Winter 2018-19 Summary for Southwest and Northcentral Montana

A look back at the winter of 2018-19 reveals that, although the extreme cold and snow of February and March sticks out, it did have mild and dry periods as well. Outlooks for the winter indicated that, due to the influence of a weak El Niño pattern, the winter would lean towards warmer than normal with precipitation forecasts more uncertain (Di Liberto, 2019). The outlook covered the period from December through February. The outlook was close, until February arrived. A phenomenon known as sudden stratospheric warming occurred in late December (CPC, 2019) (Fig. 1) which caused a split in the stratospheric polar vortex (Garthwaite, 2019). Initially there were three lobes of the split, with one moving over eastern North America. In February, it moved westward and caused a longer-term upper level trough of low pressure to remain over western North America (Kalnay et al 1996) (Fig. 2). This was an uncommon pattern and caused much of the western United States and Canada to experience rare cold and snow.

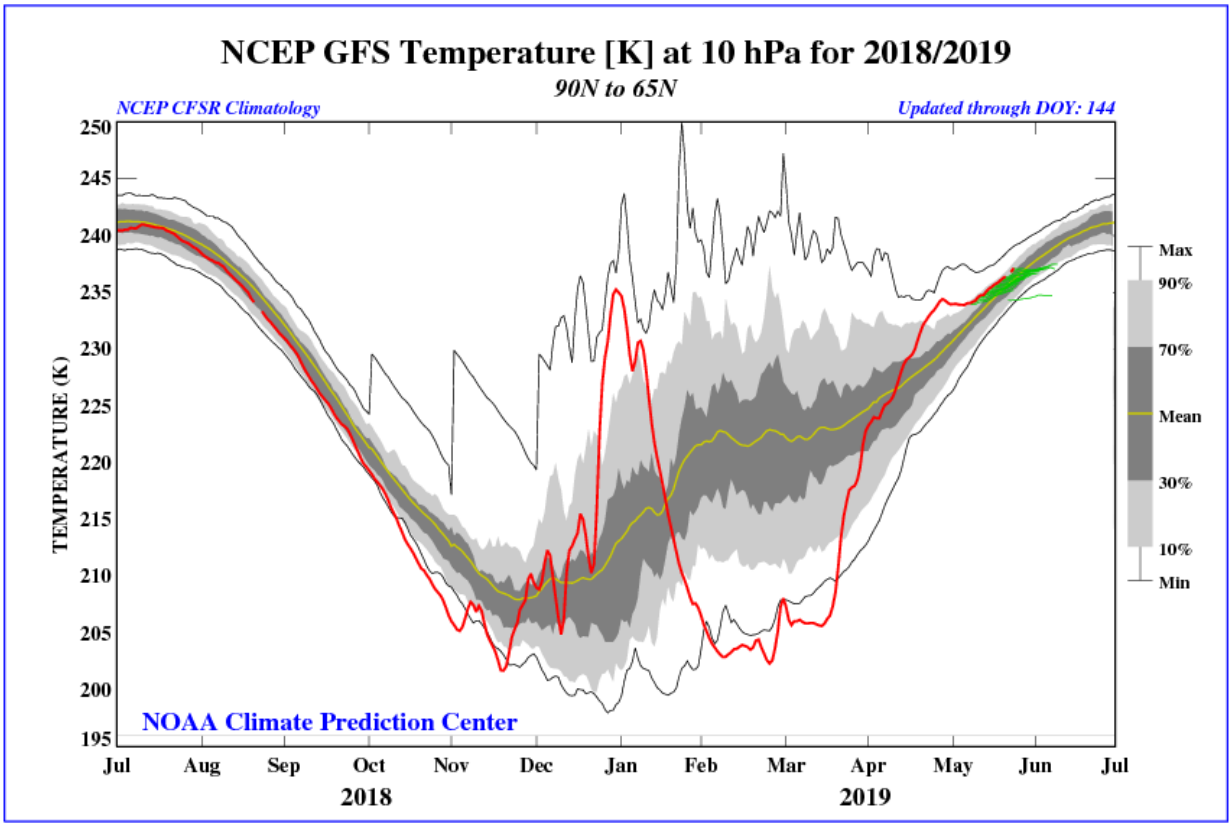

Figure 1. Global Forecast System temperature time-series at 10 hPa. Note the strong warming in late December and January. NOAA Climate Prediction Center.

