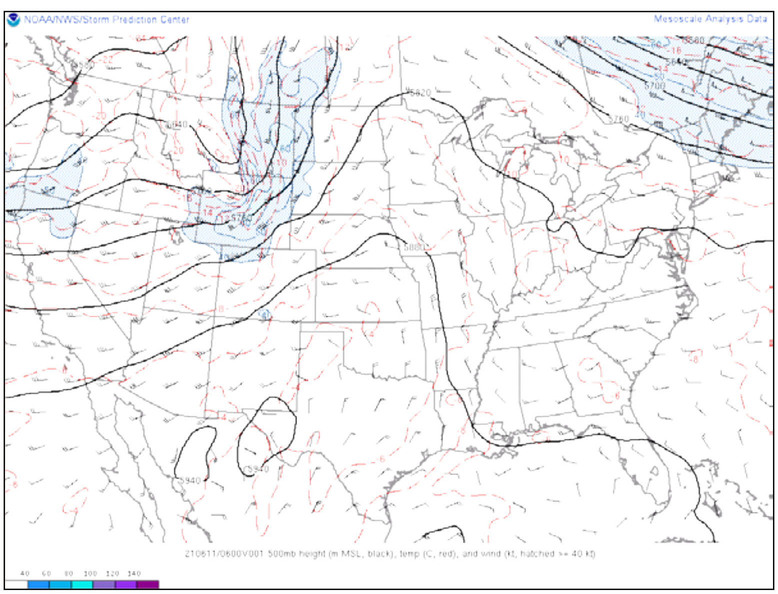


Figure **13**. 500 mb height map at 06 GMT, June 11, 2021.
(www.spc.noaa.gov/exper/mesoanalysis/new/viewsector.php?sector=19&parm=500mb)

[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 (southerly) low-level jet (LLJ): Also on a large scale, this south-to-north flow is responsible for transporting a deep layer, a near-surface layer of moist air from Gulf Coastal and southern Plains states, up and into our northern Plains region. This flow of low-level atmospheric moisture is quite temperamental and can combine with local effects to produce very high humidity and widespread drenching rains, or it can be totally tapped by storm development in the southern or central Plains.

The image below (Figure 14) depicts the low-level jet stream (950-850 MB level) at roughly 1 a.m. CDT (06 UTC) on June 11, 2021. The highest wind core of the low-level jet stream is punching northward through the Plains states and "converging" with a low-level cold front pushing eastward through western North Dakota. This low-level convergence produces increased updraft throughout that frontal zone, where the low-level moisture will rise, cool and condense over a broad area. In this case, it will produce a squall line that will progress rapidly eastward across central and eastern North Dakota during the next few hours.

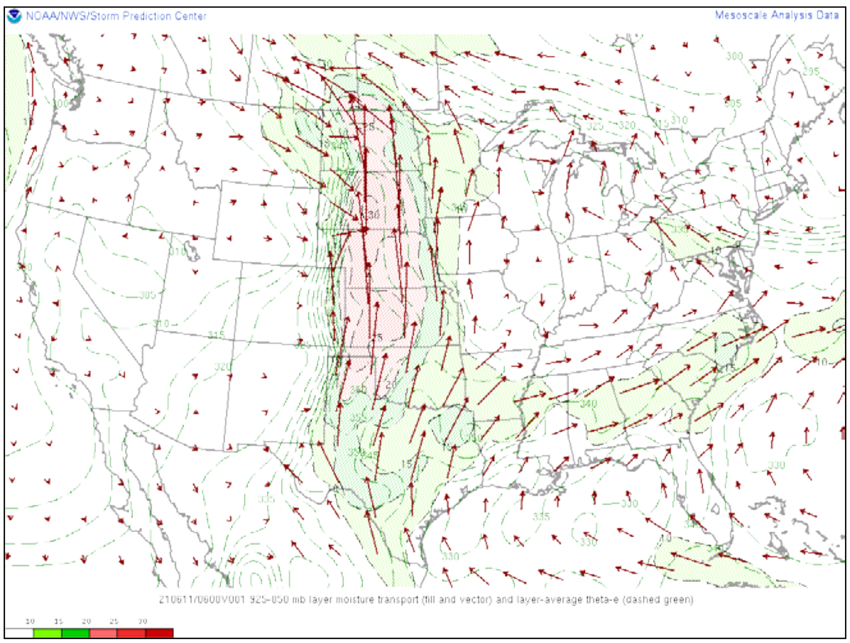


Figure 14. Low-level jet stream (950-850 MB level) at roughly 1 a.m. CDT (06 UTC) on June 11, 2021. (www.spc.noaa.gov/exper/mesoanalysis/new/viewsector.php?sector=19&parm=tran_925-850)

Local evapo-transpiration (ET): As the name implies, this is a much more localized effect and can vary greatly from one county or one area of the state to another. It is the combined effect of **evaporation** off of land or water surfaces and **transpiration** from the crop canopy, grassland or natural landscape features.

