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In This Issue

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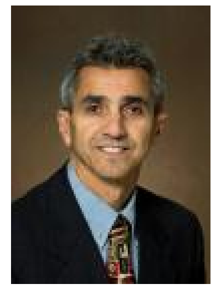


The North Dakota Climate Bulletin is an online quarterly publication of the North Dakota State Climate Office in the College of Agriculture, Food Systems, and Natural Resources, North Dakota State University, Fargo, N.D.

The overall fall average temperature was only 0.5 degrees warmer than average, which would make it the 41st warmest fall on record. Precipitation-wise, the statewide accumulation was 2.03 inches drier than average (49% of average), which would make it the 20th driest fall on record. Conditions prior to fall also were dry, and North Dakota experienced the 13th driest six-month (June through November) period on record since 1895. As much as 92% of the state experienced drought with the highest Drought Severity and Coverage index of 232 during the weeks of November 1 and November 8.

Overall, 123 temperature- and precipitation-related records across the state were tied or broken. Six significant storms also were reported. Readers will enjoy reading outlooks forecasting winter and even spring 2023 as the next growing season starts shaping.

Detailed monthly climate summaries for September, October and November can be accessed at www.ndsu.edu/ndsco.

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 autumn season (September 1 through November 30) was 1.97 inches, which was 4.6 inches less than the last season (summer 2022), and 3.03 inches less than last autumn (autumn 2021) and 2.03 inches less than the 1991-2020 average autumn precipitation (Table 1). This would rank the autumn of 2022 as the 20th driest autumn since such records began in 1895.

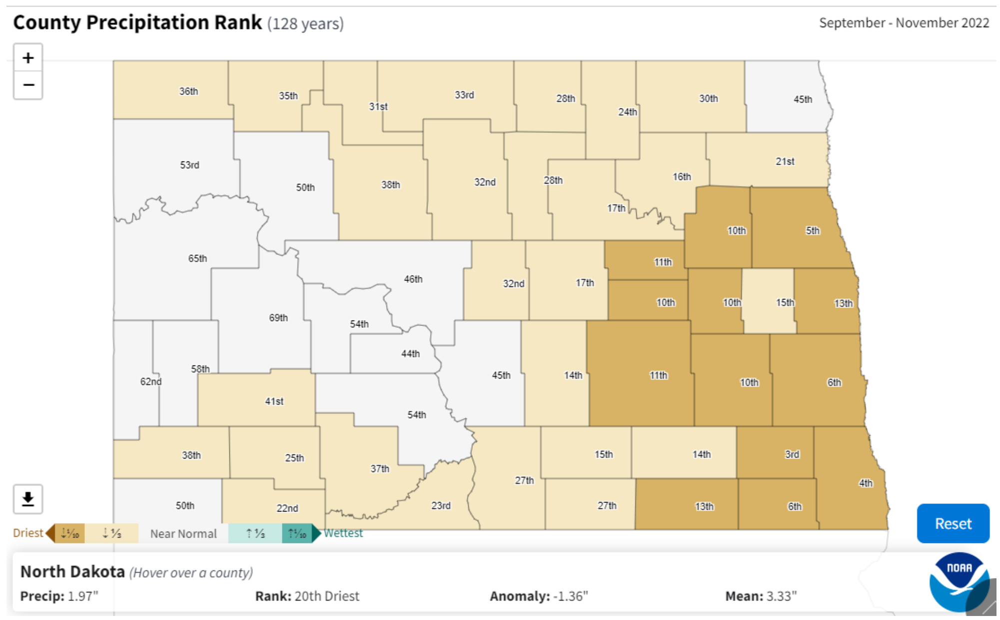


Figure 1. Precipitation rankings in fall of 2022 for North Dakota. (National Centers for Environmental Information, NOAA)

The counties shaded in brown in Figure 1 indicate drier-than-average conditions in fall 2022 and white shadings indicate near-average conditions. The numbers inside the counties are the precipitation rankings, with 1 being the lowest ranking (driest) and 128 being the highest ranking (the wettest).

The greatest seasonal precipitation accumulation of the season was 4.35 inches, recorded in Walhalla, Pembina County. The greatest seasonal snowfall accumulation was 25.5 inches, recorded in Elgin, Grant County.

Based on historical records, the state average fall precipitation showed a positive long-term trend of 0.8 inches per century during this period of record since 1895. The state's highest and lowest seasonal fall average precipitation ranged from 8.92 inches in 2019 to 0.99 inches in 1976. The "Historical Fall Precipitation for North Dakota" time series (Figure 2) shows a graphical depiction of these statistics.

