North Dakota Climate Bulletin

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Image Credits
NCEI, NDSCO, NDAWN, UCAR, NOAA, CPC, USDM.

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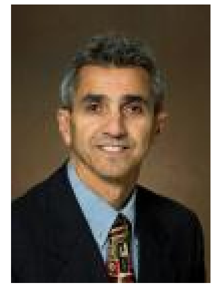
From the State Climatologist



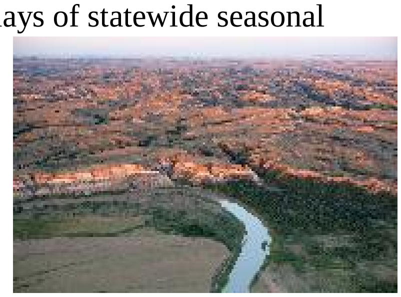
The North Dakota Climate Bulletin is a digital quarterly publication of the North Dakota State Climate Office, College of Agriculture, Food Systems, and Natural Resources, North Dakota State University, Fargo.

This autumn was the 48th warmest and the 57th driest on record since 1895 in North Dakota. Overall, 73 highest and 33 lowest daily temperature records were broken or tied. In addition, 25 highest daily precipitation records were broken or tied, including seven daily snowfall records. A total of 131 records were tied or broken including temperature-and precipitation-related occurrences across the state. Six tornados, eight hail events and eight wind damage reports were filed. Drought conditions improved, compared with the previous season. However, by the end of the season, the western half of the state still was experiencing the drought hangover. Drier-than-average-autumn in the area, combined with parched soil and lack of snow, are signaling toward a continuation of the 2017 drought into 2018.

Detailed monthly climate summaries for September, October and November can be individually accessed via https://www.ndsu.edu/ndsco/climatesummaries/monthlyclimatesummary/2017/

The bulletin contains graphical displays of statewide seasonal temperature, precipitation and other weather highlights.

This bulletin can be found at http://www.ndsu.edu/ndsco/, along with several other local resources for climate and weather information.



Little MO River, near Medora 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 autumn season (Sep. 1, through Nov. 30, 2017) was 3.01 inches, which was 3.29 inches less than the last season (summer 2017), 2.18 inches less than the last autumn (autumn 2016), 0.84 inches less than the 1981-2010 average autumn precipitation, and was the driest autumn since 2014. This would rank autumn 2017 as the 57th driest autumn since such records began in 1895. Figure 1 shows the percent of normal precipitation distribution geographically. Based on historical records, the state average autumn precipitation showed a positive average long-term trend of 0.08 inches per decade since 1895. The highest and the lowest seasonal autumn average precipitation for the state ranged from the highest amount of 7.25 inches in 1994 to the lowest amount of 0.99 inches in 1976. The “Historical Autumn Precipitation For North Dakota” time series on Page 5 shows a graphical depiction of these statistics.

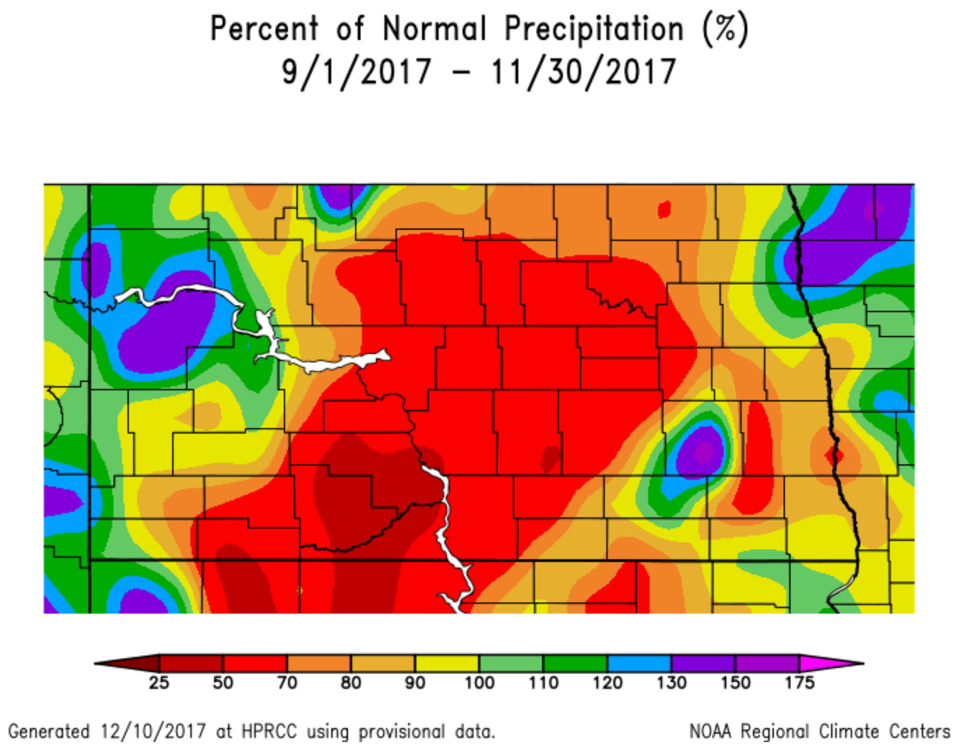


Figure 1. Precipitation percent of normal in autumn 2017 for North Dakota (HPRCC).

Temperature

The average North Dakota temperature for the season (Sep. 1 through Nov. 30, 2017) was 43.2 F, which was 24.3 F cooler than the last season (summer 2017), 4.8 F colder than the last autumn in 2016, but 0.6 F warmer than the 1981-2010 average autumn temperature, and was the warmest autumn since 2014. This would rank autumn 2017 as the 48th warmest autumn since such records began in 1895. Figure 2 shows the departure from normal temperature distribution geographically. Based on historical records, the average autumn temperature showed a positive trend of 0.19 F per decade since 1895. The highest and the lowest seasonal autumn average temperatures for the state ranged from the highest amount of 49.1 F in 1963 to the lowest amount of 32.2 F in 1896. The “Historical Autumn Temperature For North Dakota” time series on Page 6 shows a graphical depiction of these statistics.