In this sense, the old saying that "wet begets wet and dry begets dry" rings true. If we have wet grounds for evaporation and active plant growth, then that local moisture can feed back into the next set of storms that may move into a region.

Dewpoint temperature (Td)[6]: The dewpoint temperature is defined as the temperature to which a parcel of air must be cooled for saturation to occur and dew (or frost) to form. Td is a good measure of the local contribution of moisture to local convection because higher Td values directly relate to the number of water molecules in the air.

[6] The Glossary of Meteorology: http://glossary.ametsoc.org/wiki/Main_Page

The image below (Figure 15) depicts the surface analysis across the northern Plains region at roughly 1 a.m. CDT (06 UTC) on June 11, 2021. At each station, the air temperature is shown as the upper left (red) number, while the dewpoint temperature is shown as the lower left (green) number. Dewpoint values in the 50s are shown behind the frontal area from southeastern Saskatchewan through far western North Dakota and eastern Montana. In comparison, dewpoints in the 60s and low 70s stretch ahead of the front through east and central North Dakota. An animated radar image for this episode is available online at www.weather.gov/images/bis/regional_radar_loop_june102021.gif.

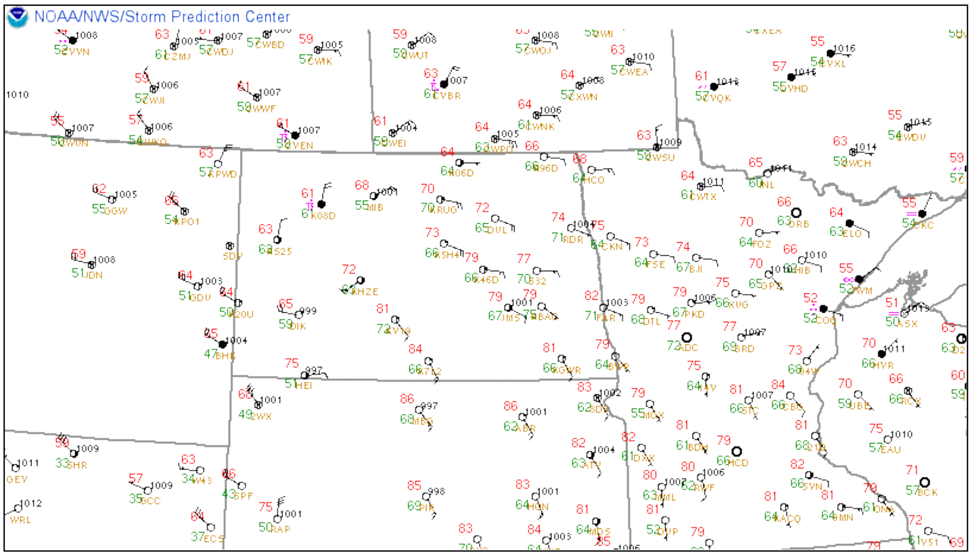


Figure 15. Surface analysis across the northern Plains region at roughly 1 a.m. CDT (06 UTC) on June 11, 2021.

Just a week earlier, storms on June 5-6, 2021, struggled to form and sustain, with dewpoints ranging only from the 50s into the low 60s. More surface moisture and active plant growth, i.e., more ET, was part of the equation that led to a larger coverage area and impact from the June 10-11, 2021, storms.

In any given year, as one transitions geographically from a wetter region to a drier region (or vice versa) across these northern Plains, our typical spring-summer convective storms maintain fairly similar structures, yet often substantial reductions (increases) occur in overall storm size, the resultant rainfall and any storm damage footprint. Likewise, as any portion of North Dakota transitions from a wetter to a drier period (or vice versa), it is likely to still experience storminess but with a decreased (increased) footprint.

Look for **Part 2: A Examination of Tornadic Supercell Types** in the upcoming summer 2021 edition of the North Dakota Climate Bulletin.

In the meantime, you can check out the online event review webpages produced by the National Weather Service (NWS) Bismarck and NWS Grand Forks offices, covering the June 10-11, 2021, episode:

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

June 11 Severe Event Review: www.weather.gov/fgf/2021_06_11_SevereEvent

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[7].

North Dakota State Climate Office

College of Agriculture, Food Systems, and Natural Resources
North Dakota State University
304 Morrill Hall, Fargo, ND 58108
Climate Services: 701-231-6577

URL: www.ndsu.edu/ndsco
Email: Adnan.Akyuz@ndsu.edu

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