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

The overall autumn average temperature was nearly average, which would make it the 60th coolest or (67th warmest) autumn on record. Precipitation-wise, the statewide accumulation was 2.63 inches drier than average, which would make it the third driest autumn on record. An extreme drought category was introduced at the end of the season as the severe drought expanded eastward and southeastward as a result of progressive dryness in these areas. Grand Forks, Sheridan and Wells counties experienced the driest autumn in 2020 following the wettest autumn in 2019. The extreme contrast existed statewide, moving from the wettest autumn in 2019 into the third driest season in 2020. A summary of the statewide swift and extreme transition is discussed in the Hydro-Talk and Science Bits sections of this bulletin.

Overall, 324 records, including temperature- and precipitation-related occurrences across the state, were tied or broken.

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

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

Aspens in autumn by F.A. Akyüz, Turtle Mountain, N.D.

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 autumn season (Sept. 1 through Nov. 30, 2020) was 1.22 inches, which was 7.17 inches less than the last season (summer 2020), 7.7 inches less than last autumn (2019 season) and 2.63 inches less than the 1981-2010 average autumn precipitation (Table 1). This would rank the autumn of 2020 as the third driest autumn since such records began in 1895. The numbers less than 100 in Figure 1 are shaded in orange and red to depict the region with below-average rainfall.

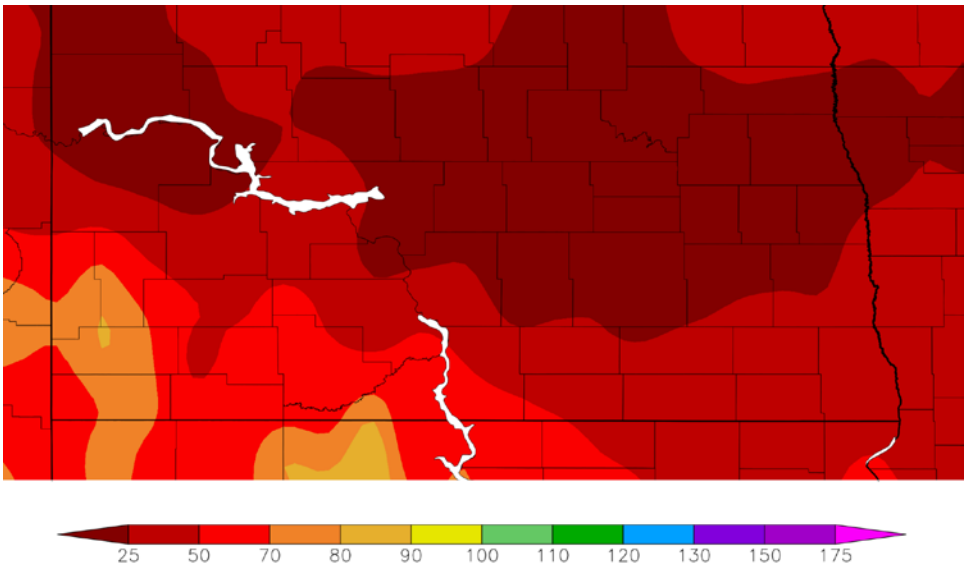


Figure 1. Precipitation percent of normal in autumn 2020 for North Dakota. (High Plains Regional Climate Center, HPRCC)

The greatest precipitation accumulation of the season was 2.65 inches, recorded in Fargo, Cass County. The greatest snowfall accumulation of the season was 13.5 inches, recorded in Rhame, Bowman County.

Based on historical records, the state average autumn precipitation showed a positive long-term trend of 0.84 inch per century during this period of record since 1895. The lowest and highest seasonal autumn precipitation for the state ranged from 0.99 inch in 1976 to 8.92 inches in 2019. The historical autumn precipitation for North Dakota time series (Figure 2) shows a graphical depiction of these statistics.