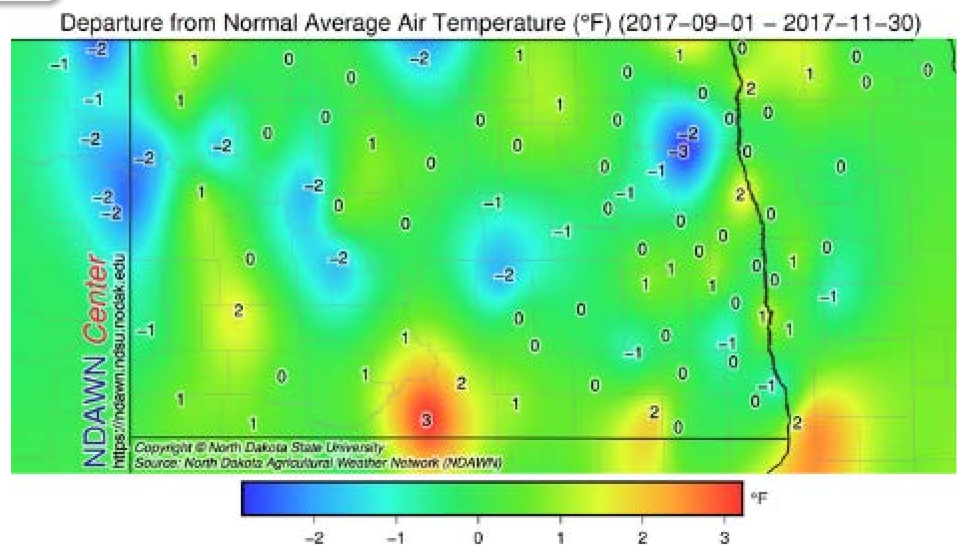


Figure 2. Temperature departure from normal in autumn 2017 for North Dakota (NDAWN).

Drought: Following the ninth driest spring, the end of the summer yielded the seventh driest six months in a row from March through August. Even though the September statewide precipitation averaged much above normal, the dryness in October and November was too overwhelming to overcome large deficits in precipitation. Although, the dryness during the last days of the growing season positively impacted the amount of work done in the field. In fact, progressive rainfall in August and September caused widespread improvements of the drought conditions generally. Figure 3 below shows the drought conditions in the beginning and the end of summer (USDM).

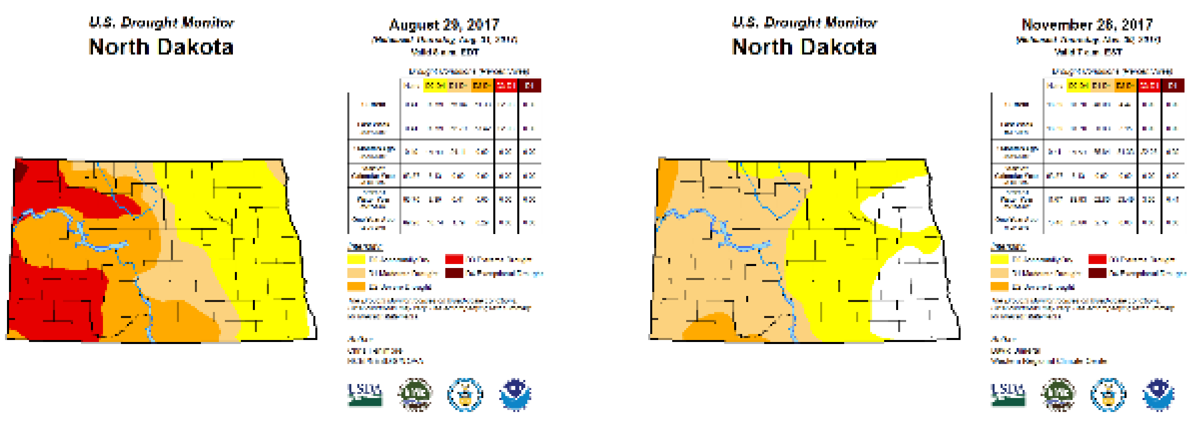


Figure 3. Drought Monitor map comparison for North Dakota in the beginning (on the left) and at the end (on the right) of autumn 2017.

Figure 4 below shows the statewide drought coverage in percentage and intensity (i.e., DO, D1, etc) in time scale representing the state from the beginning to the end of the month with one-week resolution.