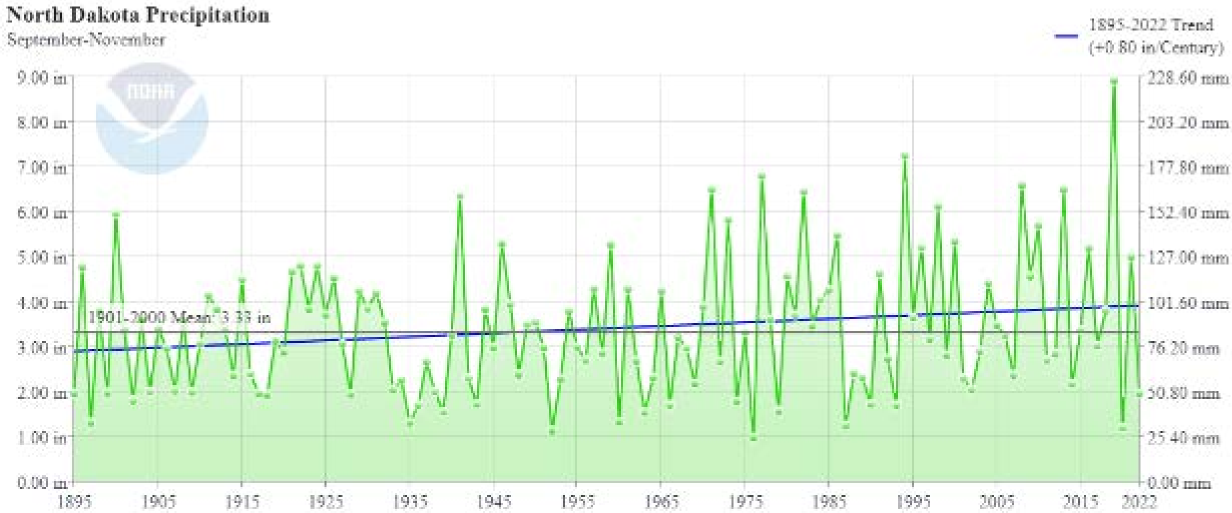


Figure 2. Historical fall precipitation time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Wettest/Driest Since	Record Year
Fall 2022	**1.97”**	**4”**	2.03”	**20th driest** **109th wettest**	**Driest since 2020** **Wettest since 2021**	**0.99” (1976)** **8.92” (2019)**

[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 (September 1 through November 30) was 43.5 F, which was 24.7 degrees cooler than the last season (summer 2022), and 4.2 degrees cooler than last fall (fall 2021). However, it was 0.5 degrees warmer than the 1991-2020 average fall temperature, despite its warmer-than-average status in the distribution, and it was still ranked as the 41st coldest fall since such records began in 1895 (Table 2).

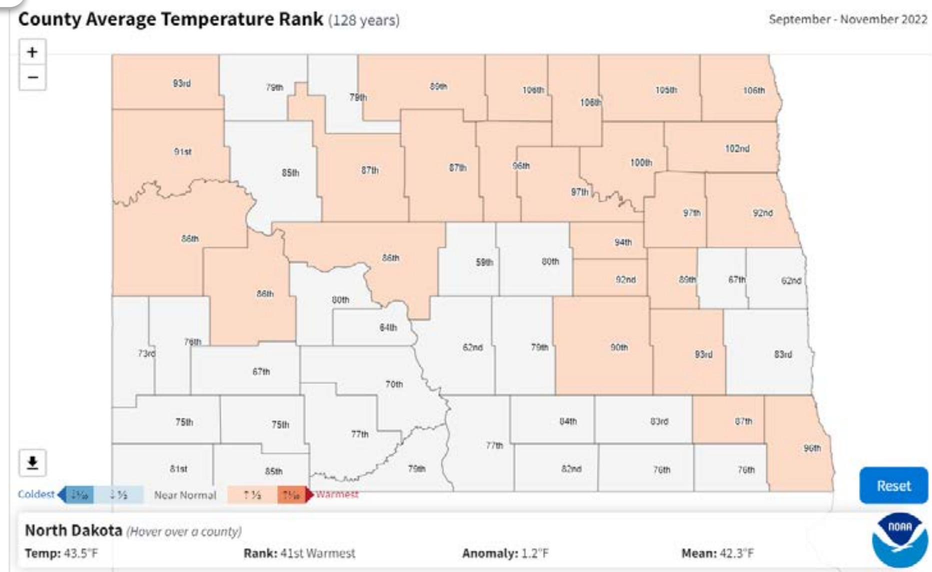


Figure 3. Temperature rankings in the fall of 2022 for North Dakota. (National Centers for Environmental Information, NOAA).

The counties shaded in peach 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 fall temperature showed a positive trend of 1.7 degrees per century since 1895. The state's highest and lowest seasonal fall average temperatures ranged from 49.1 F in 1963 to 32.2 F in 1896. The "Historical Fall Temperature for North Dakota" time series (Figure 4) shows a graphical depiction of these statistics.

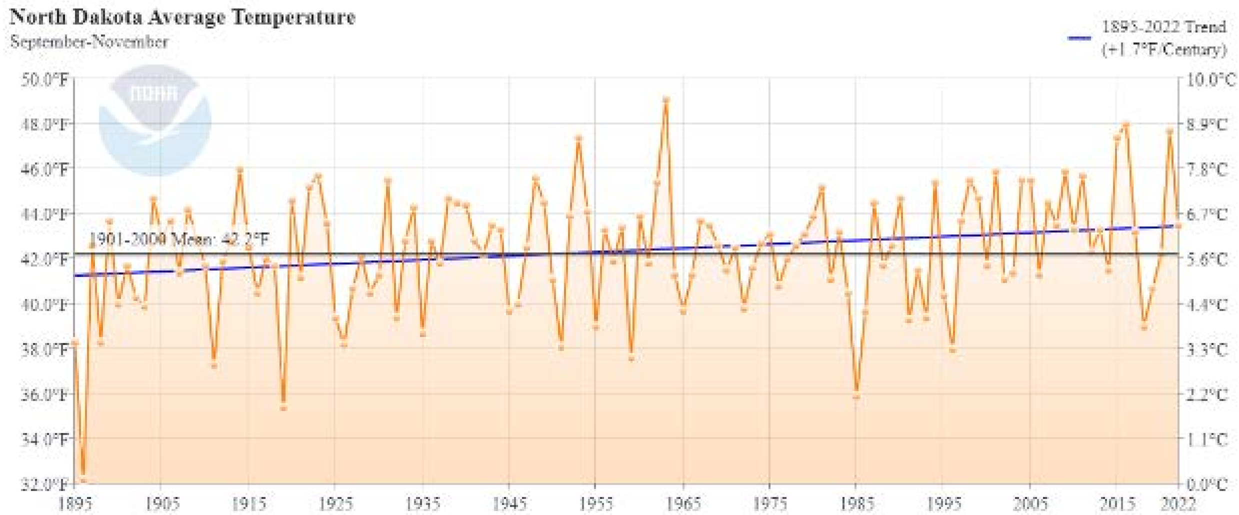


Figure 4. Historical fall temperature time series for North Dakota.