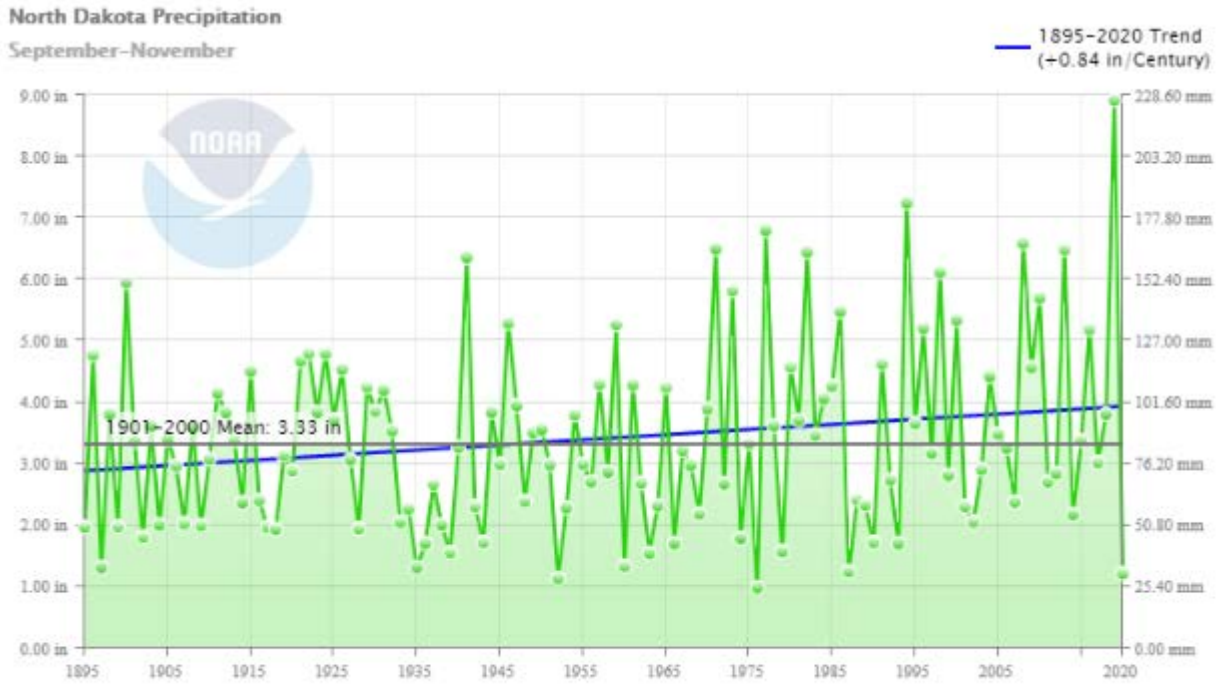


Figure 2. Historical autumn precipitation time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Wettest/Driest Since	Record Year
Autumn 2020	**1.22”**	**3.85”**	2.63”	**3rd driest 124th wettest**	**Driest since 1976 Wettest since 2019**	**0.99” (1976) 8.92” (2019)**

[1] NOAA National Centers for Environmental Information, Climate at a Glance: Statewide Time Series, published December 2020, retrieved on Dec. 11, 2020, from www.ncdc.noaa.gov/cag.

Temperature

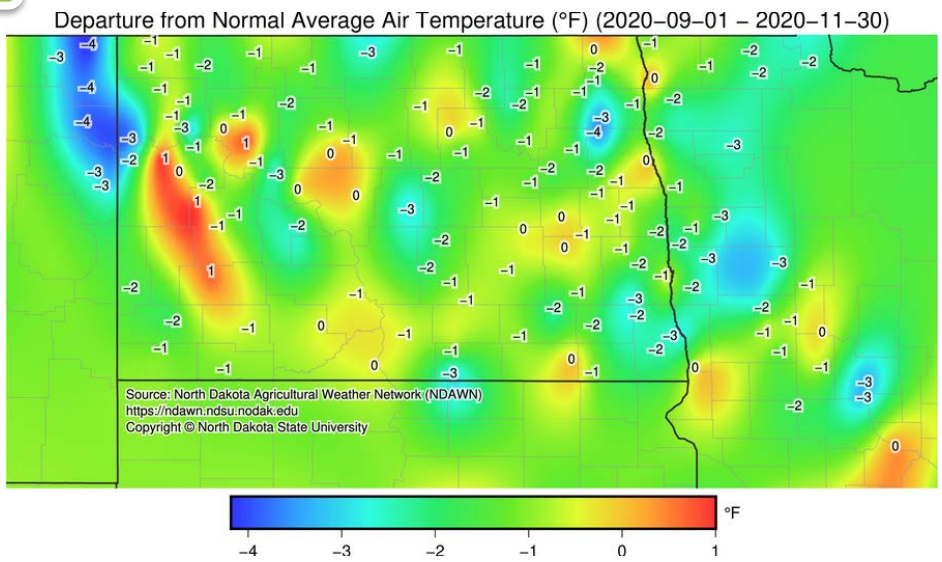


Figure 3. Temperature departure from normal in autumn 2020 for North Dakota. (North Dakota Agricultural Weather Network)

The average North Dakota temperature for the season (Sept. 1 through Nov. 30) was 42.3 F, which was 26 degrees cooler than the last season (summer 2020), but 1.6 degrees warmer than last autumn (2019 season). It was only 0.3 degree cooler than the 1981-2010 average autumn temperature, which would rank autumn 2020 as the 60th coldest (or 67th warmest) autumn since such records began in 1895 (Table 2). Figure 3 shows the departure from normal temperature distribution geographically. The negative numbers in Figure 3 are shaded in green and blue to depict the region with below-average temperatures. In contrast, numbers greater than zero in the same figure are shaded in orange and red to depict the region with above-average temperatures. Based on historical records, the average autumn temperature showed a positive trend of 1.6 degrees per decade since 1895. The lowest and highest seasonal autumn temperatures for North Dakota ranged from 32.2 F in the 1896 season to 49.1 F in the 1963 season. The historical autumn temperature for the North Dakota time series (Figure 4) shows a graphical depiction of these statistics.