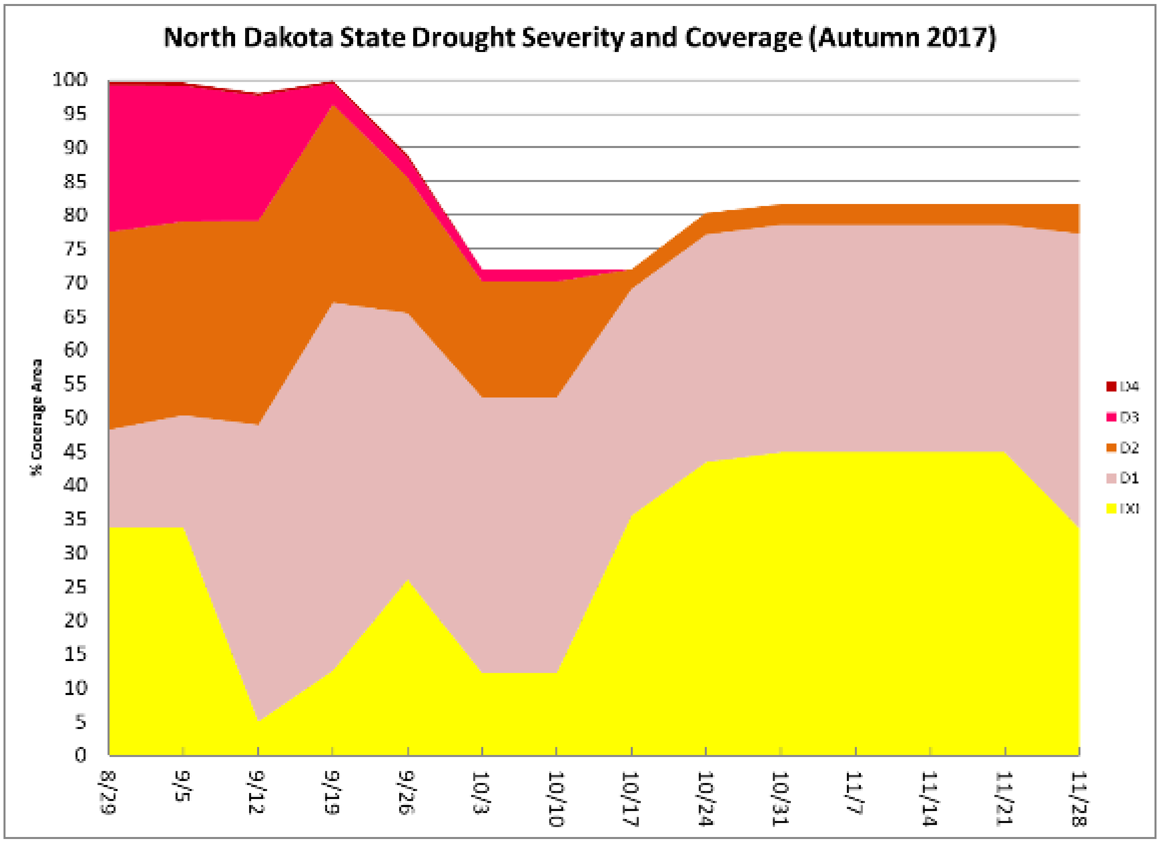


Figure 4. Statewide drought coverage (%) and intensity (Dx) in autumn 2017.

Based on the index that takes into account intensity (D-level) and coverage (%) called Drought Intensity and Coverage Index (DSCI), the index by the end of the season was 153. However, the index value reached its maximum value of 295 in the first week of August (Figure 5).

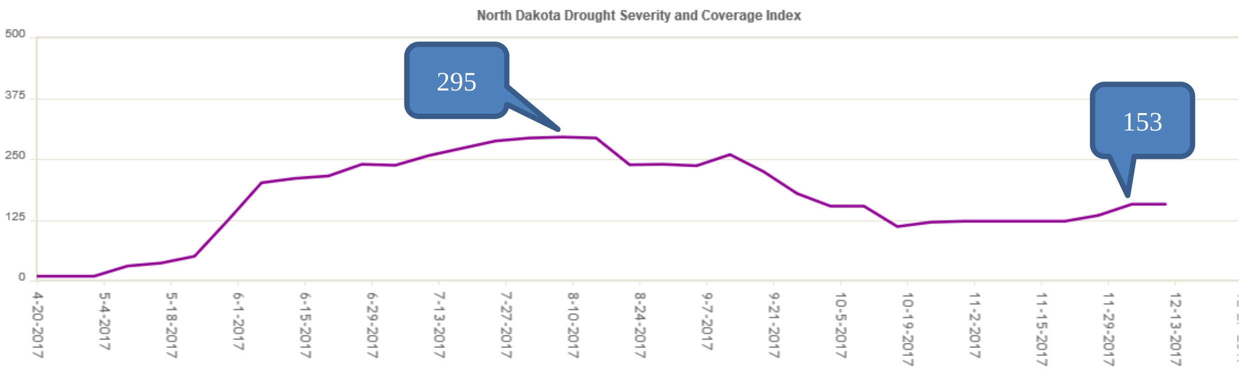
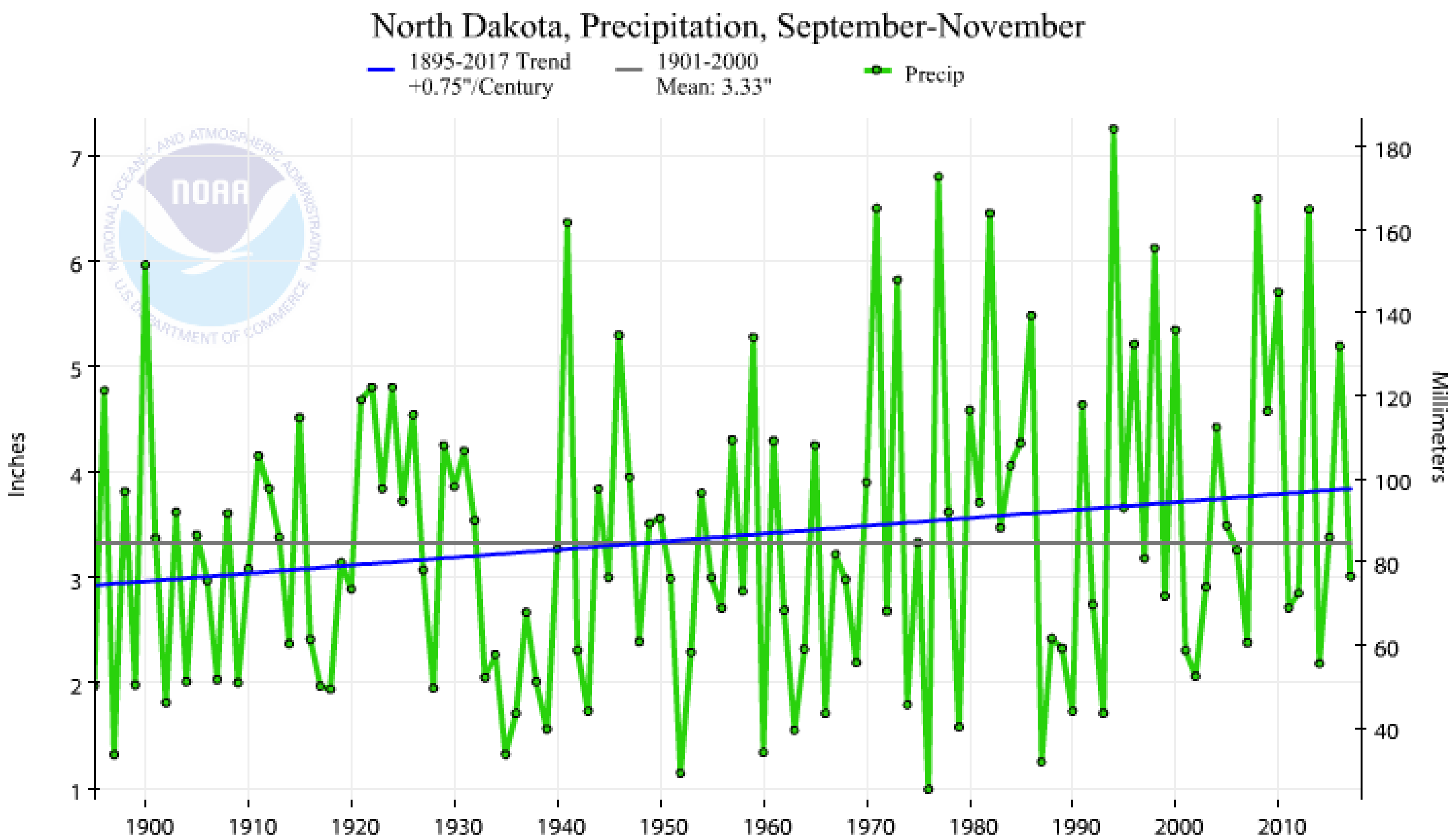