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

Period	Value	Normal	Anomaly	Rank	Warmest/Coolest Since	Record Year
Fall 2022	**43.5 F**	**43 F**	**0.5 F**	**88th coolest** **41st warmest**	**Coolest since 2020** **Warmest since 2021**	**32.2 F (1896)** **49.1 F (1963)**

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

Drought: The drought conditions intensified 187 DSCI points (from 29 on August 30 to 216 on November 29). In the beginning of the season, only 0.5% of the state was experiencing drought (in Richland County only). By the end of the season, 87% of the state was in drought. Figure 5 below shows the drought conditions at the beginning and the end of the fall. The surface water for livestock was declining along with the water quality throughout the season in drought-stricken areas. Corn, sunflowers and soybeans started to show stress, and grasshoppers started to become concerning as the producers were harvesting. Figure 6 shows the drought intensity and coverage on a time scale. Both of the figures show drought conditions spatially and temporally.

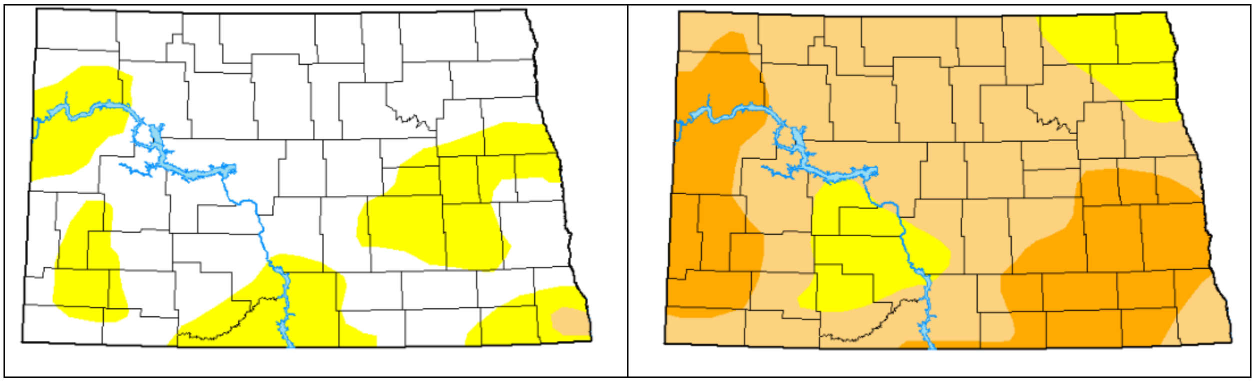


Figure 5. Drought Monitor map comparison for North Dakota in the beginning (on the left) and at the end (on the right) of autumn 2022. (U.S. Drought Monitor)