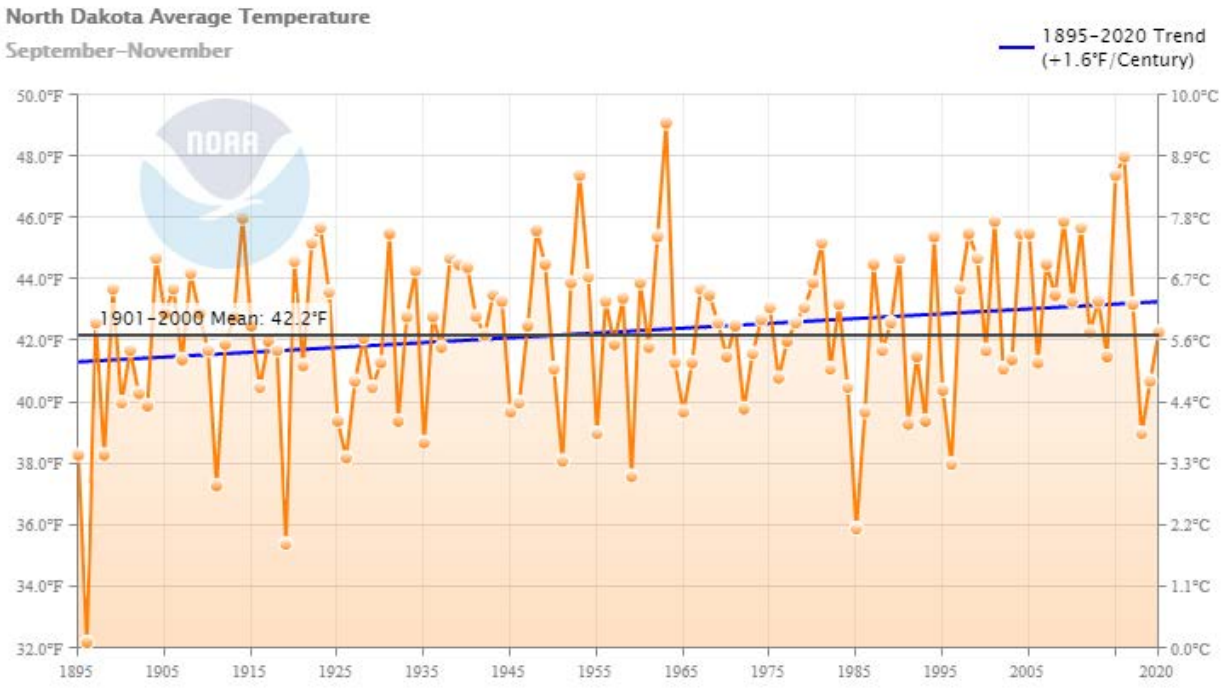


Figure 4. Historical autumn temperature time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Warmest/Coolest Since	Record Year
Autumn 2020	42.3 F	42.6 F	-0.3 F	60th coolest 67th warmest	Coolest since 2019 Warmest since 2017	32.2 F (1896) 49.1 F (1963)

[2] NOAA National Centers for Environmental Information, Climate at a Glance: Statewide Time Series, published December 2020, retrieved on Dec. 11, 2020, from www.ncdc.noaa.gov/cag.

Drought: The drought conditions intensified throughout the season. By the end of the season, 77% of the state was in drought, impacting 441,718 North Dakotans. Fifty-five percent of the state was at least in the severe drought (D2) category, 7 % of which was in the extreme drought category. Grand Forks experienced the driest fall on record in 2020 following the wettest fall on record in 2019. The entire state experienced the third driest fall in 2020 following the wettest fall on record in 2019. The change between the two seasons in one year was remarkable. Figure 5 below shows the drought conditions in the beginning and the end of autumn. Figure 6 shows the drought intensity and coverage in a time scale. Both of the figures show no drought conditions spatially and temporally.

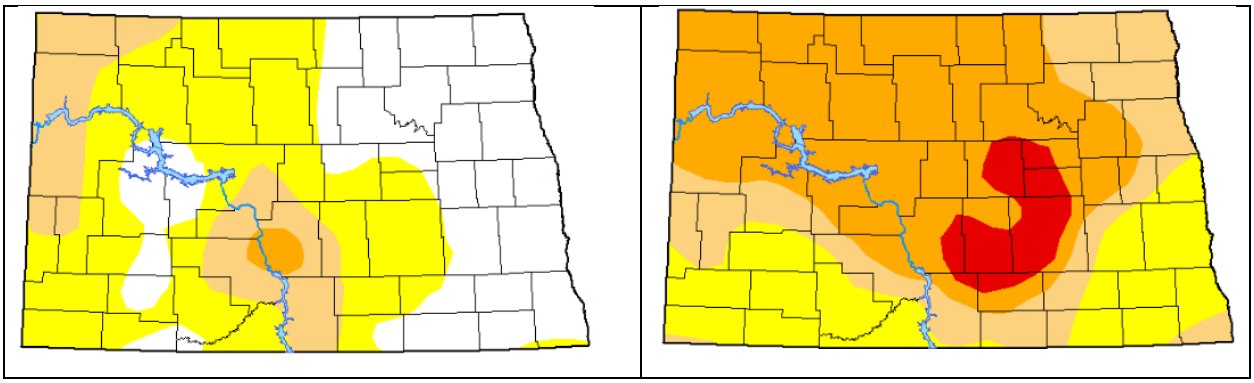


Figure 5. Drought Monitor map comparison for North Dakota in the beginning (on the left, 5a) and at the end (on the right, 5b) of autumn 2020. (U.S. Drought Monitor)