Figure 5. Statewide Drought Coverage and Intensity Index (DSCI) in autumn 2017.

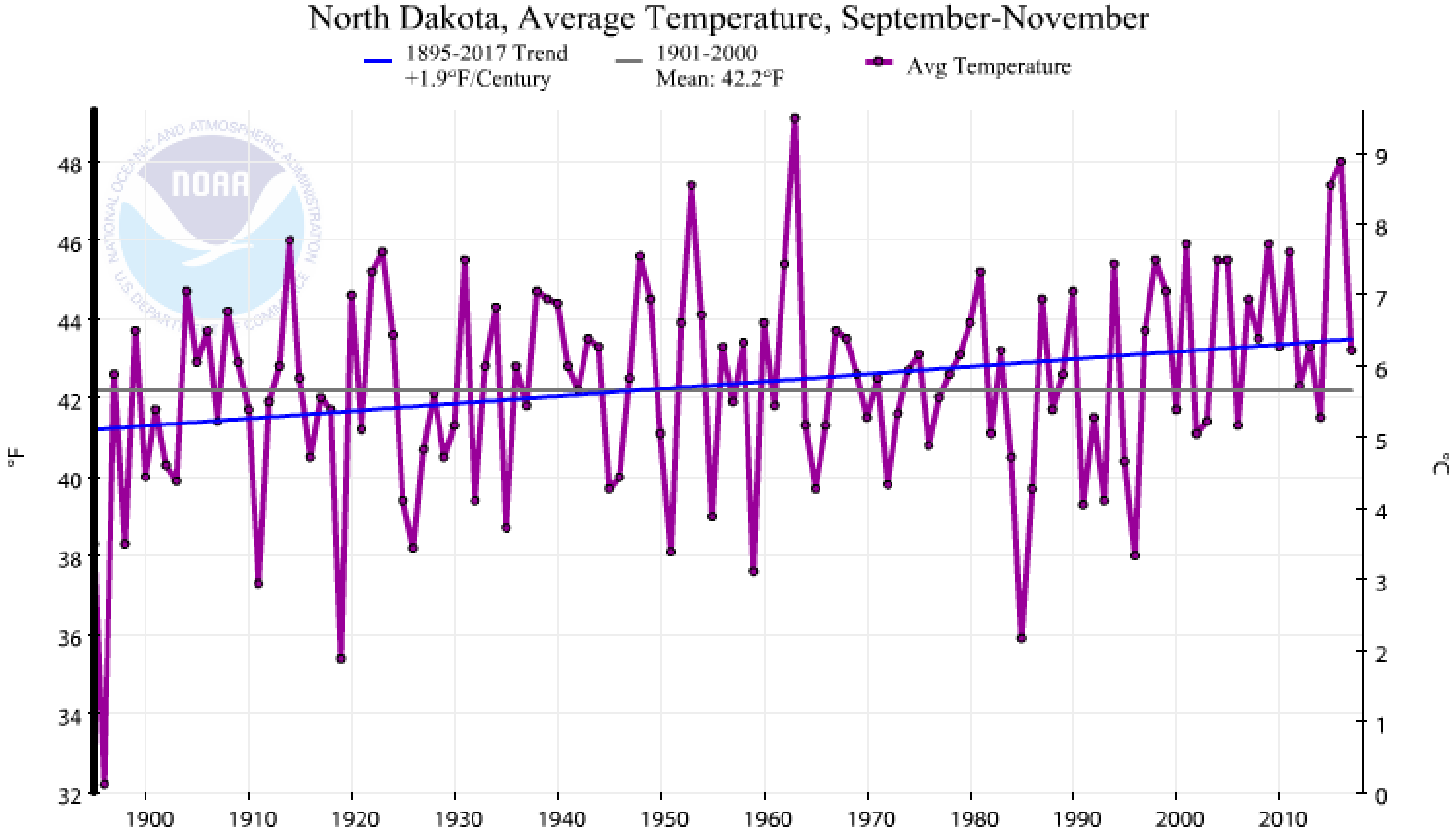
HISTORICAL AUTUMN PRECIPITATION FOR NORTH DAKOTA