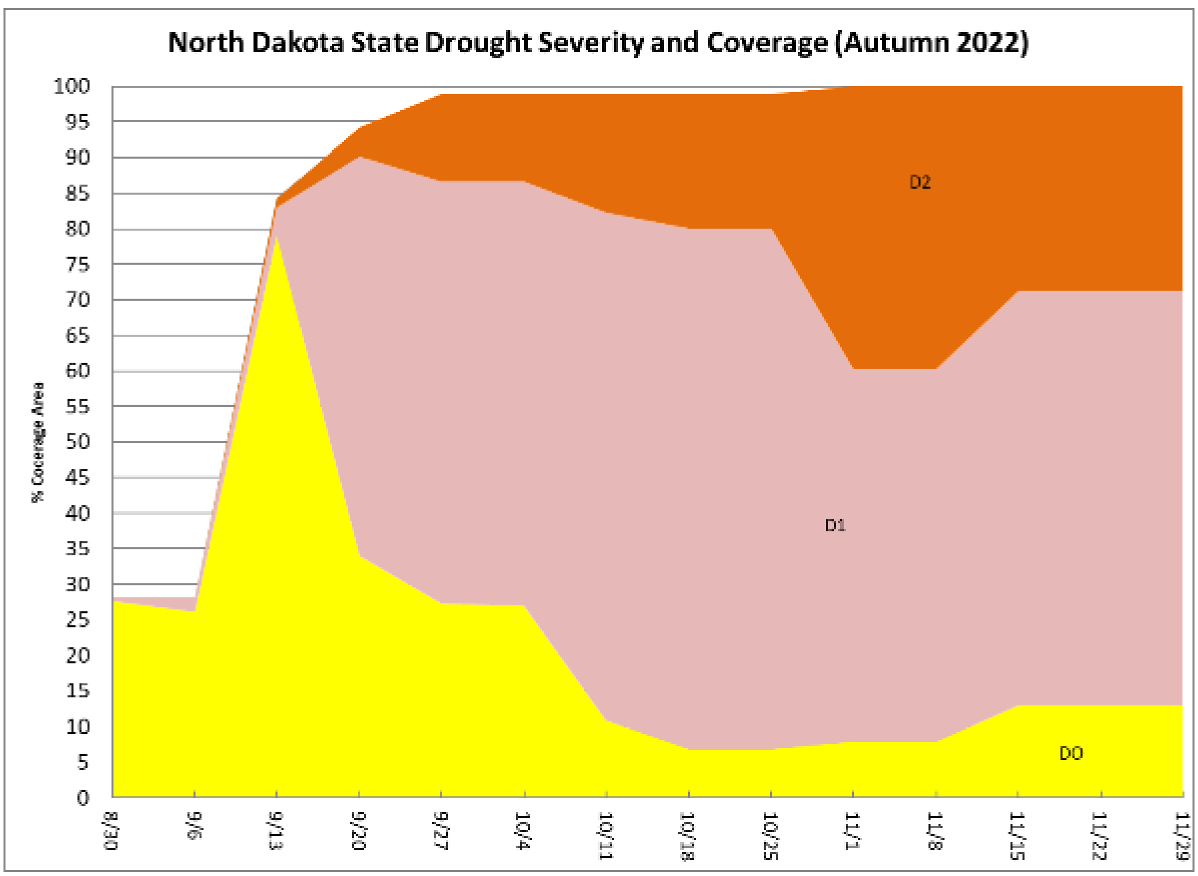


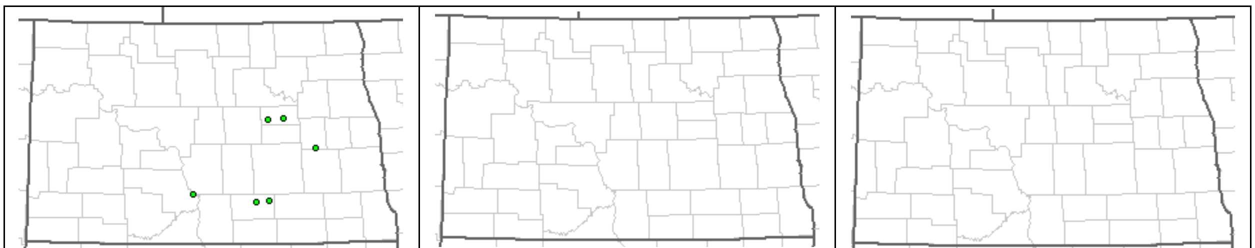
Figure 6. Statewide drought coverage in percentage and intensity (DO through D4) in a time scale representing the state from the beginning to the end of the season, with a one-week resolution in fall 2022.

Storms and Record Events

State Tornado, Hail and Wind Events for Fall 2022

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

	September 2022	October 2022	November 2022	Seasonal Total
Tornado	0	0	0	0
Hail	6	0	0	**6**
Wind	0	0	0	**0**
Total	**6**	**0**	**0**	**6**



September 2022 North Dakota Storm Events	October 2022 North Dakota Storm Events	November 2022 North Dakota Storm Events

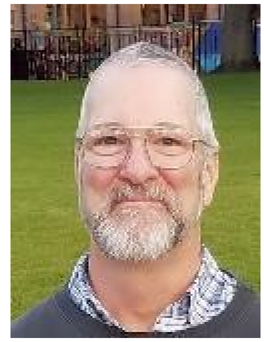
Figure 7. Geographical distribution of the storm events in the table above in each month. The dots are color-coded for each event (red: tornado; blue: wind; green: hail).

State Record Events for Fall 2022

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.	12	6	19	**37**
Highest daily min. temp.	6	5	11	**22**
Lowest daily max. temp.	0	2	10	**12**
Lowest daily min. temp.	0	7	7	**14**
Highest daily precipitation	1	2	17	**20**
Highest daily snowfall	0	2	16	**18**
Total	**19**	**24**	**80**	**123**

Seasonal Outlook



Winter 2022-23 Outlook — By M. Ewens[3]

The meteorological fall months of September through November were generally warmer and significantly drier than normal across the Red River Valley of the North region. The largest and most persistent areas of excess warmth and dryness were in the western, central and northern Plains states, the western U.S. and portions of the Ohio Valley. Large swaths of the Intermountain West and Great Basin saw above-median rainfall and early-season snows. Despite the relative warmth, portions of the southwest and southeast U.S. experienced wetter conditions due to late season tropical activity.

The 2023 late winter/early spring will feature trends to below median temperature from the Red River Valley of the North region west to the Pacific Northwest from California to Washington. Warmer-than-median values are expected from the southwest U.S. region along the Gulf Coast and much of the south and eastern regions. Little signals for above, below or near-median conditions exist in the Mississippi and Ohio River Valleys and parts of the Intermountain West. The U.S. precipitation outlook suggests wetter-than-median values along the northern tier from Washington State to the Great Lakes and the Ohio Valley. The southeast and southwest U.S. favor a drier climate region January through March 2023.

Historical composites, optimal climate normal methods, constructed analog methods and soil moisture/multiple linear regression tools are employed to produce long range forecasts. The North American Multi-Model Ensemble [MME], a combination of climate models from various meteorological centers such as UCAR, Environment Canada and The European Center for Medium Range Forecasting also contribute to the outlook process. The current Climate Prediction Center (CPC) Winter Outlook takes into account all available model outputs to create one consolidated outlook for each variable. It calls for below-average temperatures (Figure 8a) and above-average precipitation (Figure 8b) for North Dakota. The next 90-day outlook from the CPC should be available on January 19 at http://www.cpc.ncep.noaa.gov/products/predictions/90day

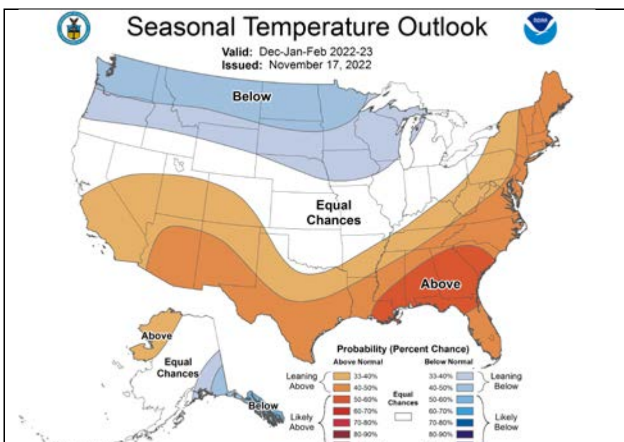


Figure 8a. Dec 2022 through Feb 2023 temperature outlook. (Climate Prediction Center, NOAA)

