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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 winter average temperature was 3.3 degrees warmer than average, which would make it the 15th warmest winter on record. Precipitationwise, the statewide accumulation was 0.78 inch drier than average, which would make it the third driest winter on record. Conditions prior to winter were also dry. North Dakota experienced the driest October-February period on record since 1895. An extreme drought category appeared briefly in central North Dakota in December. Lack of snowpack and warm conditions may spark early spring planting, but lack of soil moisture and prolonged drought expectations are very much a concern for North Dakota agricultural communities.

Overall, 235 records, including temperature- and precipitation-related occurrences across the state, were tied or broken.

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

Aurora behind an oil field near Mandaree, N.D. (by Vern Whitten)

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 winter season (Dec. 1, 2020, through Feb. 28, 2021) was 0.64 inch, which was 0.58 inch less than the last season (fall 2020), 0.67 inch less than last winter (winter 2019-20) and 0.78 inch less than the 1981-2010 average winter precipitation (Table 1). This would rank the winter of 2020-21 as the third driest winter since such records began in 1895.

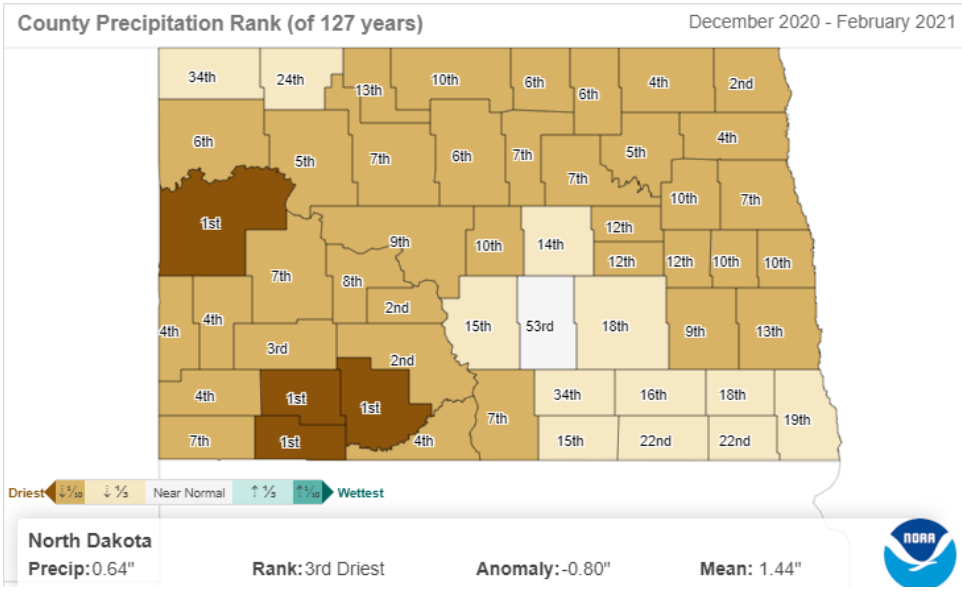


Figure 1. Precipitation percent of normal in winter of 2021-21 for North Dakota. (High Plains Regional Climate Center, HPRCC)

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 1.81 inches, recorded in Kindred, Cass County. The greatest seasonal snowfall accumulation was only 24.5 inches, recorded in McHenry, Foster County.

Based on historical records, the state average winter precipitation showed a slight negative long-term trend of 0.04 inch per century during this period of record since 1895. The highest and lowest seasonal winter average precipitation for the state ranged from 0.59 inch in the 1989-90 season to 2.99 inches in the 1968-69 season. The "Historical Winter Precipitation for North Dakota" time series (Figure 2) shows a graphical depiction of these statistics.