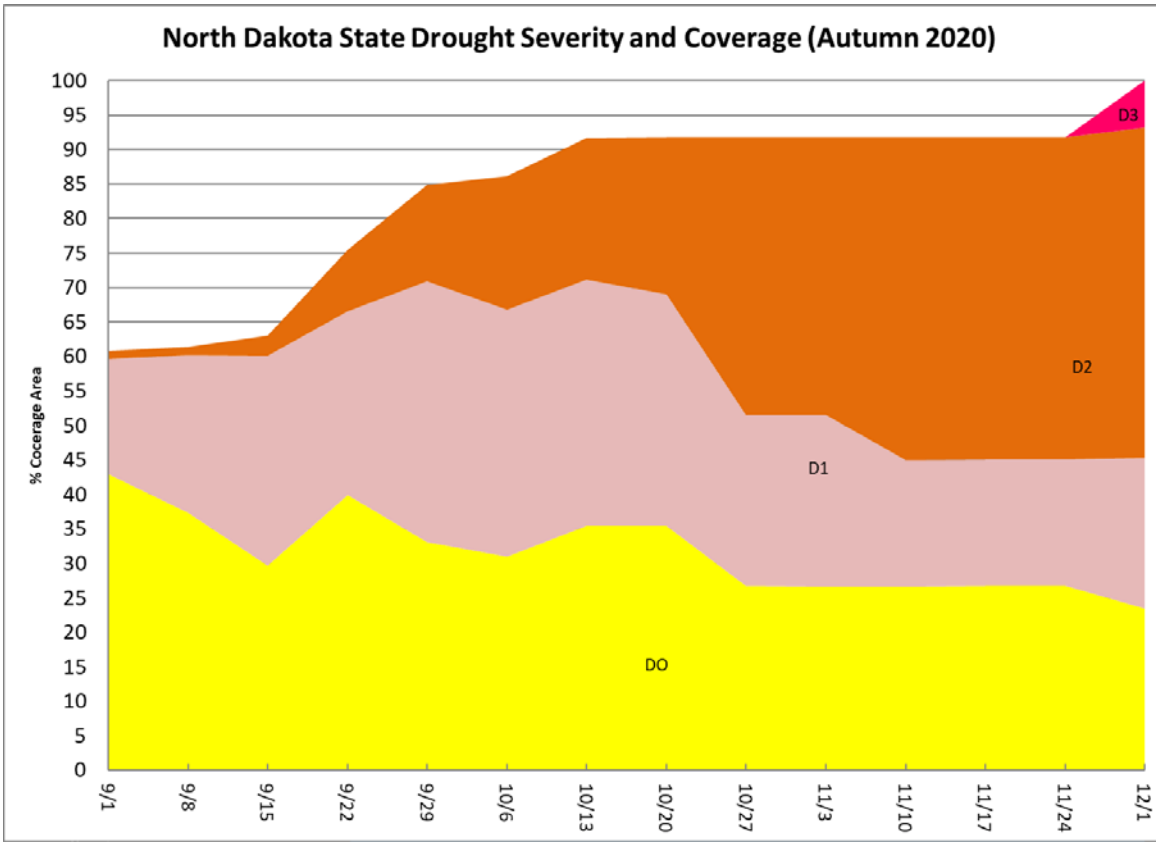


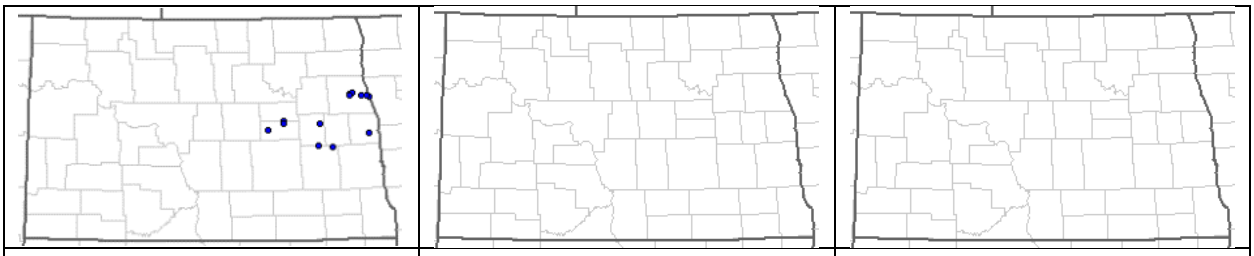
Figure 6. Statewide drought coverage in percentage and intensity (DO, D1, etc.) in a time scale representing the state from the beginning to the end of the season, with a one-week resolution, in autumn 2020.