Record High Value: 7.25” in 1994
Record Low Value: 0.99” in 1976
Seasonal Trend: 0.08” per Decade

Autumn 2017 Value: 3.01”
1981-2010 Average: 3.81”
Seasonal Ranking: 57th Driest Autumn
Record Length: 123 years

HISTORICAL AUTUMN TEMPERATURE FOR NORTH DAKOTA



Record High Value: 49.1°F in 1963
Record Low Value: 32.2°F in 1896
Seasonal Trend: 0.19°F per Decade

Autumn 2017 Value: 43.2°F
1981-2010 Average: 42.6°F
Seasonal Ranking: 48th Warmest Summer
Record Length: 123 years

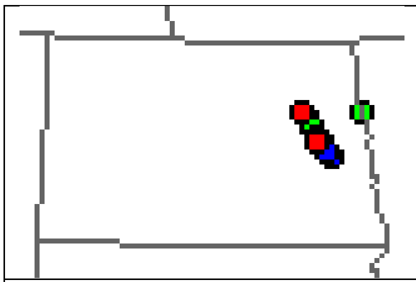
Storms & Record Events

State Tornado, Hail, and Wind Events for Autumn 2017

Table 1. Numbers in the table below represent the number of tornado, hail and wind events accumulated monthly and seasonally.

Month	Tornado	Hail	Wind	Total
September Total	6	8	8	**22**
October Total	0	0	0	**0**
November Total	0	0	0	**0**
Seasonal Total	**6**	**8**	**8**	**22**

The graphics below show the 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).

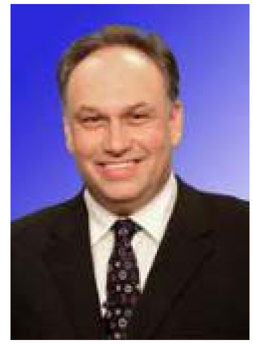
	None Reported	None Reported
September 2017 North Dakota Storm Events	October 2017 North Dakota Storm Events.	November 2017 North Dakota Storm Events.

State Record Events for autumn 2017

Table 2. 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.	26	11	8	**45**
Highest Daily Min Temp.	1	8	19	**28**
Lowest Daily Max Temp.	7	4	9	**20**
Lowest Daily Min Temp.	1	5	7	**13**
Highest Daily Precipitation	15	1	2	**18**
Highest Daily Snowfall	0	1	6	**7**
Total	**50**	**30**	**51**	**131**

Seasonal Outlook



Winter 2017 Outlook

By R. Kupec[1]

The fall outlook called for below-average precipitation with large temperature swings that, in the end, would put the season near average. For most of the state, this forecast was accurate, with some minor exceptions. Parts of northeastern North Dakota saw so much rain in September that even dry Octobers and Novembers could not erase the surplus. South-central and southeastern North Dakota had temperatures that were 1 to 2 degrees above average, while the remainder of the state was much closer to seasonal normals.

In September, it appeared as though the neutral phase of the La Niña/El Niño sea surface temperature regime in the southern Pacific would hold through the upcoming winter. In October, a weak La Niña (cold sea surface temperatures) began to develop and that is now forecast to last through the winter. Historically, La Niñas tend to bring colder-than-average temperatures to North Dakota in the winter. This is not always the case, as last winter was also a weak La Niña and warmer-than-average temperatures were recorded. Precipitation trends with a La Niña are less clear. Long-term averages tend to run slightly higher during La Niña winters, and this seems to be slightly more pronounced in northeastern North Dakota.

One factor that will be different than last year is the weather pattern in the Atlantic Ocean. High pressure is forecast to set up in such a way that storm systems will bring much warmer air over the icecap in Greenland. Most often when this occurs, cold air is displaced toward the middle of North America. This, combined with the La Niña, should mean temperatures several degrees lower than average, but also with considerable variability, as we saw this fall.

Precipitation this winter should be greater than last year but should end the season close to average. The one exception is northeastern North Dakota, which will continue the trend of slightly above-average precipitation. Many La Niñas are dominated by what is known as northwest flow, where the jet stream comes mostly out of the Canadian Prairie Provinces. The weather systems that ride this flow, usually referred to as Alberta Clippers, tend to bring numerous small snow events with low moisture content.

The current Climate Prediction Center (CPC) Winter Outlook also is predicting below-average temperatures for all of North Dakota (Figure 6a). For precipitation, the CPC forecast differs with the one presented here, calling for greater-than-average precipitation across the state, with an even higher probability in the far west and north-central portions of North Dakota (Figure 6b). The next 90-day outlook from the CPC should be available after December 21 at http://www.cpc.ncep.noaa.gov/products/predictions/90day.