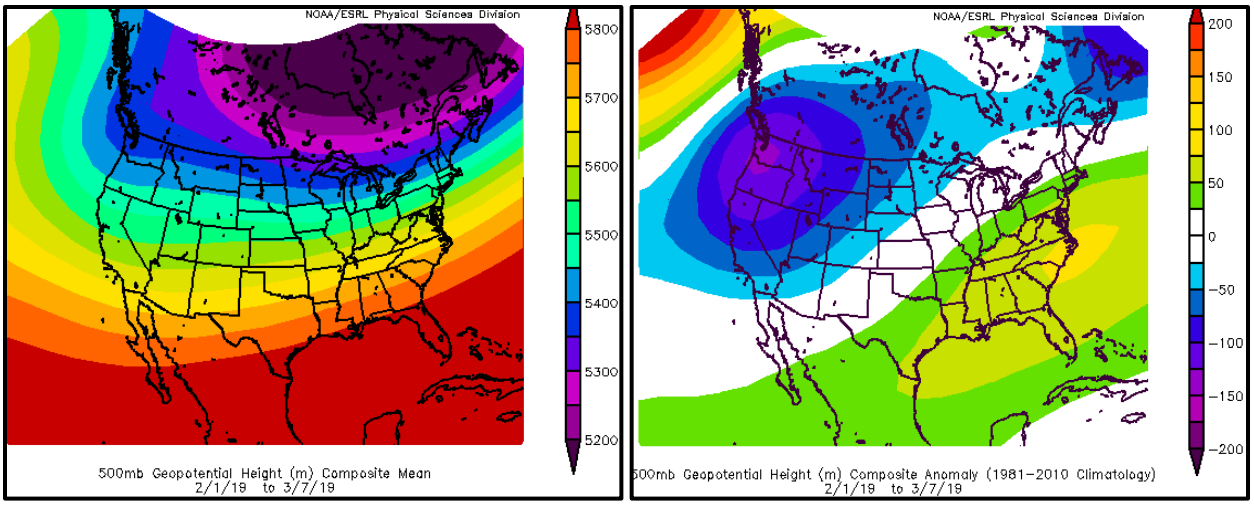

Figure 2. 500 hPa Geopotential Height and departure from normal for February 1 – March 7, 2019. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their web site at http://www.esrl.noaa.gov/psd/.

Monthly discussion

The first snow fell on September 30, which is close to the seasonal average for the first snowfall, which is October 3. With snow at Great Falls on eight of the first 15 days of October, many perceived winter as having an early start. Amounts during this period were generally light. Heavier snow fell over the northern Rocky Mountain Front. A storm dropped nearly two feet from the 2nd-4th, while another dropped nearly 10 inches in the Choteau and Bynum areas on the 9th and 10th. After this snowy and rather cold start to October, the rest of the month was mild, with temperatures reaching 83°F at Loma on the 20th. The last 70°F reading for the fall season occurred on October 28 at Armells Creek. This was about one week earlier than normal. October ended up averaging a little cooler and drier than normal.

Summary of winter averages	October	Departure from normal
Average Temperature	42.2°F	-0.8°F
Average Precipitation	0.88-inches	+0.07-inches
Average Snowfall	3.0-inches	-0.8-inches
Average Wind speed	8.0-mph	-0.8-mph

November had typical cold and warm periods, and temperature averaged near normal. Precipitation and snow was above normal most areas. Cut Bank had their 5th snowiest November of record, with 14.6-inches of snow. The first cold period of the season pushed low temperatures into the single digits from the 7th-9th. The area's first sub-zero reading occurred on the 8th, about a week behind schedule. Elk Park bottomed out at -20°F on the 12th. This was the area's earliest -20°F value in the area since 2014, and about two weeks earlier than normal. With cooler than normal temperature for the fall period (September through November), it was the area's coolest since 2000.