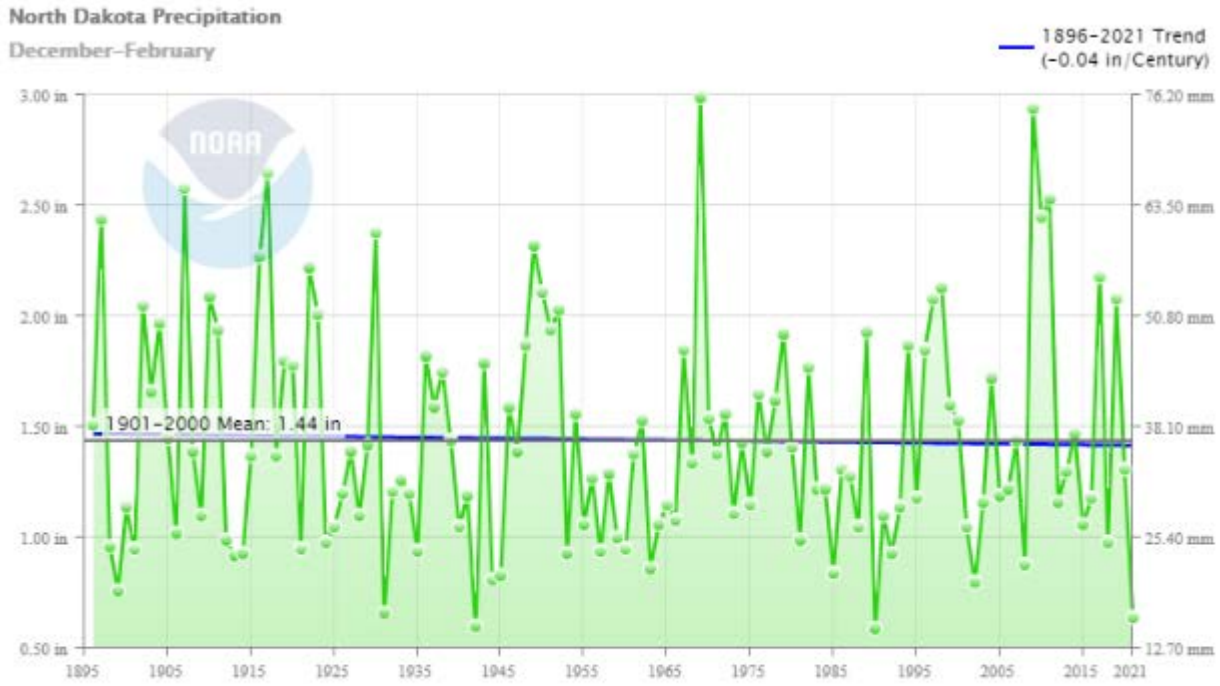


Figure 2. Historical winter precipitation time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Wettest/Driest Since	Record Year
Winter 2020-*21*	**0.64”**	**1.42”**	- 0.78”	**3rd driest 124th wettest**	**Driest since 1990 Wettest since 2020**	**0.59” (1989-90) 2.99” (1968-69)**

[1] NOAA National Centers for Environmental Information, Climate at a Glance: Statewide Time Series, published December 2019. Retrieved on Dec. 11, 2019, from www.ncdc.noaa.gov/cag.

Temperature

The average North Dakota temperature for the season (Dec. 1, 2020, through Feb. 28, 2021) was 16.8 F, which was 25.5 degrees cooler than the last season (fall 2020), but 1.2 degrees warmer than last winter (2019-20 season). It was 3.3 degrees warmer than the 1981-2010 average winter temperature, which would rank winter 2020-21 as the 15th warmest winter since such records began in 1895 (Table 2).

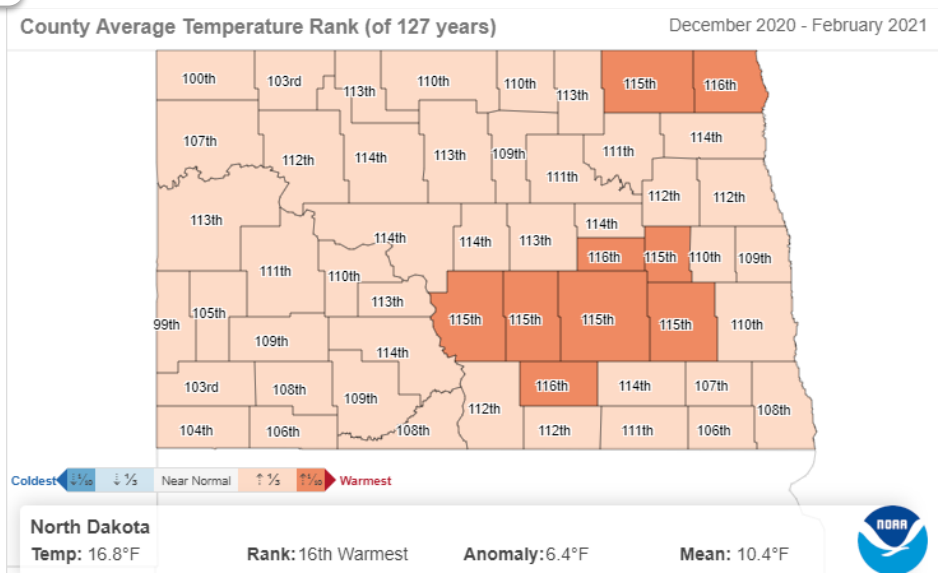


Figure 3. Temperature departure from normal in winter 2020 for North Dakota. (North Dakota Agricultural Weather Network)

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 winter temperature showed a positive trend of 4.7 degrees per decade since 1895 (the highest long-term temperature trend in the U.S.) The highest and lowest seasonal winter average temperatures for North Dakota ranged from minus 3 F in the 1935-36 season to 22.2 F in the 1986-87 season. The "Historical Winter Temperature for North Dakota" time series (Figure 4) shows a graphical depiction of these statistics.