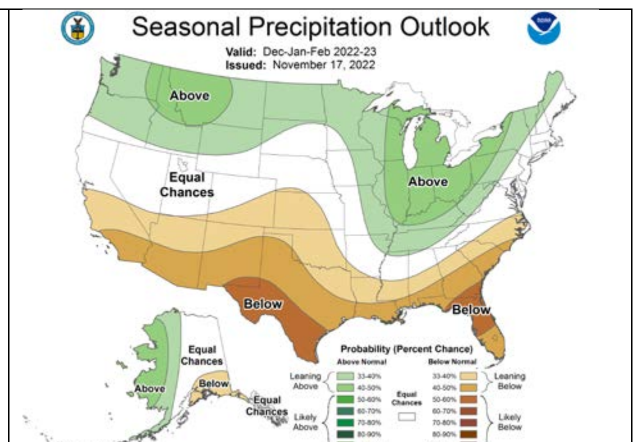


Figure 8b. Dec 2022 through Feb 2023 precipitation outlook. (Climate Prediction Center, NOAA)

[3] Corresponding author, Mark Ewens, Home on the Prairie Weather. Email: SLAPM7@msn.com

Hydro-Talk

So Far, So Good? By A. Schlag[4]

In the last rendition of Hydro Talk, I ended by discussing the likely effects of a La-Nina-affected winter season. Included was the whiskers distribution plot shown in Figure 9. Thus far in December, Bismarck has recorded an average temperature of 14.6 degrees, which for December 15 is 5.8 degrees below normal. Given that we have the normally cooler half of the month remaining, with a significant cold spell coming in the week before Christmas, it seems safe to assume we will end the month well below normal for temperature. This is in keeping with the overall La Nina expectations noted in the official Winter Outlook.

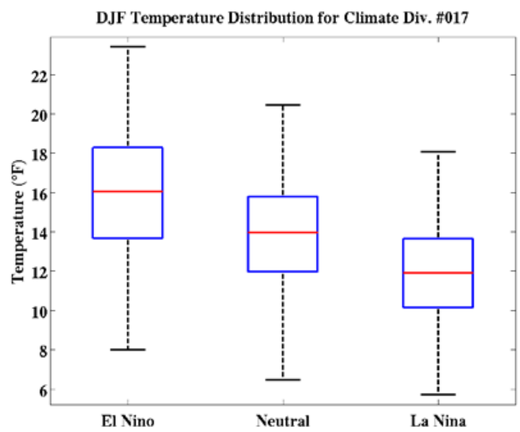


Figure 9. CPC December-February Temperature Distributions for Western North Dakota, CD 17.

However, the October dated outlook for precipitation now appears to have been a little conservative as meteorologic winter arrived this year with the early November blizzard, and the region really hasn't seen much letup. As shown in Figure 10, a bit of an expansion in the Above Normal Precipitation category now has almost all of North Dakota with an expectation for a wetter-than-normal winter season. Arguably, this may still be a bit conservative, as much of North and South Dakota have been unusually snowy to start off the winter season. Nonetheless, while I would prefer to see the moisture later in the cold season, it's still welcome. So the question now becomes one of quantifying the effects of this early snow, and then we can discuss the most likely outcomes with an eye towards the spring melt season.

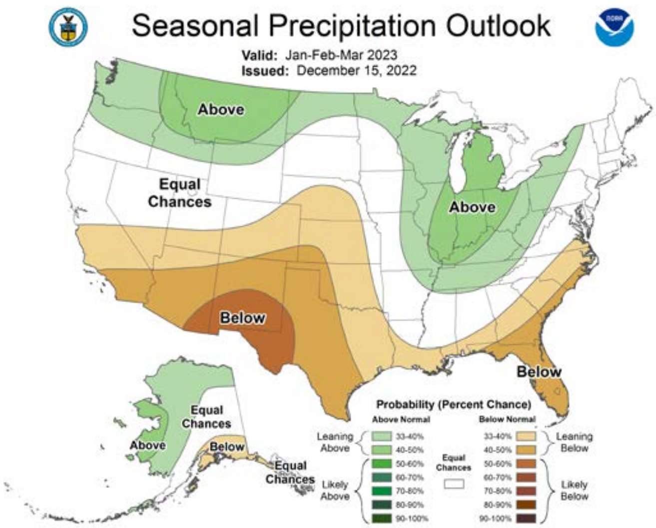


Figure 10. Current Precipitation Outlook for January-through-March, 2023.