Storms and Record Events

State Tornado, Hail and Wind Events for Autumn 2020

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

	September	October	November	Seasonal Total
Tornado	0	0	0	**0**
Hail	0	0	0	**0**
Wind	13	0	0	**13**
Total	**13**	**0**	**0**	**13**



September North Dakota Storm Events	October North Dakota Storm Events	November 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 Autumn 2020

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	September	October	November	Seasonal Total
Highest daily max. temp.	6	2	61	**69**
Highest daily min. temp.	3	5	6	**14**
Lowest daily max. temp.	24	90	0	**114**
Lowest daily min. temp.	37	39	0	**76**
Highest daily precipitation	0	5	2	**7**
Highest daily snowfall	0	44	0	**44**
Total	**70**	**185**	**69**	**324**

Seasonal Outlook

Winter 2020-21 Outlook

By R. Kupec[3]

What a wild ride the fall of 2020 has been. Temperatures in September began near normal, then swung wildly colder for October, around 6 to 8 degrees below average. Just as quickly, the pendulum swung the other way and November temperatures ran about 3 to 6 degrees above average. The cold of October was just too much to overcome and the season ended 1 to 3 degrees below average (see the October report). Precipitation this autumn was below average all three months across the state. This is despite many locations seeing one of the snowiest Octobers on record. Even with the snow, October was a drier month, just like September and November.

The Fall Climate Outlook called for above-average temperatures and average to slightly below-average precipitation. The precipitation was certainly below average but the warmer temperatures did not manifest until November and now are carrying into December. The fall forecast was based on a developing La Niña in the Southern Pacific. The La Niña pattern has taken hold and has become stronger, compared with recent events. More often than not, La Niña winters tend to be colder with more snow. The two most recent winters where a stronger La Niña was present were 2010/11 and 2007/08. Those winters brought colder than average temperatures across the state but wetter conditions mostly west of the Red River Valley. The 2010/11 and 2007/8 La Niñas were marked by very cold and snowy Decembers. Nearly two weeks into the month at the time this is being written, we are seeing dry and very warm conditions, with some spots up to 20 degrees above average. Certainly, this will tamp down winter averages for temperature and precipitation should we turn colder and snowier, as I believe we will.

In summation, this winter should end colder than average and in most spots wetter than average but likely not as much as in previous La Niña years, given the conditions we are seeing at the start of December. The chances of a wetter than average winter in the Red River Valley are not as great as areas west of the valley. The current Climate Prediction Center (CPC) Winter Outlook has a similar forecast. It is calling for below-average temperatures and above-average precipitation for all of North Dakota. The CPC precipitation forecast gives a higher chance of above-average precipitation for the western part of the state and the northern Red River Valley (Figure 8). The next 90-day outlook from the CPC should be available on Dec. 17 at www.cpc.ncep.noaa.gov/products/predictions/90day.

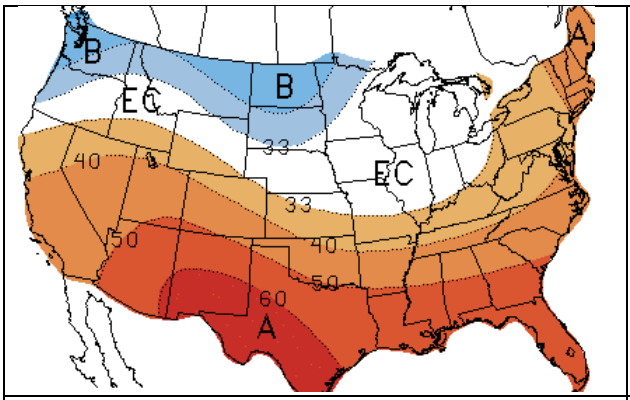


Figure 8a. December through February temperature outlook. (Climate Prediction Center, NOAA)

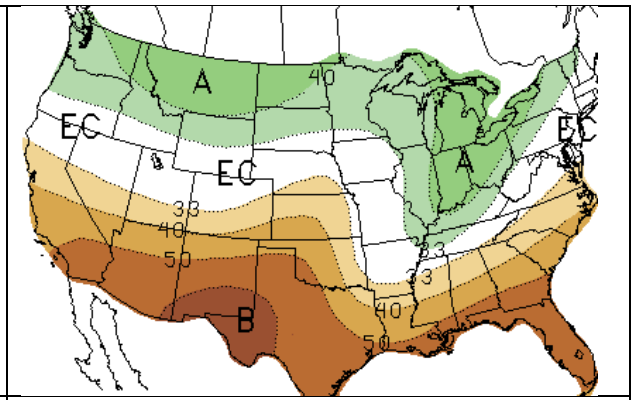


Figure 8b. December through February precipitation outlook. (Climate Prediction Center, NOAA)

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

Hydro-Talk

From One Extreme to the Next, Again!

By A. Schlag[4]

I'm going to hazard a guess that I've said this before, but in North Dakota, we tend to simply go from one extreme to the next and simply wave at "normal" on our travels. Once again, we seem to have done exactly that. After a wet second half of 2019, it edged into the overall wettest year on record for North Dakota. Fast forward to the spring of 2020 and we experienced an unremarkable spring runoff as the state quickly transitioned into a much drier weather pattern. The initial signs of drought were recognized back in late March, see Figure 9. Fast forward again to early December's depiction of drought in Figure 10 and we see the net result of what has been a steady expansion and degradation of conditions across North Dakota.