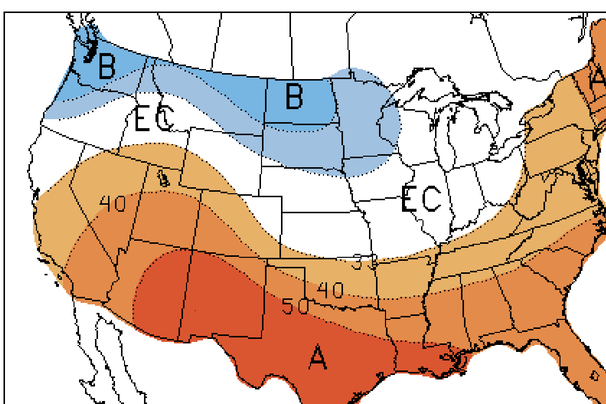


Figure 6a. December through January Temperature Outlook

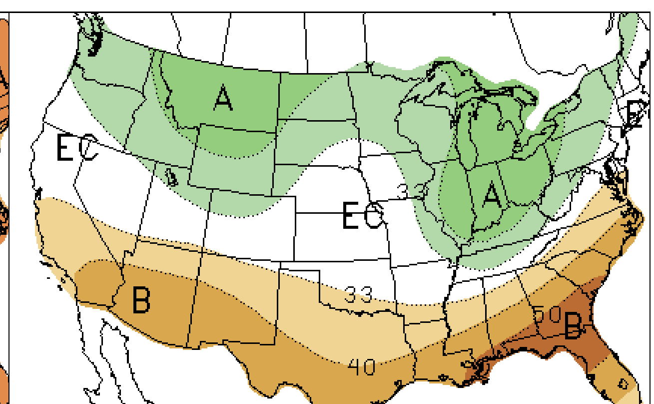


Figure 6b. December through January Precipitation Outlook

[1] The corresponding author; Rob Kupec, is chief meteorologist at KVRR TV in Fargo, ND. Email: rkupec@kvrr.com

(Climate Prediction Center, NOAA.)	(Climate Prediction Center, NOAA.)

Hydro-Talk

Odds for Drought Conditions Continuing Into Spring of 2018 — By A. Schlag[2]

This past September, I discussed how the drought rapidly evolved from a wet winter to a dry spring (pleasant by most people's standards) to a debilitating drought that seriously harmed many crop producers during the critical June and July growing stages. A brief respite with some above-normal moisture arrived in August and continued through early September. This lessened the blow to some crops, primarily row crops and late cuttings of alfalfa. However, a relatively wet August and September was not enough to ward off the negative effects of what would be a well below-normal precipitation pattern for October and November. That pattern seems to have carried all the way up to my writing this article after the first full week of December. For example, the Minot Experiment Station (North Central Research Extension Center) with 10.91 inches of moisture thus far into the calendar year, is the eighth driest on record, and even with normal moisture for the rest of December, it likely will finish in the top 10 driest out of 112 years of data when years with significant missing data are eliminated. On the north side of Minot, the National Weather Service operated ASOS station was even drier, with a mere 7.55 inches of moisture being recorded thus far in 2017, making it the driest on record. It should be noted, though, that the period of record for this site only goes back to 1949 and ASOS stations can have a low bias for snow accumulation.

Out to the east, the Grand Forks area has fared considerably better with an even 19 inches of moisture so far, and that puts it right in the middle of the pack at about the 52nd driest year going back to 1893. Fargo hasn't kept pace with its neighbor a mere 70 miles to the north as its 14.67 inches of moisture ranks as the sixth driest going back to 1942. Working our way back west, the State Hospital in Jamestown, with a record going all the way back to 1893, is the 10th driest with 12.54 inches of moisture so far in the year (Figure 7).

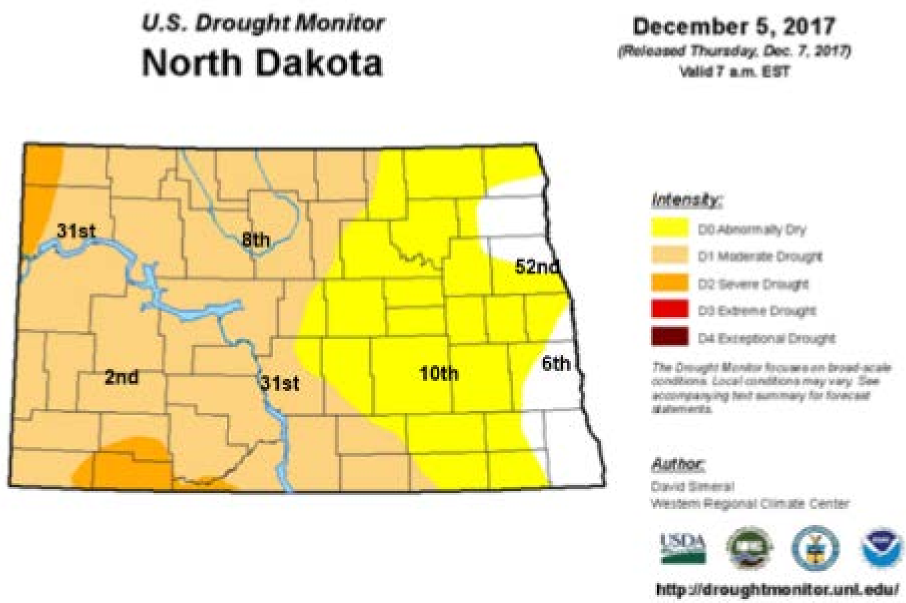


Figure 7. Drought conditions in North Dakota at the end of autumn. Numbers indicate rankings of year-to-date precipitation accumulations.

Bismarck appears to be a bit of an anomaly as it is tied for the 31st driest year on record going back to 1875, with 13.50 inches of moisture. Granted, 2017 would rank much worse for Bismarck if it weren't for August, when 5.09 inches of water fell from the skies. Bismarck is a pretty good reflection of almost the entire Missouri River corridor through North Dakota as widespread beneficial rains fell from Williston to Sioux County during August and September. In the southwestern part of the state, the Dickinson site ranks second driest on record,

[2] 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

with 10.23 inches of moisture going back to 1949. Lastly, Williston comes in at the 31st driest going back to 1894, although a couple of years are missing significant data.

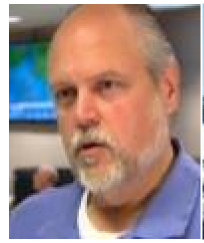
When a person overlays the data on a recent USDM image, the results are a little hard to make immediate sense of in the context of their historical rankings. A ranking of 52nd would suggest there should be no drought designation within miles of Grand Forks, and conversely, a ranking of second overall driest would suggest the drought ranking does not adequately reflect how dry it has been. What is missing in a snapshot, like that to the right, is one of timeliness with the moisture received. This also can be the same thing that individuals miss when looking at a snapshot of time with precipitation deficits in mind. Perhaps the deficits fit a little better with an image from the USDM when the drought was in full effect during this past summer, as in Figure 7.