As seen in Figure 11, modeled estimates for how much snow-water equivalent (SWE) are shown for the region. Values between 2 and 4 inches are widespread with lesser coverage areas containing either less than an inch, or greater than 4 inches of SWE. Overall, this should be considered an above-normal SWE content for this time of year. For example, in the Bismarck area, November received 1.44 inches of moisture with another 1.13 thus far in

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December. This moisture by and large came as either snow or freezing rain, so it provides the basis for spot checking NOHRSC's estimates for SWE in place. At slightly over 2.5 inches of SWE received and roughly 1.60 inches above normal since November 1, we can subtract a few tenths of an inch as moisture lost to sublimation and still conclude that NOHRSC's estimate of greater than two inches seems quite reasonable and well above normal for this time of year. A simple tallying up of monthly averages going through winter suggests something around 1.8-2.5 inches of SWE going into mid-late March defines our normal SWE just before the spring melt. This suggests that not only are we at or near our long-term cold season average for SWE, but we have roughly three months remaining to add to our available moisture. Even with nearer normal snowfall the remainder of winter, we would add around two inches of SWE to the current values, which would put most areas around 3.5-4.5 inches of SWE going into the spring melt season. That higher range of roughly 4.5 inches is what generally tends to grab my attention as we start considering the risks of widespread spring flooding. With that being said, the next questions we need to look at are moisture and temperature data for the soil profiles across North Dakota. As shown in Figure 12, soil moisture values really have not yet recovered from the significant drought of last summer. These dry soils are patiently awaiting next spring and will likely be available for absorbing much of the existing SWE. Soil temperature data available from NDAWN show a soil profile that has generally been well insulated from recent cold weather. Temperature profiles showing frost depths greater than 16 inches are rare, while profiles with temperatures greater than freezing at depths of 2 to 4 inches are not uncommon.

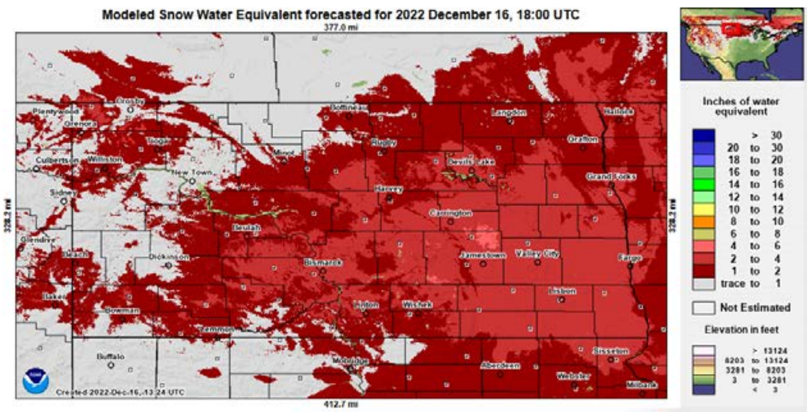


Figure 11. Snow-Water Equivalent Estimates from the National Observational Hydrologic Remote Sensing Center (NOHRSC).

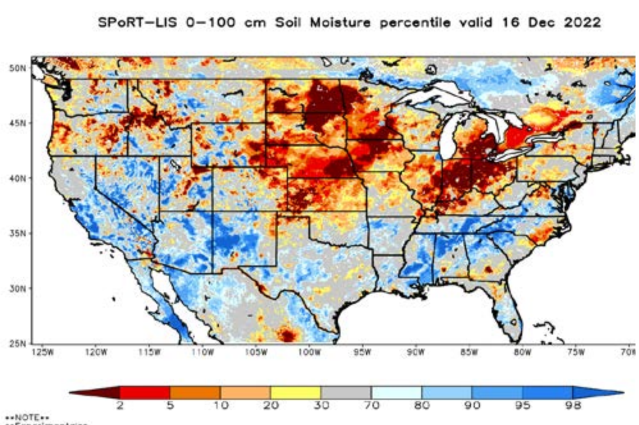
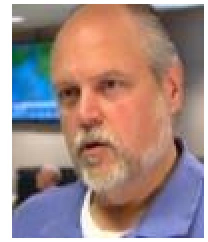


Figure 12. Soil Moisture Percentile for the Root Zone.

So, after all is considered, here's where we are most likely to find ourselves come the spring melt season of 2023. The cool and wet winter is most likely to continue and provide the region with an above-normal to well-above-normal SWE content. However, with anything resembling a normal to extended melt season this coming spring, warm and dry soils under the snowpack are going to significantly minimize runoff as generated meltwater finds its way into the soil. At this point, the ground is so well insulated, that deeper-than-normal frost depths will be difficult to achieve. So, while the snowpack may grow to levels that cause concerns among the general public, there are legitimate reasons in the soil profile for not yet having great concerns over the coming spring flood season.

Science Bits



LaNiña **By G. Gust[5]**

NWS Hydrologist Allen Schlag introduced the topic back in the Summer 2022 edition of the ND Climate Bulletin; NOAA's National weather Service (NWS) emphasized key points in the lead sentence of the U.S. Winter Outlook, issued on October 20, 2022; and the NWS Climate Prediction Center (CPC) has reinforced those same topics with a recent update.

In the El Nino/Southern Oscillation (ENSO) Diagnostic Discussion, last updated by the NWS Climate Prediction Center (CPC) on December 8, 2022, a La Nina Advisory remains in effect. In their synopsis, NWS/CPC forecasters state that "La Niña is expected to continue into the winter, with equal chances of La Niña and ENSO-neutral during January to March 2023. In February to April 2023, there is a 71% chance of ENSO-neutral."

The short story is that the La Nina (Cold Phase) of the ENSO cycle is starting to wane and could end its reign during the late winter or early spring periods – stay tuned!

The International Research Institute (IRI) produces a set of climate model indicators and their general trend towards warming oceanic conditions in an area of the tropical Pacific Ocean that most impacts North America.

What's ENSO all about? The El Nino/Southern Oscillation cycle is a global interaction of oceans and the atmosphere that was first detected across the tropical Pacific Ocean as a build-up of anomalously warm water in the western tropical Pacific, and correspondingly cooler water in the eastern Pacific Ocean. This is the warm phase of ENSO, commonly called El Nino because of the abundant anchovy harvest (cool upwelling dependent) it leads to off coastal Peru near the Christmas Season.