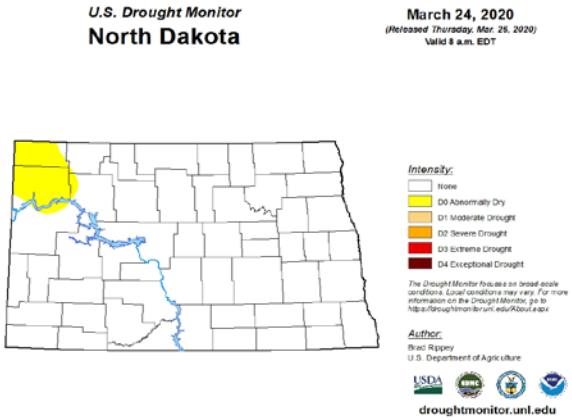


Figure 9. Initiation of drought in 2020.

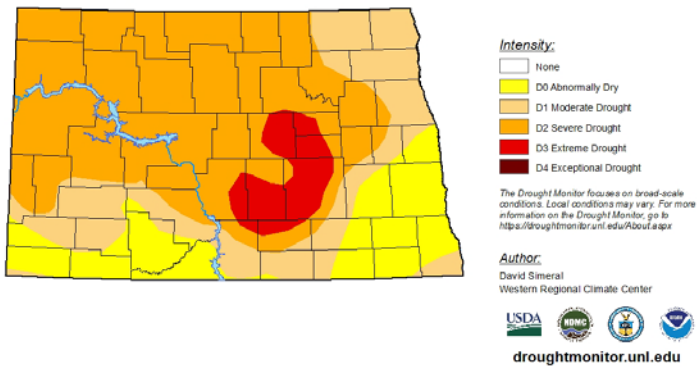


Figure 10. USDM Map for North Dakota on Dec. 8, 2020.

Many things go into the U.S. Drought Monitor (USDM) interpretation of conditions across an area: precipitation, soil moisture, streamflow, crop health, etc. In the 2020 example, streamflow and soil moisture, having been buoyed by the wet 2019, mitigated some of the drought severity early in the spring and summer. Actually, as my article in the Summer 2020 Climate Bulletin noted, we had, and continue to have, a large number of excess surface water problems across North Dakota.

In Table 4, precipitation totals up through early December are listed for some of the major cities across the state. These point values help us understand the often expressed disappointment in the USDM designations across North Dakota, for not only are some of these values less than 50% of their 30-year normal, but they are in general one-third to one-half of the 2019 precipitation totals up to this point in the year. In fact, several of the current values will put these locations in the top 10 driest on record for their respective historical data.

[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 thing that is a near certainty is that without near-normal spring rains and snowmelt runoff, agricultural and ecological impacts will be felt much sooner in the late spring and summer than those observed in 2020.

Table 4. Spot Precipitation Values Across North Dakota.

Location	2020 YTD Precip	+/- of Normal	2019 YTD Precip	+/- from 2019 YTD
Williston - Airport	6.15	-7.74	16.09	-9.94
Minot Exp Station	11.63	-5.30	23.41	-11.78
Grand Forks - NWS	17.92	-3.27	32.52	-14.60
Fargo	18.71	-3.33	29.92	-11.21
Jamestown St. Hosp	13.44	-5.06	26.44	-13.00
Bismarck - NWS	8.15	-9.37	29.23	-21.08

Precipitation values are in inches of water, as of Dec 11, 2020.
YTD = Year To Date

So let's now take a look at current conditions, our expectations for winter of 2020-2021 and reasonable ranges of outcomes for the spring of 2021. Given the dry conditions over central and western North Dakota this past summer, soils all across North Dakota are somewhere between slightly dry and extremely dry for this time of year. The Climate Prediction Center has consistently called for a higher-than-normal risk of a cooler and wetter-than-normal winter of 2020-2021 (Figures 8a and 8b). This higher-than-normal risk of cool and wet weather continues well into the spring of 2021. As I consider all the above, I expect the dry soils to substantially temper the spring runoff under all but the most extreme of spring runoff seasons. However, the expectation of a wetter-than-normal winter and spring, if it comes to fruition, can overwhelm the dry soils during a fast melt (less than one week) and leads me to expect below-normal to near-normal runoff with little impactful flooding along rivers and streams.

In those large lakes and wetlands in the Prairie Pothole Region that have risen significantly during the past several years, I expect many of those problematic bodies of water to continue to be a problem going forward. Many of those lakes and wetlands are well connected to groundwater sources that contain much greater amounts of groundwater than the lakes have in surface water. This large but hidden reserve of water will continue to influence lake levels for years to come, and reaching previous high water marks is likely, even with near-normal spring runoff.

As usual, come March, I will have a much better understanding of where we stand with respect to spring flood risks. Until then, each passing storm or dry week will influence my opinion on spring flood risks.