Summary of winter averages	October-November	Departure from normal
Average Temperature	36.1°F	-0.4°F
Average Precipitation	1.74-inches	+0.04-inches
Average Snowfall	12.2-inches	-0.8-inches
Average Wind speed	8.4-mph	-0.7-mph

December's temperatures averaged above normal over all but the southwest. An average temperature of 4.1°F above normal made it the warmest December since 2014. The first week was cold with below normal temperatures. Snow amounts of up to six-inches fell on the 1st and 2nd, with most of the rest of the month dry. The area's first -30°F of the season occurred on the 5th, about a week ahead of normal. Above normal temperatures began around the 10th and lasting through the 25th. Exceptionally windy conditions occurred during this period. The area's peak gust was 102 mph at Deep Creek on the 29th, while a location near Bynum recorded 86 mph. Although the monthly wind speed averaged only slightly above normal, the last three weeks of the month were very windy. Great Falls had seven days with gusts of 50 mph or higher. This is the highest number of such days in any month since December 1991. Through the end of the year, the weather was variable, but temperatures averaged slightly above normal with somewhat below normal precipitation and snowfall.

Summary of winter averages	October-December	Departure from normal
Average Temperature	32.1°F	+0.9°F
Average Precipitation	2.14-inches	-0.25-inches
Average Snowfall	20.2-inches	-5.1-inches
Average Wind speed	8.7-mph	-0.4-mph

Mild temperatures continued in January. Windy conditions from December continued through the first four days of January. The area's average temperature departure from normal was 3.2°F above normal and the warmest since 2006. From the 16th-27th, a series of storms brought snow to much of north central Montana. Total monthly precipitation amounts were over 2-3 times normal, but still less than one-inch. The peak wind gust was 103 mph at Deep Creek and 94 mph at Two Medicine on the 3rd. The gust at Two Medicine was their strongest gust of record.

Summary of winter averages	October-January	Departure from normal
Average Temperature	30.1°F	+1.6°F
Average Precipitation	2.92-inches	-0.09-inches
Average Snowfall	33.0-inches	-3.4-inches
Average Wind speed	8.9-mph	-0.3-mph

Although there were periods of winter-type weather up to this point, winter began in earnest on February 2nd as a trough of low pressure set up over central North America. After reaching 60°F at Fort Benton on the 2nd, a strong cold front pushed through the area causing a rapid drop in temperature. At Loma, the temperature dropped 31°F in 20 minutes, from 57°F to 26°F. Similar drops occurred throughout the region. Once this occurred, most of the plains remained in a deep freeze through early March. Warm air did make intrusions from the southwest, but generally did not move north of the Little

Belt Mountains. Several daily cold high temperature records were set. A temperature of -46°F was recorded north of Havre on the 7th. The persistent cold was accompanied by heavy snowfall. The area's average February temperature of 4.1°F was the third coldest of record and coldest since 1936. This was also the coldest month since January 1979. Great Falls, Helena and West Yellowstone had their wettest February of record. At Great Falls, the monthly precipitation of 2.57-inches made this the wettest of all winter months from November through March. The area's precipitation average of 1.91-inches is the wettest of record. Snowfall was heavy. Bozeman had their snowiest month of record. The area's average snowfall of 26.6-inches was the snowiest of record, exceeding that of February 2018 (21.5-inches). The extreme cold was accompanied by some of the lightest winds of record. The area's average was the 6th calmest of record, while Great Falls recorded their calmest February of record. At this point in the winter, temperatures averaged 2.8°F below normal and precipitation averaged 1.20-inches above normal. Great Falls had 22 days with measurable precipitation. This tied May 1927 for the most for any month. Due to the persistent cold, pipes froze and water mains burst as the frost depth reached several feet.