Its reverse is when warmer near-surface waters slosh back towards the eastern Pacific, and cooler water upwells in the west – this is the cold phase of ENSO, commonly called La Nina. La Nina conditions in the tropical western Pacific means colder waters, less deep convective rains, and often widespread drought condition in the western Pacific nations with more heat and convection in the eastern tropical Pacific, and fewer anchovies off the coast of Peru.

For the northern Plains, the tele-connections are not as clear. We in the northern Plains depend on the secondary transport of heat and moisture from those tropical Pacific areas, via both the transverse (north-south) ocean currents and the vagaries of our global atmospheric circulation. For a quick look at the current global winds, at various levels, check out https://earth.nullschool.net/.

Suffice it to say that the ocean currents and atmospheric currents are not always well aligned, which was illustrated by the first declaration of this current long-winded La Nina, back in the fall of 2020. Without going into too much detail, the tropical Pacific Ocean moved into a distinctly La Nina pattern from late summer into fall and was expected to continue throughout the winter season 2020-21. However, the north Pacific had a huge area of anomalously warm near-surface water which took a long time to redistribute, and the atmosphere across the Pacific Northwest into northcentral North America maintained a flow that was distinctly reminiscent of a warm El Nino episode.

[5] The corresponding author, Greg Gust, is the former warning coordination meteorologist at the National Weather Service, Grand Forks, N.D. Email: gcgusts@gmail.com

The Figure 13, below, shows the monthly temperatures at eight representative North Dakota locations through the months from October 2020 through April 2021. Though November, December and January should have been cooler than normal under a La Nina regime, those months were quite warm (and dry). There was a distinct and sharp drop in temperatures in February of 2021, that was fairly short-lived. However, that Feb 2021 cold snap may indicate the true start of La Nina's influence in our Northern Plains weather regime.

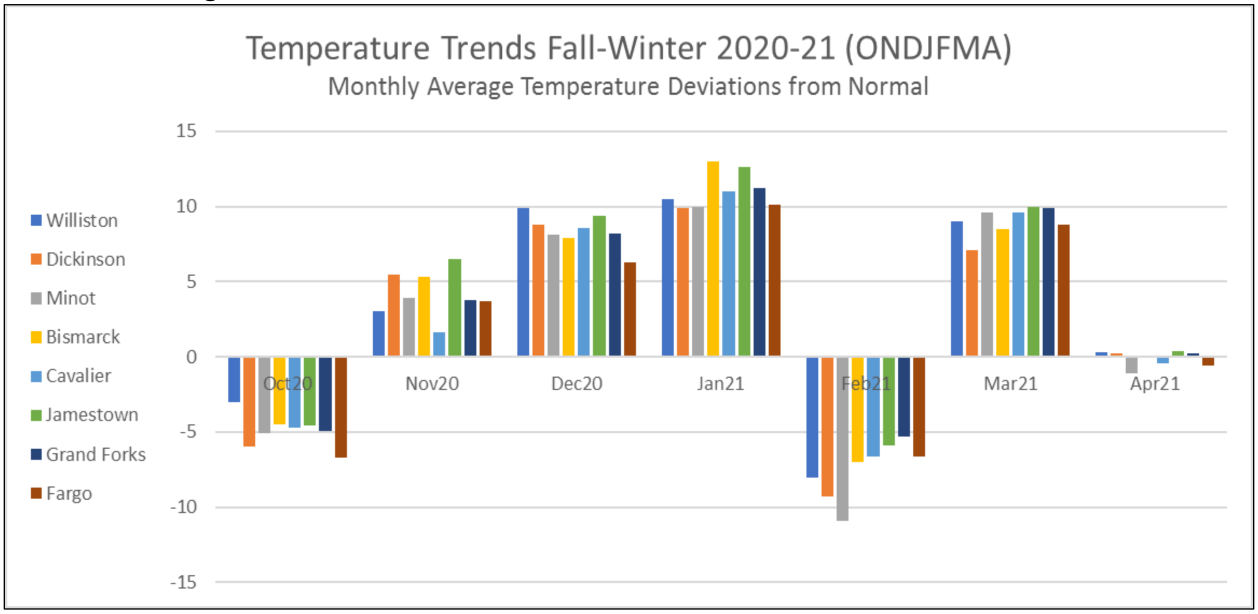


Figure 13. Temperature trends for the Fall-Winter of 2020-21 for eight representative ND locations. Data taken from a combination of Airport and Cooperative Observer records, and accessible on NWS Bismarck and NWS Grand Forks websites as NOWData

Recall that 2021 was marked by widespread and significant drought across the northern Plains states, which began with a warm and dry winter, and continued with a hot and dry spring-summer period. Rains did resume across the much of the state of North Dakota through the late summer and fall months, and the fall-winter of 2021-22 set up as a more classic La Nina type period.

The Figure 14, below, shows a similar image as before but for the fall-winter 2021-22 period. Here we can see the more classic cooling that occurs during the winter season, when ENSO traditionally has its most pronounced impacts on our northern Plains weather – typically strongest in December-January-February, but often carrying into the early spring months.

So how is La Nina affecting this current fall-winter period? The Figure 15, below, only includes local data from October 1 through December 11, 2022. Please note that this late fall period moved quickly into a well-below-normal temperature pattern more quickly than in either of the preceding two La Nina flavored fall-winter seasons. Use your imagination to superimpose the first image from IRI, showing the climate model projections for spring, and note the optimism for a return to near-normal conditions by spring.

As a last note, since 1950 there have been two other periods when the Oceanic Nino Index (ONI) was in La Nina conditions for a three-year period. One was the fall-winter periods of 1973-74, 1974-75 and 1975-76. The next was 1998-99, 1999-2000 and 2000-01. You can find the monthly ONI information on the CPC ENSO webpages at https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php.