Science Bits

Wet Fall, Dry Fall: Will This Affect the Freeze and Thaw?

By G. Gust[5]

I suspect that the answer to the question *Will a wet or dry fall have an impact on the subsequent winter/freeze and spring/thaw processes?* is a yes! But like most of our seasonal transitions, more than a few factors may come into play.

Flood to Drought: Figure 10 shows the statewide drought condition mapping at the end of this autumn season. As has been discussed previously, this past autumn season (September through November 2020) had been the third driest for North Dakota, statewide, in the past 126 years. And this comes on the heels of autumn 2019, which was the statewide wettest autumn season on record (Figure 11).

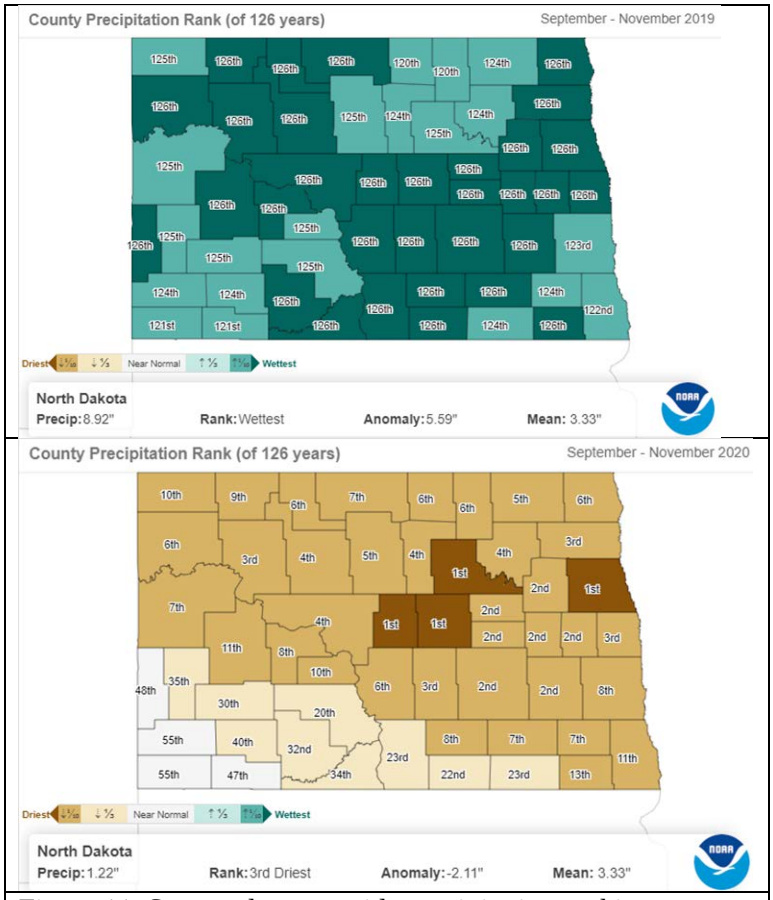


Figure 11. State and countywide precipitation ranking comparison between two consecutive autumns: 2019 (above) and 2020 (below), NOAA-NCEI[6].

Extreme Continentality and Variability: This is somewhat common, given our state's location at the geographical center of North America, where we have some of the greatest variability in the day-to-day, week-to-week, month-to-month and year-to-year values of temperatures and precipitation.

Figure 2 shows state and county precipitation rankings from fall 2019 and 2020, with anomalies calculated using the full 126-year period of record.

Of the four first-place "driest" counties, three of those (Grand Forks, Sheridan and Wells counties) were first place "wettest" in fall 2019. All 37 (of 53) Top Ten driest counties in 2020 were among the 53 (of 53) Top Ten wettest counties in 2019. Note that the areas having extreme drought (D3: red), as depicted in Figure 10, don't line up exactly with those areas having the greatest precipitation deficits for the fall season. Precipitation and soil moisture available throughout the entire year is one factor. Another is temperature - seasonal air temperature as well as soil temperature. One thing we learn in physical science classes is that all else being equal, dry soil will warm and cool more quickly than wet soil, mainly due to its specific heat or heat capacity. The water that is present in wet soil takes/releases more energy as it warms/cools than the dry soil particles. In meteorology classes, we learn about additional factors such as latent heat, the energy

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

involved in the phase change of water from solid to liquid to gaseous form. Add plants to the system and the process of plant growth, as influenced by available root-zone moisture and sunlight, will use (or deflect) even more solar energy.

Neither Record Hot Nor Cold: Figure 12 shows state and county temperature rankings from fall 2019 and 2020, with anomalies calculated on the full 126-year period of record.

Even though fall precipitation levels were quite low, temperature rankings for the fall 2020 period were very near normal across the state and even a touch cool across the southeast. Residual soil moisture from the previous year and adequate precipitation during the earlier growing season were likely factors and also acted to delay the onset of moderate to extreme drought.

Note that fall 2019 was anomalously cool across the state, in large part due to the increased cloud cover during those prolonged rain and snow events and the increased evapotranspiration that followed.