Summary of winter averages	October-February	Departure from normal
Average Temperature	24.9°F	-2.8°F
Average Precipitation	4.96-inches	+1.20-inches
Average Snowfall	58.8-inches	+13.3-inches
Average Wind speed	8.6-mph	-0.6-mph

The cold continued into March with the large trough of low pressure remaining over the region for the first 10 days. Great Falls had 32 consecutive days below freezing. This broke the old record by one day and was only one of eight years that had a consecutive stretch of sub-freezing days of more than 20 days. This illustrates how westerly down-slope winds are the normal along the eastern slopes of the Rockies. Although warmer air pushed in later, it was still a cold month. A fast moving weather disturbance brought blizzard conditions to north central Montana on the 1st. The lowest temperature of -46°F was observed at Elk Park on the 3rd. This is one of the coldest temperatures of record for Montana in March. Temperature were as much as 50°F below normal on the 3rd. The first day with above average temperatures occurred on the 20th. The persistent snow-pack aided in keeping temperatures below normal. Great Falls had 13 days with a foot or more of snow on the ground (2nd longest), while Helena had a 20 day stretch – a new record. Bozeman MSU reported 18-inches or more on the ground for 33 consecutive days (from February 25-March 29). This exceeded their old record of 21 days set in February 2001. The persistent and deep snow also caused several roof collapses across the region. Bozeman and Dillon recorded their coldest March of record. Temperatures averaged as much as 17°F below normal.

Precipitation was generally below normal. Areas from Lincoln to Boulder and Dillon to Jackson had more than double their normal March precipitation. Winds were at near record lows for the month (see Figure 3). Area-wide, this was the calmest March since 1998, while Bozeman, Dillon and Helena had their calmest March of record. Havre's monthly peak gust of 37-mph was the lowest for March since 1992. Helena had a 51-day streak with peak wind gusts of 25-mph or less. This smashed their old record of 33-days from December 28, 2003-January 29, 2004. Once conditions began to warm, the warmer air brought melting snow and flooding. From the 16th through the end of the month, many rivers and streams were flooding. An ice jam on the Missouri River at the Fred Robinson Bridge produced one of the highest stages since the 1950s.

Combining February and March, this was the coldest of the two months combined at most locations across the area (See Figure 3 [Kalnay et al 1996]). Great Falls' average temperature was 11.6°F, setting a new record. The previous record of 14.4°F was set in 1936.

At this point in the winter, the area's average temperature was 24.4°F, or 4.1°F below normal and the 14th coldest of record. Precipitation averaged 5.59-inches. Although December and January were windy, the winter to this point had an average of 8.2-mph, about 1-mph below normal.