The best message on drought in North Dakota is that last spring and early summer were brutal and a hangover with impacts is likely. Soil moisture levels remain below normal across most of North Dakota, as are stock dams and dugouts in western North Dakota. Oftentimes we think of winter in North Dakota as something akin to hitting the reset button on drought. However, the early part of winter this year continues on a path of below-normal accumulation of snow. While many may not appreciate a snowy winter, the majority of the state sure could use an above-normal snowpack come early March. Anything less than 2 to 3 inches of water equivalent is unlikely to reduce the current soil moisture deficits and fill a majority of the surface water features.

Now we are left with the question of: **Is the drought going to improve or worsen as we go into spring**? The best information we have to go on is the official Climate Prediction Center's winter outlook, shown in Figure 6b. The outlook covers the December, January and February timeframe and provides reason to be optimistic. However, the mean water equivalent received during this period for the Bismarck area is 0.51, 0.47, and 0.47 inch of water for December, January, and February, respectively. This winter season total of 1.44 inches of moisture does not reach the level of what I believe would significantly relieve the pressure of drought on the region. Even if we add in the 0.85 inch of moisture typically received in March, the resulting 2.29 inches of expected moisture between now and April 1 is at the lower end of what is probably necessary to relieve the pressure on our agricultural community.

The bottom line here is that while anything can happen, a mere return to normal this time of year is likely to leave some interests feeling the effects of a dry 2017. It would instead require a significantly above-normal precipitation pattern combined with consistently cool temperatures to provide the necessary snow-water equivalent on the ground ahead of the spring melt season. This would suggest we need a fairly miserable second half of winter to help ward off a continuation of the drought come spring.

Science Bits



GOES-R Next Generation Weather Satellites

By C. Jones[3] and G. Gust[4]

Weather, Water and Climate Satellites. Earth-observing satellites have given environmental scientists the power to view and study our planet as a whole. From the vantage of space, we can observe the planet's systems moving, breathing and living in a way we are not capable of from the ground. Most people are familiar with imagery from geostationary satellites (think of your favorite news network's weather broadcast). Geostationary satellites are those that follow an orbit moving at the same speed as the Earth's rotation. This allows the satellite to constantly monitor atmospheric conditions for a particular portion of the Earth by "remaining in one spot" above the Earth. Within meteorology, the continuous observing power of geostationary satellites has a great advantage over other satellites with different orbits by allowing meteorologists to see how the atmosphere behaves in near real time. Figure 8 shows a sketch of polar-orbiting and geostationary satellites (Courtesy of UCAR COMET Program)

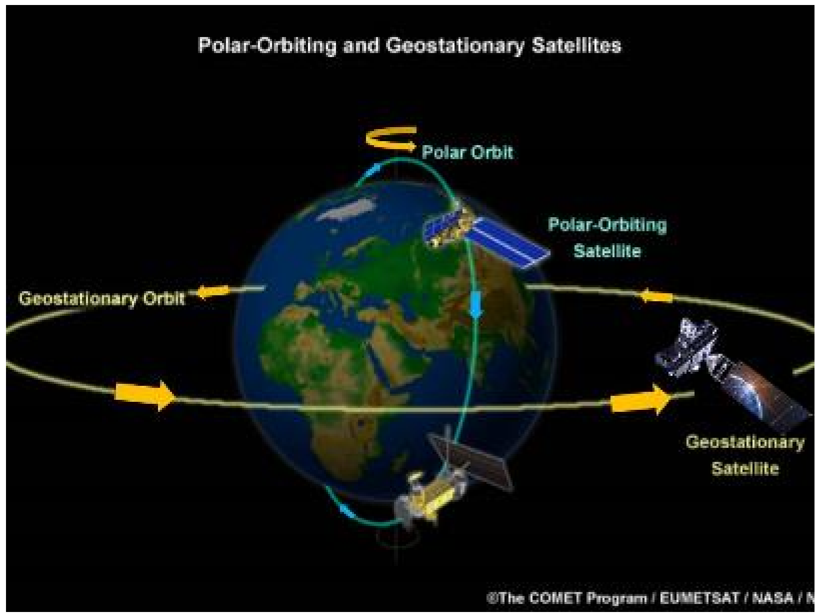


Figure 8. Polar-Orbiting and Geostationary Satellites (UCAR-COMET)

The first geostationary Earth observing satellite was placed into orbit more than 50 years ago, providing unprecedented imagery for its time. Of course, this imagery would look very old and coarse, compared with what we are used to seeing today. However, we do get to enjoy the same privilege of seeing new and unprecedented imagery with the advent of the GOES-R series of satellites launched and operated by the National Oceanic and Atmospheric Administration (NOAA).

New GOES R Series Begins. The GOES (Geostationary Operational Environmental Satellite) - R Series is NOAA's next generation of geostationary weather satellites. They host a new suite of instruments replacing the previous GOES series of instruments not upgraded since 1994. This will significantly improve the detection and observation of environmental phenomena directly impacting public safety, protection of property, and our nation's economic health and prosperity. The satellites will provide advanced imaging with increased spatial resolution and faster coverage for more accurate forecasts as well as real-time mapping of lightning activity. Not only will the GOES-R series significantly improve terrestrial monitoring, it also will carry new instruments to improve monitoring of solar activity and space weather.

[3] Carl Jones is a meteorologist intern at the National Weather Service Grand Forks, N.D. Email: carl.jones@noaa.gov
[4] Greg Gust is the warning coordination meteorologist at the National Weather Service Grand Forks, N.D. Email: gregory.gust@noaa.gov

The first satellite in the series known as GOES-R was launched on Nov. 19, 2016, from Cape Canaveral Air Force Station in Florida. Once in orbit, GOES-R was renamed GOES-16 and will be replacing an aging GOES-13 as NOAA's operational GOES East satellite in mid-December 2017. The program consists of four satellites (GOES-R/S/T/U) that will extend the availability of the operational GOES satellite system through 2036. Each satellite is designed to have an operational lifespan of at least 10 years, preceded by up to five years of on-orbit storage.