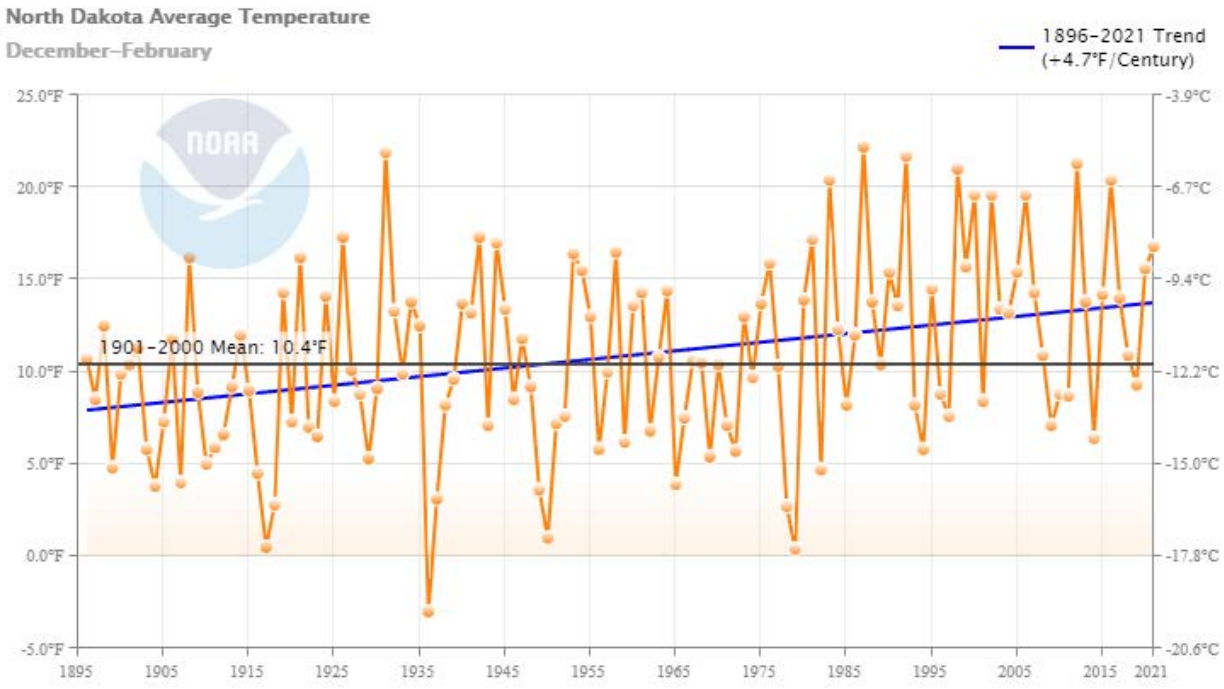


Figure 4. Historical winter temperature time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Warmest/Coolest Since	Record Year
Winter 2020-21	16.8 F	13.5 F	3.3 F	112th coolest 15th warmest	Coolest since 2020 Warmest since 2016	-3 F (1935-36) 22.2 F (1986-87)

[2] NOAA National Centers for Environmental Information, Climate at a Glance: Statewide Time Series, published December 2019. Retrieved on Dec. 11, 2019, from www.ncdc.noaa.gov/cag.

Drought: A D3 (extreme) drought category was introduced for the first 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, even though the extreme drought was eliminated, 16% more land in North Dakota was experiencing drought compared with the beginning of the season. Figure 5 below shows the drought conditions at the beginning and the end of winter. Figure 6 shows the drought intensity and coverage on a time scale. Both of the figures show no drought conditions spatially and temporally.

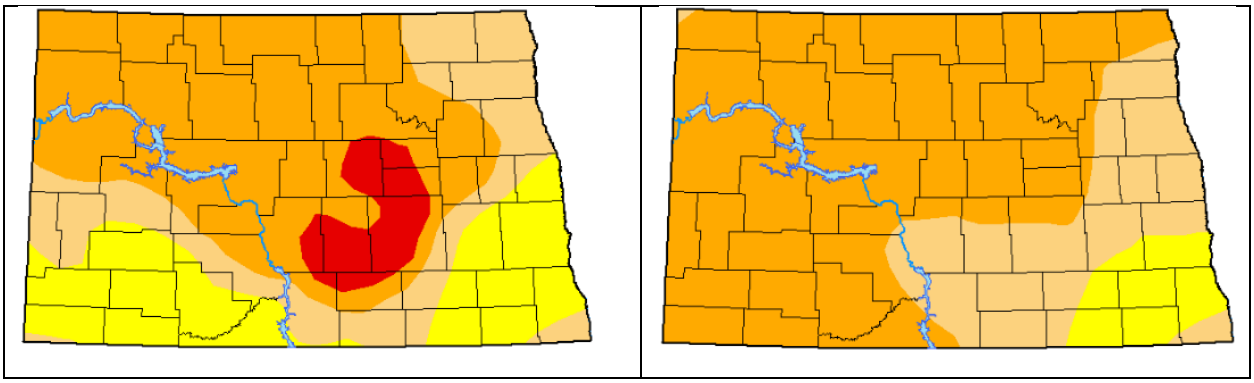


Figure 5. Drought Monitor map comparison for North Dakota in the beginning (on the left) and at the end (on the right) of winter 2020-2021. (U.S. Drought Monitor)