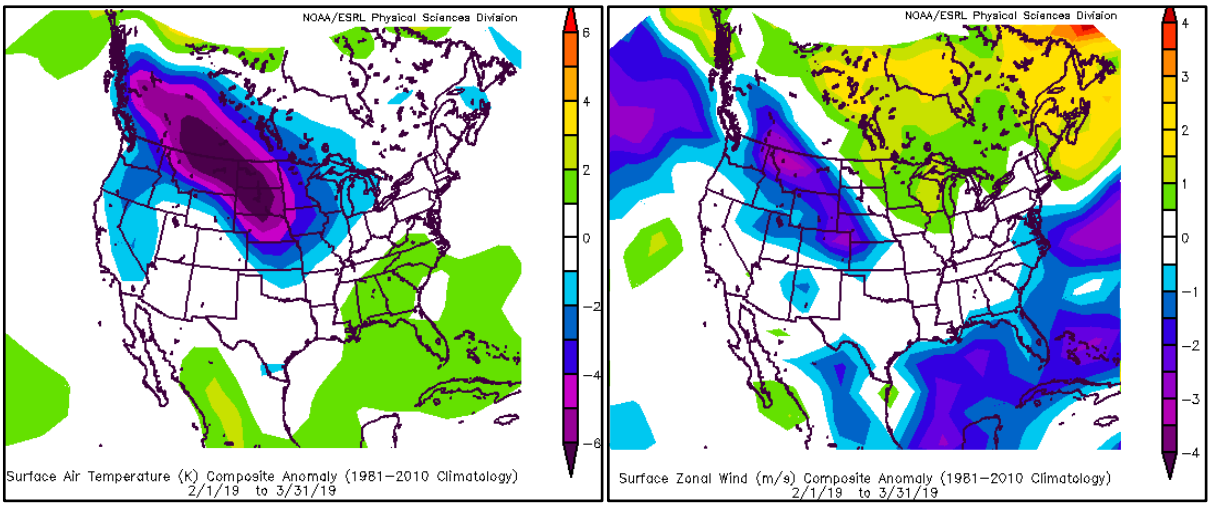

Figure 3. February and March surface air temperature (Kelvin) anomaly (left). 6K is about 11°F. February and March surface zonal (westerly) wind anomaly (right). 3 meters/sec is about 7 mph. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their web site at http://www.esrl.noaa.gov/psd/.

Summary of winter averages	October-March	Departure from normal
Average Temperature	24.4°F	-4.1°F
Average Precipitation	5.59-inches	+0.89-inches
Average Snowfall	64.8-inches	+8.8-inches
Average Wind speed	8.2-mph	-1.0-mph

April returned to temperature averages near normal, with above normal precipitation most areas. Upper level flow from the west produced this pattern. There were no significant storms until the 9th. From the 9th-12th, up to two-feet of snow fell over sections of the northern Rocky Mountain Front. Another series of storms brought precipitation across the area on the 20th. Rainfall of one to two inches were reported over central Montana, with one-half to one-inch amounts more common. After a relatively mild month, the coldest air arrived on April 28th. This accompanying storm system produced light snow amounts at lower elevations, but 24-30-inches in the Highwoods and Little Belts. Blizzard conditions raged over the plains as high temperatures struggled to reach freezing. Gusts of 35 to 60 mph were common. Newlan Creek fell to -1°F on the 29th. This was one of the coldest temperatures so late in the season since 2006. At this point in the winter, temperatures averaged 3.5°F below normal and precipitation 1.54-inches above normal. Winds averaged 8.4-mph.

Summary of winter averages	October-April	Departure from normal
Average Temperature	30.4°F	-3.5°F
Average Precipitation	7.60-inches	+1.54-inches
Average Snowfall	67.9-inches	+4.1-inches
Average Wind speed	8.4-mph	-0.9-mph

The cold continued into May. Newlan Creek recorded a temperature of 0°F on May 1. Again, this was one of the coldest area temperatures so late in the season since 2006. With continued below normal temperatures, snow fell on the 5th. Amounts ranged from 1-3 inches across north central Montana. After a couple of warm days with some areas seeing temperatures above 80°F on the 12th, snow fell again on the 18th, with amounts from a trace to 6-inches. Some parts of central Montana had high temperatures in the 30s. At Great Falls, considering that the first measurable snow fell on September 30, 2018 and the last was May 18, 2019, it was a 231-day period. This was the longest since the 2008-09 season and 35-days longer than normal. The persistent cold is reflected in the delay of the budding of trees. By the 22nd, many trees had yet to start leafing out. The US National Phenology Network indicated that the start of budding of trees (and spring) was delayed by two to three weeks across the region (USA National Phenology Network) (Fig. 4). By late May, it was becoming apparent that many trees had suffered damage from the extreme winter conditions. The needles on many pines in the Great Falls area had turned a rust color, while ash and apple trees showed signs of winterkill. This was evident in spotty leafing of the branches.