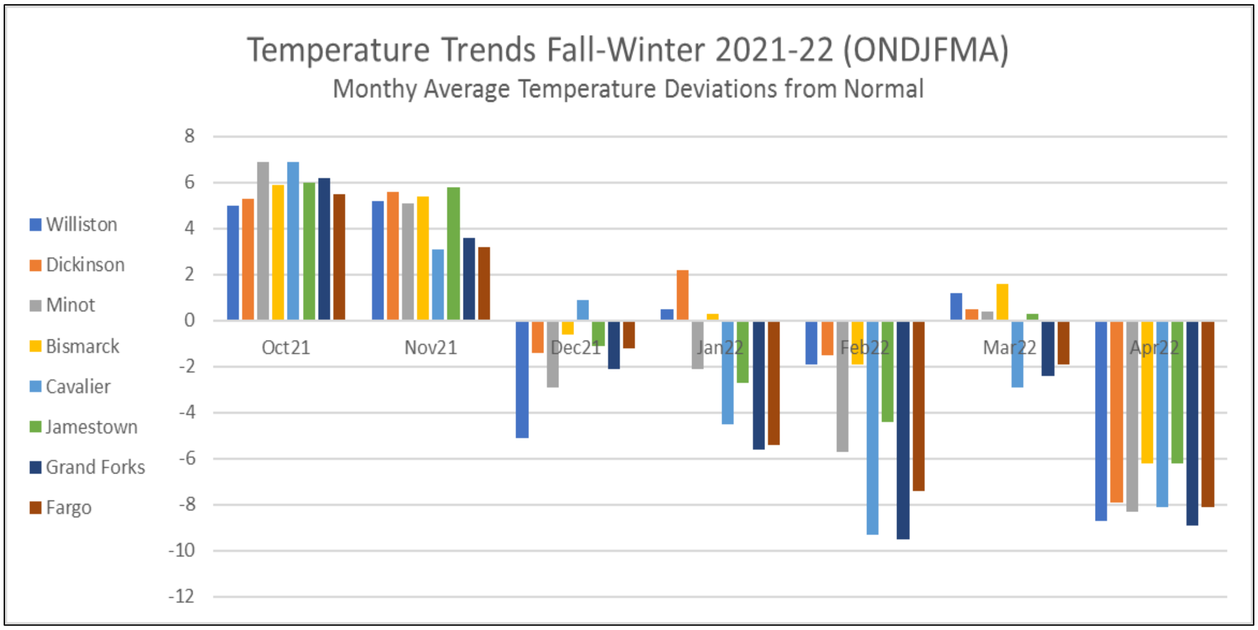


Figure 14. Temperature trends for the Fall-Winter of 2021-22 for eight representative ND locations. Data taken from a combination of Airport and Cooperative Observer records, and accessible on NWS Bismarck and NWS Grand Forks websites as NOWData.

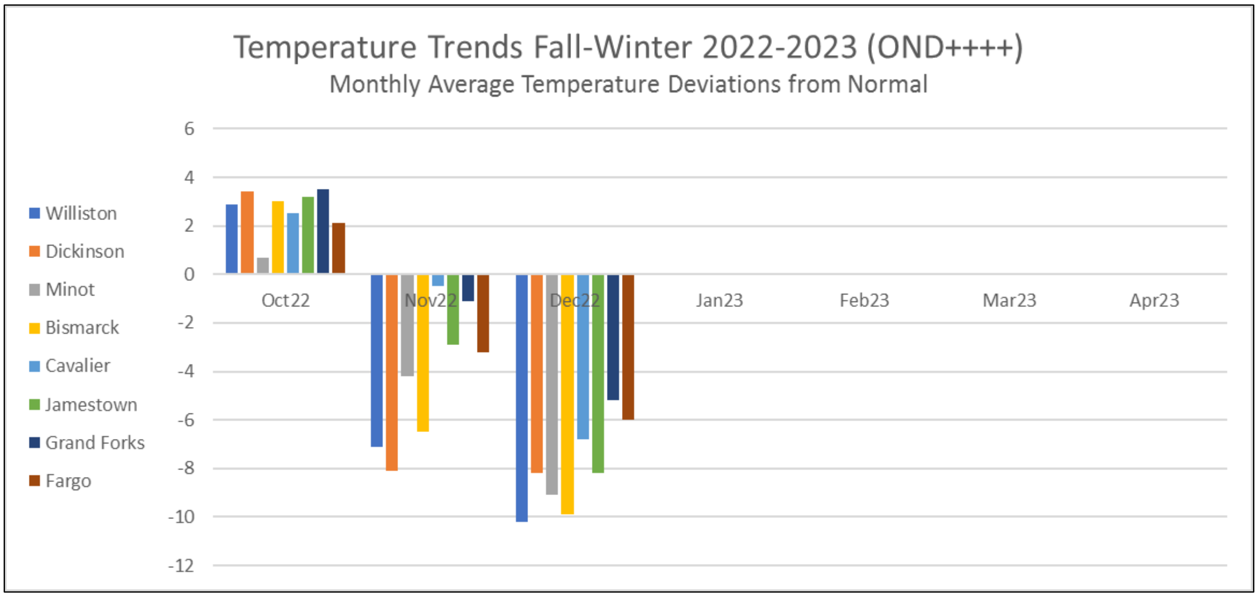


Figure 15. Temperature trends for the Fall-Winter of 2022-23 (through December 11th) for eight ND locations. Data taken from a combination of Airport and Cooperative Observer records, and accessible on NWS Bismarck and NWS Grand Forks websites as NOWData.

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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