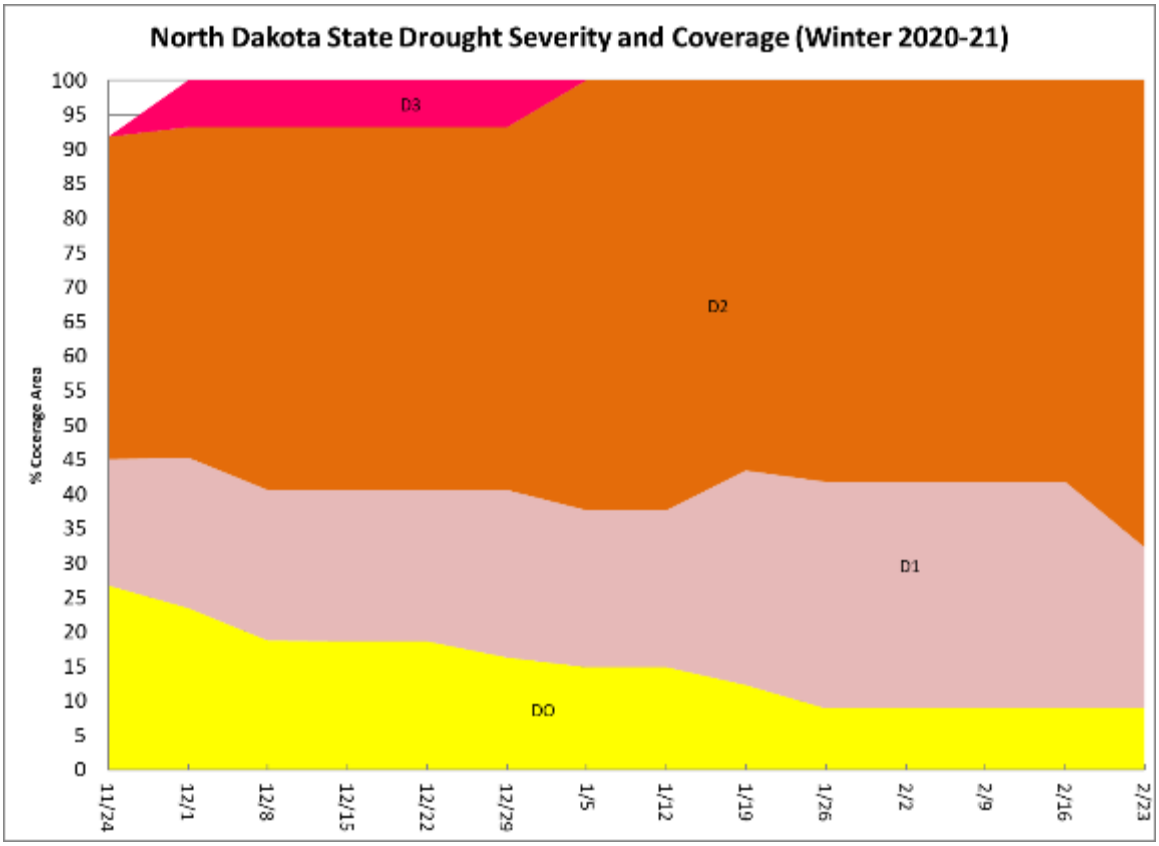


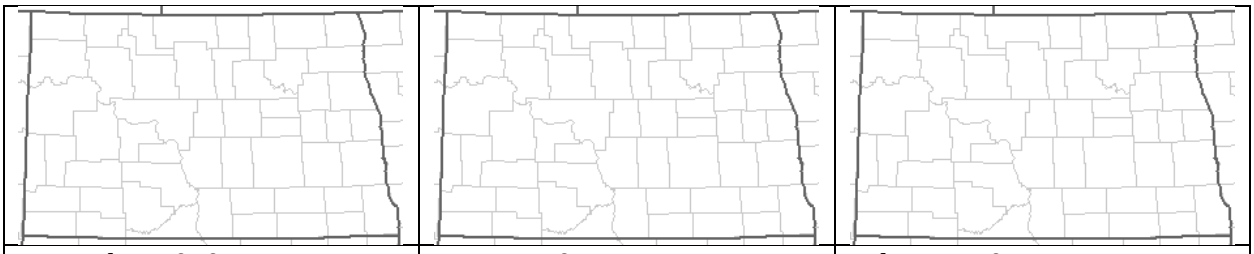
Figure 6. Statewide drought coverage in percentage and intensity (D.O., D1, etc.) in a time scale representing the state from the beginning to the end of the season, with a one-week resolution.

Storms and Record Events

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

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

	December 2020	January 2021	February 2021	Seasonal Total
Tornado	0	0	0	**0**
Hail	0	0	0	**0**
Wind	0	0	0	**0**
Total	**0**	**0**	**0**	**0**



December 2020
North Dakota Storm Events

January 2021
North Dakota Storm Events

February 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 Winter 2020-2021

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	December	January	February	Seasonal Total
Highest daily max. temp.	40	18	4	**62**
Highest daily min. temp.	17	37	8	**62**
Lowest daily max. temp.	0	0	55	**55**
Lowest daily min. temp.	0	0	35	**35**
Highest daily precipitation	2	6	7	**15**
Highest daily snowfall	1	1	4	**6**
Total	**60**	**62**	**113**	**235**

Seasonal Outlook

Spring 2021 Outlook

By R. Kupec[3]

Winters in North Dakota are colder than average about 75% of the time when a La Niña is present in the Pacific Ocean. This winter clearly fell into the 25% of La Niña years, with above-average temperatures occur during a La Niña. Were it not for a prolonged Arctic outbreak in February, this easily would have been one of the warmest winters in North Dakota. Given the odds and other conditions prevalent going into winter, the forecast was for colder than average temperatures with slightly higher than average precipitation. The northern branch of the jet stream rarely dipped south during December and January, and the southern jet stream stayed south. This put North Dakota in a bit of a weather no man's land with few storms and mild air. As we head into spring, the Devils Lake Basin and the western half of North Dakota are seeing drought conditions.

The La Niña pattern in the Pacific is still present but showing signs of dissipating. Historically a weak or fading La Niña in the spring tends toward average precipitation and average to slightly below-average temperatures. With a lack of snow on the ground, early March temperatures are running well above average and the dry conditions from the winter have not abated. Longer range computer models suggest cooler and slightly wetter weather could be coming at the end of the month. It is worth noting that the models also suggested this same scenario in December and January, which did not happen.