The first 80°F day arrived at Great Falls on May 30, about 20 days later than normal. There were 261 consecutive days with high temperatures less than 80, the most since 2004-05 and ninth longest such stretch of record.

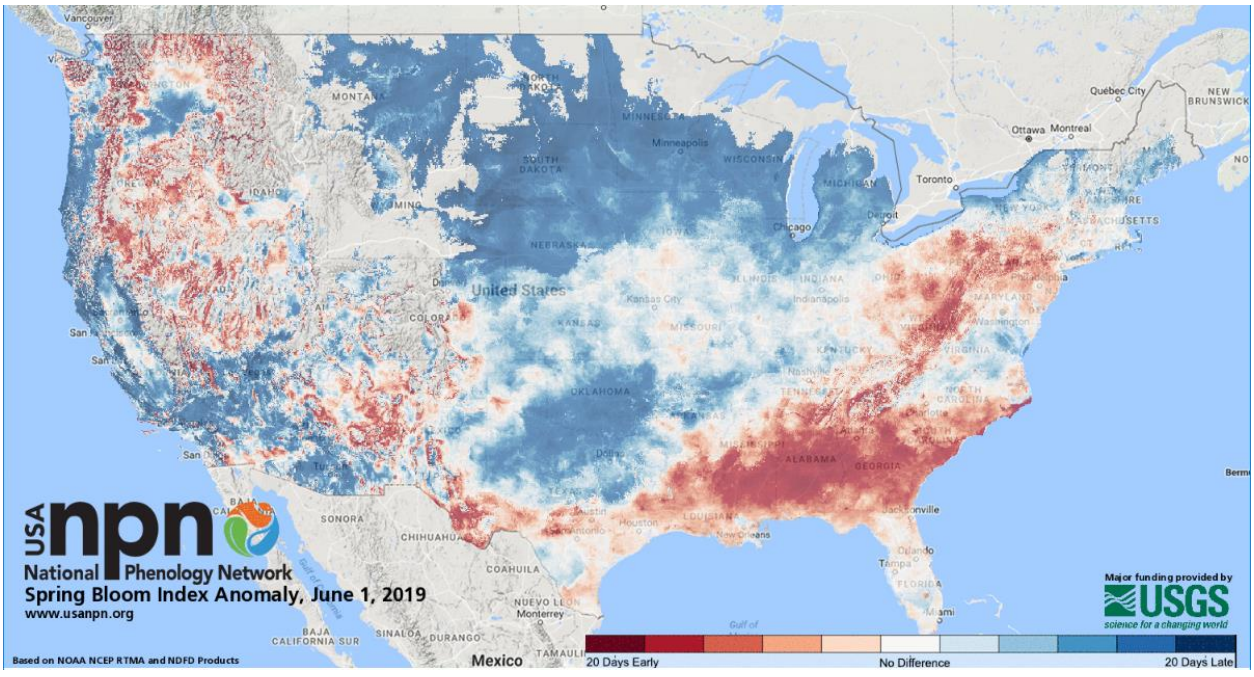

Figure 4. Spring Leaf Index Anomaly on June 1. Data were provided by the USA National Phenology Network.

For the 8-month period of October through May, temperatures averaged colder than normal. The below normal temperatures in the months from February through May contributed to this negative departure. This is the coldest such period since 1978-79 and 7th coldest of record. Precipitation was almost one-and-a-quarter inches above normal, with dryness of December and March offset by record high precipitation of February and heavier than normal precipitation of November, January and April. In all, snowfall was near normal. Although there was a windy period in December, the cold periods had very light winds. The 8-month period's winds averaged nearly 1-mph below normal. This was the calmest such period, edging out 1981-82 which had an average of 8.6-mph.

Summary of winter averages	**October-May**	**Departure from normal**
Average Temperature	29.6°F	-3.3°F
Average Precipitation	9.65-inches	+1.24-inches
Average Snowfall	68.7-inches	+2.4-inches
Average Wind speed	8.4-mph	-0.8-mph

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