So how will GOES-R help you?

More Channels. Probably the biggest impact these satellites will have on meteorology will be the improvement in short-term (0 to 24 hour) weather forecasting, on storm tracking, and on severe storm warnings. These satellites are equipped with six instruments, two of which are used for meteorological purposes. They are the Advanced Baseline Imager (ABI) and Global Lightning Mapper (GLM). The ABI is the "eye" of the satellite used to see things such as clouds, ocean currents and changes in the land, to name a few. Compared with earlier GOES satellites, the GOES-R's imager will have three times more channels (spectral resolution), four times the clarity (spatial resolution) and five times faster imaging capabilities (temporal resolution). Let's break down each of these improved resolutions.

Better Spatial Resolution. Spatial resolution refers to the size of an image pixel, or how many pixels are available to cover a specific distance. In other words, it refers to how much detail is within an image. Let's make it relatable: If you are reading this with glasses, take off your glasses and try to read. While you might still be able to see the words, you may find it harder to see the details or read at all. Whereas, your glasses may give you that extra boost in crispness and detail revealing a world you might never have fully seen without them. Being able to see extra detail allows scientists and forecasters to view never before seen phenomena that will aid in better understanding. Phenomena such as the supercell thunderstorm pictured in Figure 9 responsible for producing a tornado near Hillsboro, N.D., on July 12, 2017.

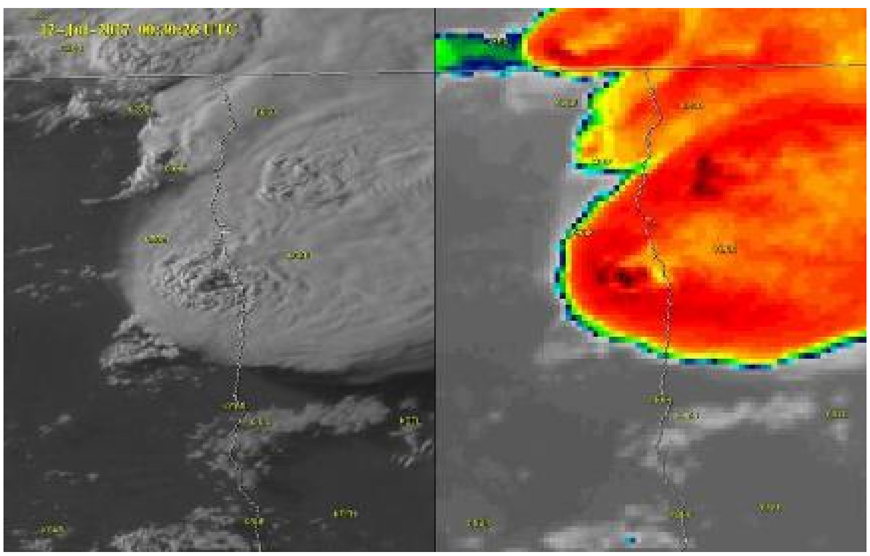


Figure 9. July 12, 2017 Red River Valley supercell image (Courtesy of Scott Bachmeier, CIMSS UW-Madison).

Better Temporal Resolution. Temporal resolution refers to how fast an image can be taken. The more temporal resolution there is, the closer the images are to each other in time. For instance, watching an animation of multiple images from a geostationary satellite can allow one to study how cloud structures behave through time. GOES-R ABI images can be taken as fast as every 30 seconds, with an image of the contiguous United States taken every five minutes (compared with 15 minutes on the older GOES series). This means satellite images can be produced as fast as, or even faster than, radar images, which are made on average every 2 to 7 minutes. Using the GOES-16 satellite, this very near real-time imagery already has been proven to be crucial in the decision-making process of severe weather warning issuance.

Better Spectral Resolution. Spectral resolution refers to how many regions within the electromagnetic spectrum an instrument can sense. The ABI can sense 16 regions, known as channels, compared with the older GOES series imagery which only could view five channels. Humans only can view a small portion of the electromagnetic spectrum known as the "visible" portion. The ABI can reveal details within the visible, near-infrared and infrared regions of the spectrum, allowing forecasters to see details within the atmosphere about cloud physical properties, thermal properties and water vapor content not seen with the naked eye.

Better Lightning Data. The other instrument meant for meteorological use is the Global Lightning Mapper, or GLM. New to the GOES family, this instrument detects lightning using complex optical sensors. It will significantly improve lightning detections mainly in two ways. First, it will be able to detect cloud-to-ground and intra-cloud lightning, and second, it can detect lightning over most of the Western Hemisphere. This is a significant improvement over current ground-based lightning detection networks due to the addition of intra-cloud lightning detection, as well as detection of total lightning over areas that are out of reach of the ground-based networks, such as lesser developed regions of the hemisphere, as well as over oceans. Meteorologists track behavior in lightning that can indicate many things, including severe weather potential.

While satellites continue to improve the science of meteorology, the GOES-R series will greatly enhance forecasting capabilities into the future. Satellites give us an introspective view upon our Earth. Like a microscope to the biologist, Earth-observing satellites provide a window in which scientists can peer into the incredibly complex network of systems that make up our atmosphere, hydrosphere, geosphere and biosphere.

Useful Links to for further information:

ND Supercell CIMSS Sat Blog:	http://cimss.ssec.wisc.edu/goes/blog/archives/24473
GOES-R ABI improvements:	https://www.goes-r.gov/spacesegment/abi-improvements.html
GOES-R Homepage:	https://www.goes-r.gov/
NOAA GOES-R:	https://www.nesdis.noaa.gov/GOES-16

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.

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