Given recent trends and history, look for near-average temperatures this spring with average to slightly below average precipitation across North Dakota. A high degree of variability week to week and month to month is likely while getting to these final seasonal numbers. The current Climate Prediction Center (CPC) Spring Outlook has a similar forecast. It is calling for an equal chance of above- or below-average temperatures and precipitation for all of North Dakota (see Figure 8b). The next 90-day outlook from the CPC should be available on March 18 at http://www.cpc.ncep.noaa.gov/products/predictions/90day.

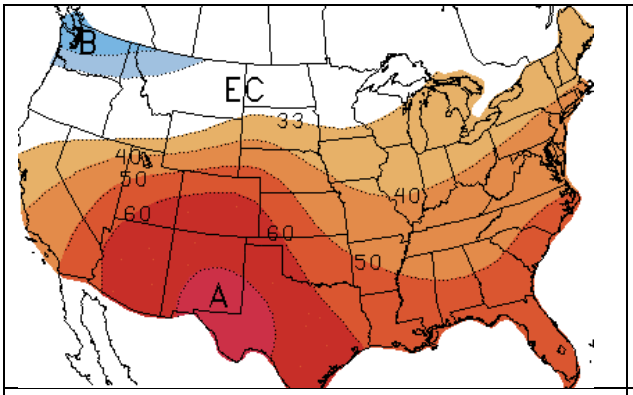


Figure 8a. March through May temperature outlook. (Climate Prediction Center, NOAA)

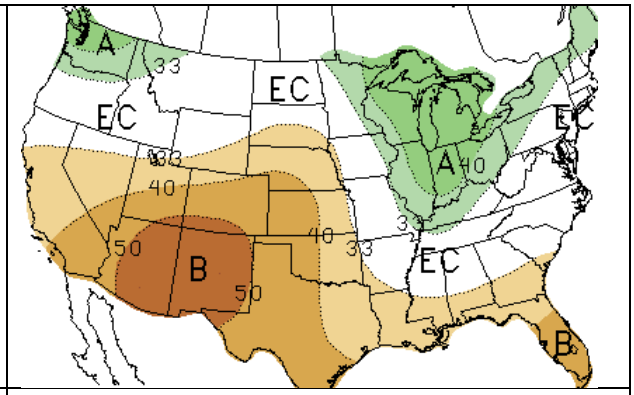


Figure 8b. March through May precipitation outlook. (Climate Prediction Center, NOAA)

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

Hydro-Talk

Spring Hydro Expectations

By A. Schlag[4]

As we are well into March, the usual questions I get asked tend to center on the risk of spring floods. Well, as I look around the state, I find it difficult to get too excited about the prospect of spring floods. Sure, I won't be surprised if a flood warning gets issued as that's just life in North Dakota. However, I will be very surprised if we see anything that resembles the high-water years of 2009, 2010, 2011, etc. At this point in March, we would need an incredible shift in weather patterns for us to get anywhere near the kinds of problematic flooding observed in those years. As shown in Figure 9, only a trace to 1 inch of snow-water equivalent (SWE) remains in small areas of North Dakota and the Souris River Basin in Saskatchewan.

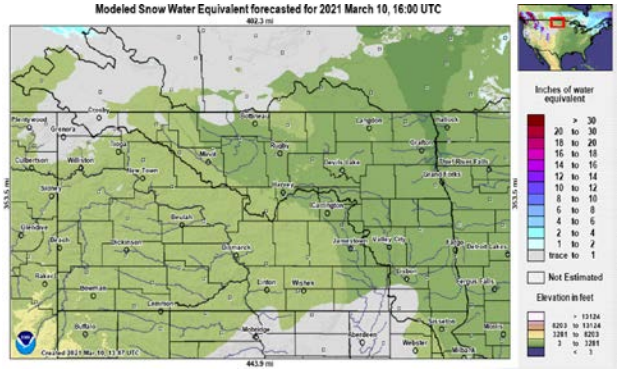


Figure 9. Snow-water equivalent in North Dakota.

In a nutshell, I am not concerned with widespread flooding in March and April; we don't have the SWE and/or expectations for heavy enough spring rains.

Now that we have that out of the way, we can talk about something far more likely to be a problem in 2021.

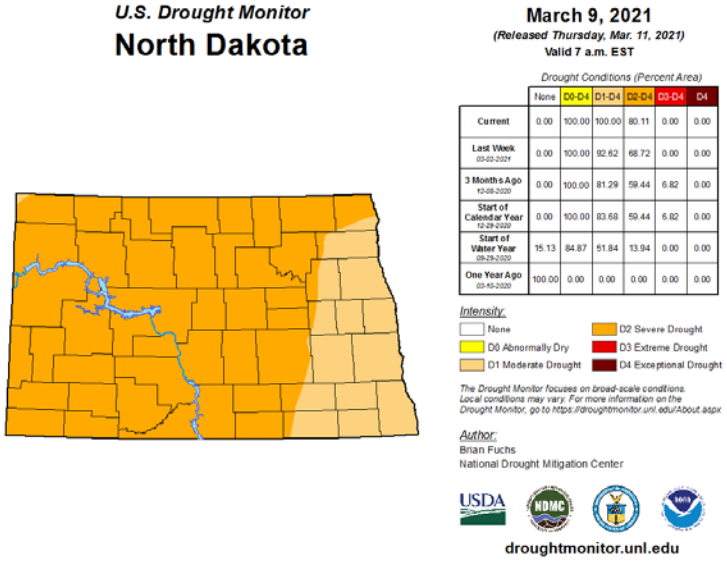


Figure 10. Most recent U.S. Drought Monitor Map for North Dakota.