Under normal levels of sunshine, that excessive moisture and early snowpack in 2019 would have required more latent heat for sublimation (phase change from snow to gas), and would have led to less heat going into the surface for absorption and emission (sensible heat exchange), thus the near-surface air would have been more humid and cool.

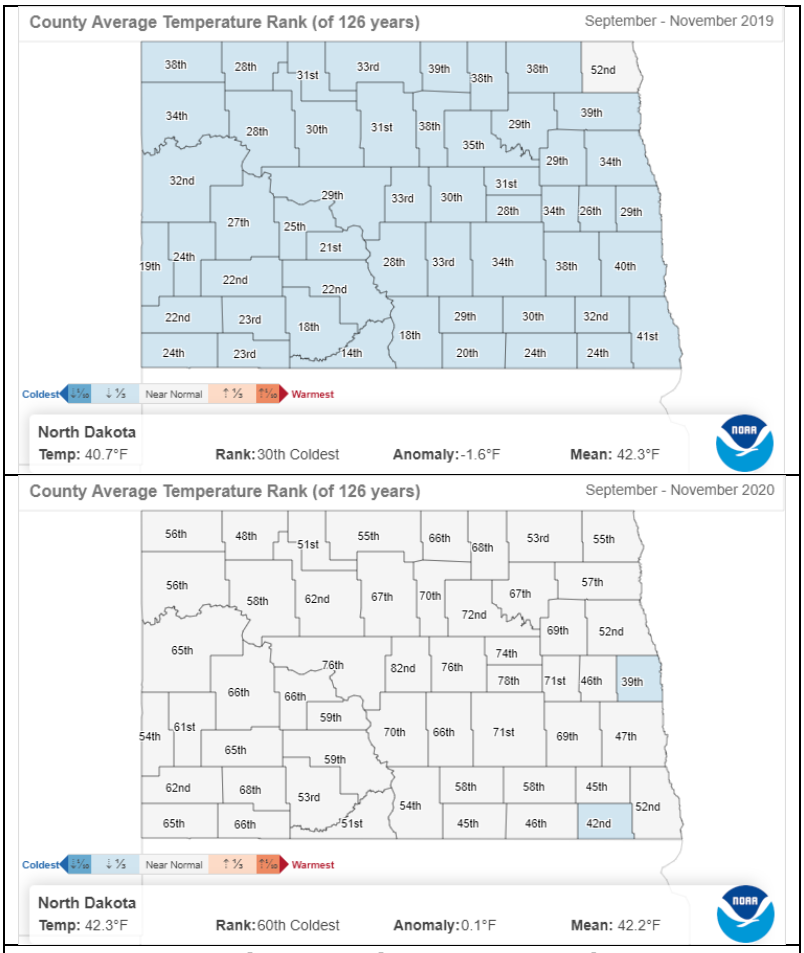


Figure 12. State and countywide temperature ranking comparison between two consecutive autumns: 2019 (above) and 2020 (below), NOAA-NCEI[6].

By comparison, our fall 2020 near-surface airmass was markedly drier and warmer. Again, residual soil moisture helped maintain sufficient plant growth and evapo-transpiration well into the otherwise dry fall period.

[6] NOAA National Centers for Environmental information, Climate at a Glance: County Mapping, published December 2020, retrieved on Dec. 15, 2020, from www.ncdc.noaa.gov/cag/

What about the winter freeze-up? Regardless of soil moisture content, early winter season snowcover and temperatures are likely the more important factors in how deep the winter frost will go.

Through the end of November 2020, statewide snowfall was low and snow cover was nearly non-existent. While autumn 2020 seasonal temperatures ran near normal, temperatures at the end of November ranged from 3 to 8 degrees above normal. Thus, frost penetration near Grand Forks, as of Nov. 30, was only around 4 to 5 inches and was negligible across southern and western parts of the state. Yet an early December cold snap has quickly driven state frost depths from 2 to 12 inches deep and 7 to 8 inches deep at Grand Forks. How much further remains to be seen.

Manual frost depth measurements are routinely taken using frost tubes at select locations around the state.

An automated network of soil moisture and temperature sensors recently was established. You can read more about that network in the autumn 2018 edition of the North Dakota Climate Bulletin at www.ndsu.edu/fileadmin/ndsco/ndsco/bulletin/fall18.pdf.

NWS Grand Forks ND Observation Program Lead (OPL), Brad Hopkins, takes a frost depth reading using a frost tube. NWS photo.

You can check the latest frost depth reading near you at https://ndawn.ndsu.nodak.edu/deep-soil-temperatures.html. Readers have to keep in mind that the NDAWN Grand Forks weather station and the NWS locations are approximately seven miles from each other. However, Akyuz et al. (2008)[7] simultaneously compared the NWS frost-dept readings and the NDAWN deep-soil temperature data at North Dakota State University with a two-year study.

[7] Akyuz, F.A, M. Ewens, R. Carcoana, B. Mullins, 2008: NWS Frost Depth Observation with Liqid-in Probes Performance: Two-year Reviw. AASC Journal of Applied and Service Climatology. V.2, No:2. https://stateclimate.org/pdfs/journal-articles/2008_2-Akyuz.pdf

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[8].

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