[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

Figure 10 reflects the current status of the U.S. Drought Monitor (USDM) drought designations across North Dakota. Eighty percent of the state is considered in the D2 category for severe drought. The remaining 20 percent is under moderate drought, or D1 category. All of this and we still have widespread areas within the Prairie Pothole Region of the state that continue to experience high water problems associated with the past 30 years of often above-normal precipitation. Similar to the USDM, the soil moisture maps reflect the lack of precipitation during 2020 across North Dakota. Figure 11 shows soil moisture as a percentile for the last day of February 2021. Parts of North Dakota fall within the single-digit percentiles for soil moisture, and that lack of moisture is in stark contrast to what the same map for the same time period showed in 2020, where soil moisture was near an all-time high. What all of this suggests is that a lack of SWE and soil moisture provides plenty of buffering capacity for heavy spring rains. Speaking of which, the Climate Prediction Center (CPC) pretty much leaves the area with little hope for the above-normal precipitation that is required to prevent a continuation or worsening of the existing drought conditions.

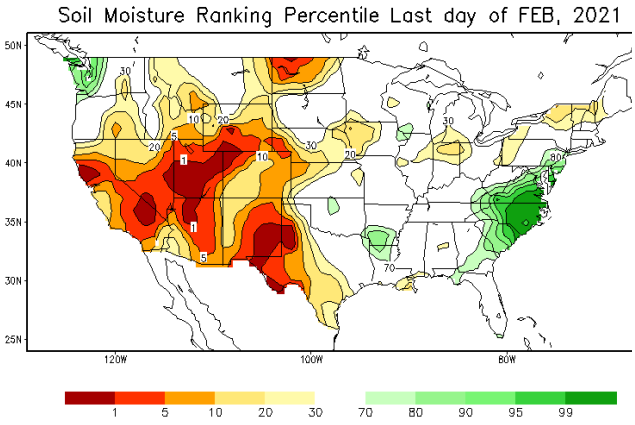


Figure 11. CPC soil moisture rankings.

Like I mentioned to someone recently, I believe farmers and ranchers will start to recover some of those acres lost to high water during the past several years. However, this will come at a cost. That cost will come in the form of impacts associated with what looks like a continuation or worsening of existing drought conditions.

Science Bits

The Role of the USGS in Monitoring N.D. Environmental Conditions

By K.R. Ryberg[5]

In the last issue, Allen Schlag and Greg Gust of the National Weather Service had excellent articles in the Hydro-Talk and Science Bits section describing, in part, the physics of water balance for a general audience. As Schlag described, much of North Dakota transitioned from wet to dry conditions in 2020. However, despite the lack of precipitation, many areas continued to have adequate streamflow and soil moisture through part of the year because of the hidden groundwater and soil reserves and lakes and wetlands. As Gust described, such changes from wet to dry are not uncommon because of our location in the continent's interior. It is our "normal" is to have a great deal of variability in temperature and precipitation.

The U.S. Geological Survey (USGS) observes the result of precipitation and temperature interacting with the environment by measuring streamflow in rivers and streams, water-surface elevation of lakes and groundwater level. Current and historical observations, details about the locations at which these observations are made and graphs of data are publicly available[6]. These data are also available in a machine-readable format for data analysts and application developers[7]. We also have a new, experimental National Water Dashboard that combines data from the USGS, National Weather Service and the National Integrated Drought Information System[8].

The USGS streamgaging network is funded through the Federal Priority Streamgages Network and in cooperation with about 1,400 federal, state, local and tribal agencies or organizations[9]. North Dakota has some of the longest-running stream gauges in the nation, including Red River of the North at Grand Forks, Red River of the North at Fargo, Devils Lake near Devils Lake, Souris River above Minot, Cannonball River at Breien and Pembina River at Neche. In 2017, we compiled some historical information about these long-term sites, and links to that information are available[10].

Having a statewide network allows us to track short and long-term changes in streamflow, a manifestation of North Dakota's climate. For example, Figure 12 shows monthly streamflow conditions across the state in September 2019. Based on long-term observations from the stream gauge network, most of the state was experiencing much above-normal streamflow conditions, indicating very wet conditions. By September 2020, we had experienced significant drying because of below-normal precipitation in most areas. While some streams were below normal, the abundant moisture supply from 2019 kept most streams at normal or above-normal conditions. Current (February 2021) streamflow conditions are challenging to assess because many stream gauges are affected by ice, and some seasonal gauges are turned off in the winter.

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[5] The corresponding author, Dr.Karen Ryberg, is acting deputy director and research statistician at the U.S. Geological Survey, Dakota Water Science Center. Email: kryberg@usgs.gov

[6] https://waterdata.usgs.gov/nd/nwis/sw

[7] https://waterservices.usgs.gov/

[8] https://dashboard.waterdata.usgs.gov/app/nwd/?aoi=state-nd

[9] https://www.usgs.gov/mission-areas/water-resources/science/usgs-streamgaging-network

[10] https://www.usgs.gov/centers/dakota-water/science/floods-droughts-and-other-hazards

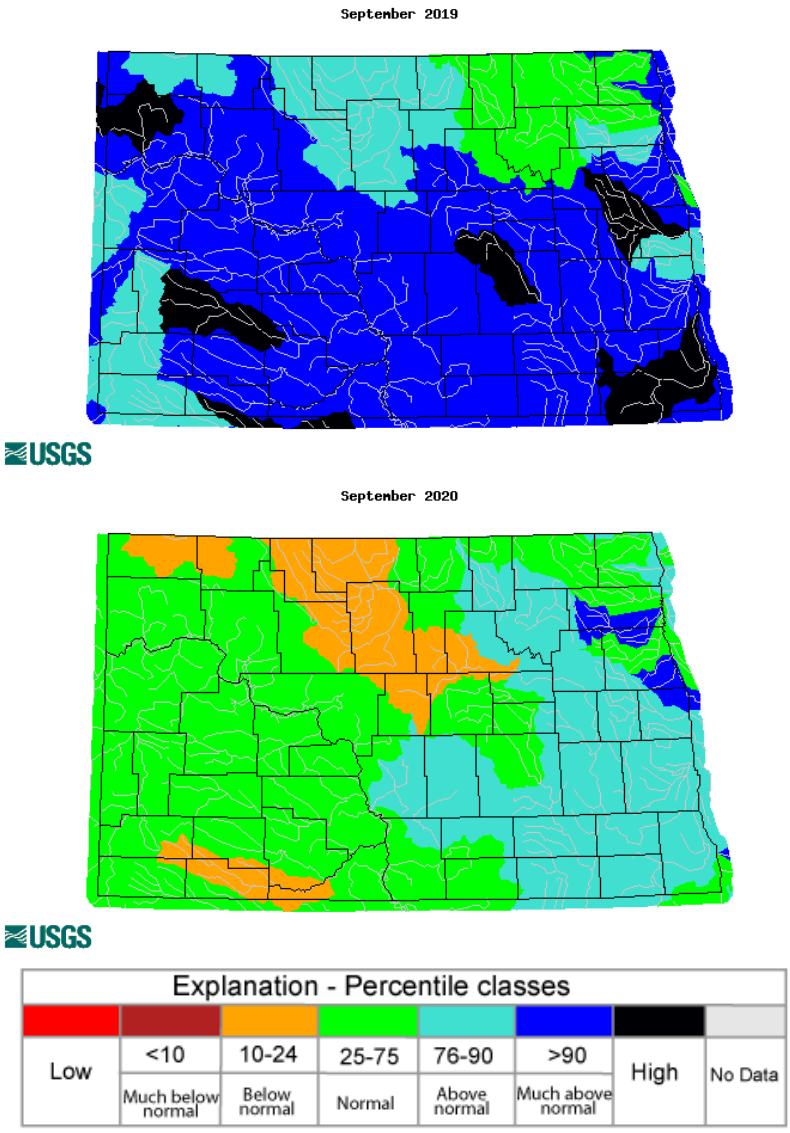

Figure 12. Comparison of monthly North Dakota streamflow, September 2019 and September 2020. Retrieved from water watch, USGS[11] Feb. 22, 2021.

Among federal agencies, the USGS has a unique funding model. As mentioned above, funding for the stream gauge network comes from a variety of partners. This is also the case for the other work we do that goes well beyond water-quantity monitoring and includes water-quality sampling and conducting scientific studies on a wide variety of topics. Some funding comes from federally appropriated programs; however, many of our projects are completed with cooperative matching funds (CMF). This funding model, in which the USGS and partner agencies fund projects, allows the USGS and its partners to promptly respond to significant or emerging water issues; sometimes, this results in local issues being raised to the regional or national level.

As an example of the type of studies we do, Figure 13 provides a sample report cover and a sampling of recent USGS reports with at least some North Dakota connection. These include:

[11] https://waterwatch.usgs.gov/index.php?st=nd&huc=&go=GO&mmt=mv01d&smt=nwc&id=wwchart_map&mdt=202009&mdt2=201909

- Spring Types and Contributing Aquifers from Water-Chemistry and Multivariate Statistical Analyses for Seeps and Springs in Theodore Roosevelt National Park, North Dakota
- Water-Quality Trends for Selected Sites and Constituents in the International Red River of the North Basin, Minnesota and North Dakota, United States, and Manitoba, Canada
- Small Basin Annual Yield and Percentage of Snowmelt Runoff in North Dakota
- Time-Series Model, Statistical Methods, and Software Documentation for R–QWTREND—An R Package for Analyzing Trends in Stream-Water Quality
- Inventory and Analysis of Groundwater Resources: Theodore Roosevelt National Park, North Dakota
- Characterization of Surface-Water and Groundwater Quality on the Fort Berthold Reservation, North Dakota

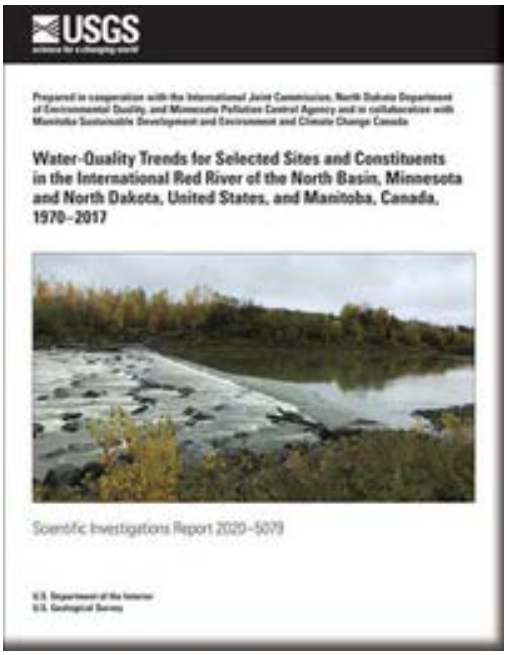

Figure 13. Cover of one of the reports listed. Note: The funding partners are listed as cooperators above the title. The full report is available at https://doi.org/10.3133/sir20205079.

- Water-Balance Techniques for Determining Available Soil-Water Storage for Selected Sandy and Clay Soil Study Sites in Cass County, North Dakota
- Analytical Framework to Estimate Water Use Associated with Continuous Oil and Gas Development

Many more publications can be found in the USGS Publications Warehouse[12].

You may be surprised to know that some of the authors or co-authors of these reports are South Dakotans! For years, the USGS model was to have a Science Center in each state, and we were known as the North Dakota Water Science Center. In fiscal year 2017, the North Dakota and South Dakota Water Science Centers were combined to form the Dakota Water Science Center. This expanded our diversity of talents in groundwater, surface water and water quality data collection and assessment.

As we know, water flows downhill, and the wetness and high flows we have experienced in the James River Basin continue to be a problem in South Dakota as the James River makes its journey to the Missouri River at Yankton, S.D. Some stream gauges on the James River in South Dakota were above flood stage for more than a year. This changing pattern in flow duration, shown in Figure 13, is another way of characterizing the climatic and hydrologic variability in our region.

[12] https://pubs.er.usgs.gov/

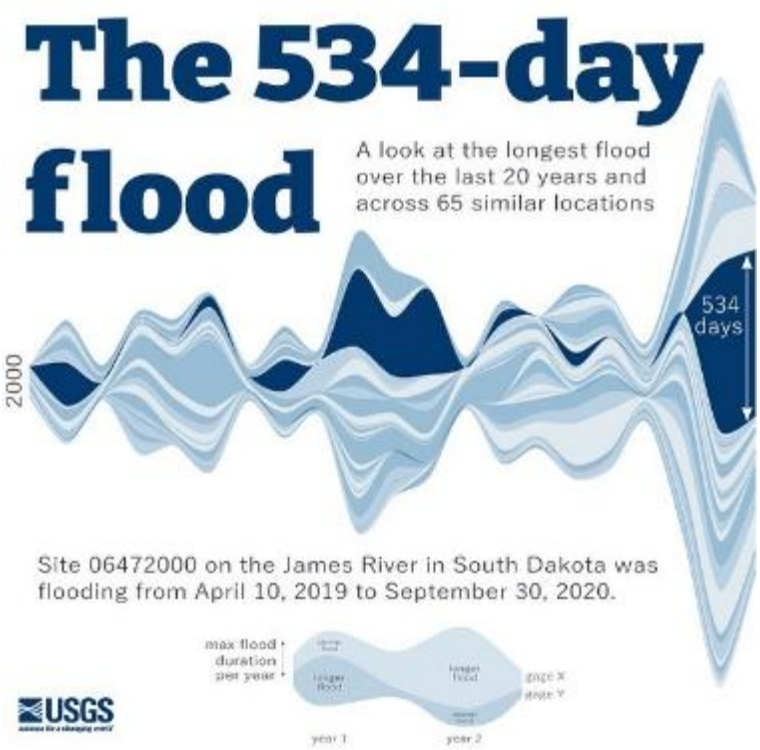

Figure 13. This visualization is highlighting Streamgage 06472000 on the James River near Stratford, S.D., which was flooding continuously for 534 days. It started flooding on April 10, 2019, and finally stopped on Sept. 30, 2020. This visualization shows this 534-day flood in context with floods at gauges in similarly sized watersheds during the last 20 years. Each band on the chart represents a different gauge. The width of each band through time represents the longest flood for that year. You can see that no other band comes close to the width of the dark blue band, which represents stream gauge 06472000. This stream gauge did experience long floods in 2009, 2010 and 2011 (the wide dark blue section in the middle of the figure), but those floods did not exceed 300 days - source: USGS Streamgages of Instagram[13]. The flood stage is defined as a gauge height of 14 feet or above at the James River stream gauge. The flood stages at the other sites in the comparison were the National Weather Service minor flood stages[14].

I share the fascination with our climate that Schlag and Gust express in their writing in the North Dakota Climate Bulletin. In terms of weather and climate, we live in a fascinating part of the country. However, the transitions from wet to dry and prolonged wet or dry conditions certainly are challenging for agriculture, infrastructure maintenance and design, and homeowners. These conditions also can be challenging for the many USGS, National Weather Service, North Dakota Agricultural Weather Network and other partner staff that are outside in all of our climate extremes, collecting important data to help us better understand and adapt to our climate. As a USGS statistician, I greatly value the long-term data we have available to us.

[13] https://www.instagram.com/usgs_streamgages/?hl=en

[14] https://water.weather.gov/ahps2/hydrograph.php?gage=sfds2&wfo=abr and https://waterdata.usgs.gov/sd/nwis/dv?referred_module=sw&cb_00060=on&cb_00065=on&site_no=06472000&period=&begin_date=2019-04-01&end_date=2020-11-01.

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[15].

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