Upper Missouri River Basin
January 2013 Calendar Year Runoff Forecast
January 3, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2012 Calendar Year Runoff

December 2012 Missouri River runoff was 0.7 MAF (80% of normal) above Sioux City, and 0.6 MAF (78% of normal) above Gavins Point. December runoff was about 0.1 MAF more than forecast due to the warmer than normal temperatures and above normal precipitation in much of the upper Missouri River basin. The (preliminary, with no holdouts) calendar year 2012 runoff summation above Sioux City, IA was **19.8 MAF** (80% of average), while above Gavins Point it was **17.8 MAF** (78% of average). These preliminary runoff numbers will be finalized within the first few months of 2013.

2013 Calendar Year Forecast Synopsis

The January 1 forecast for the 2013 Missouri River runoff above Sioux City, IA is 20.5 MAF (82% of normal). Runoff above Gavins Point Dam is forecast to be 19.2 MAF (84% of normal) using the 115 years of record from 1898 to 2012. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 28.2 MAF upper basic forecast to the 13.7 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively.   Given that 12 months are being forecasted for this January 1 forecast (0 months observed/12 months forecast), the range of wetter than normal (upper basic) and lower than normal (lower basic) is attributed to all 6 reaches for all 12 months. The result is a large range or "bracket" for each reach, and thus, for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

ENSO (La Nina)

ENSO-neutral conditions continue in the equatorial Pacific, and equatorial sea surface temperatures are near average across most of the Pacific Ocean. ENSO-neutral conditions are favored in the Northern Hemisphere through the winter of 2012-2013 and into spring 2013; therefore, there is not a strong indication of future winter temperature and precipitation conditions in the Missouri River basin based on ENSO conditions.

Drought Analysis

According to the National Drought Mitigation Center (Figure 1), drought conditions on December 25, 2012 impacted a large majority of the upper Missouri River basin with the exception of the northern half of Montana. Abnormally Dry (D0) conditions transitions to Severe (D2) and Extreme (D3) drought conditions in southern Montana and the Dakotas. Exceptional (D4) drought, which is the worst classification of drought according to the drought monitor, is present in southern South Dakota, eastern Wyoming and a very large portion of Nebraska. These conditions developed as a result of the record warmest calendar year and very low precipitation accumulations. In contrast the Missouri River basin on December 27, 2011, was impacted by Abnormally Dry (D0) conditions in a small portion of eastern Montana, the Dakotas, eastern Nebraska and northwest Iowa (Figure 2). Some Moderate (D1) drought conditions had developed in eastern Nebraska, while some Severe (D2) drought conditions had developed in northwest Iowa.

The U.S. Seasonal Drought Outlook shown in Figure 3 indicates drought conditions impacting the Missouri River basin will persist through winter and early spring 2013 with limited change in drought category. Areas that will experience drought persistence include the Dakotas, southeast Montana, most of Wyoming, Nebraska and western Iowa. There is potential for some improvement in southwest Montana and northwest Wyoming, where one-category improvement could occur. Further information about long-range climate factors that may impact drought conditions are discussed later in the climate outlook section.

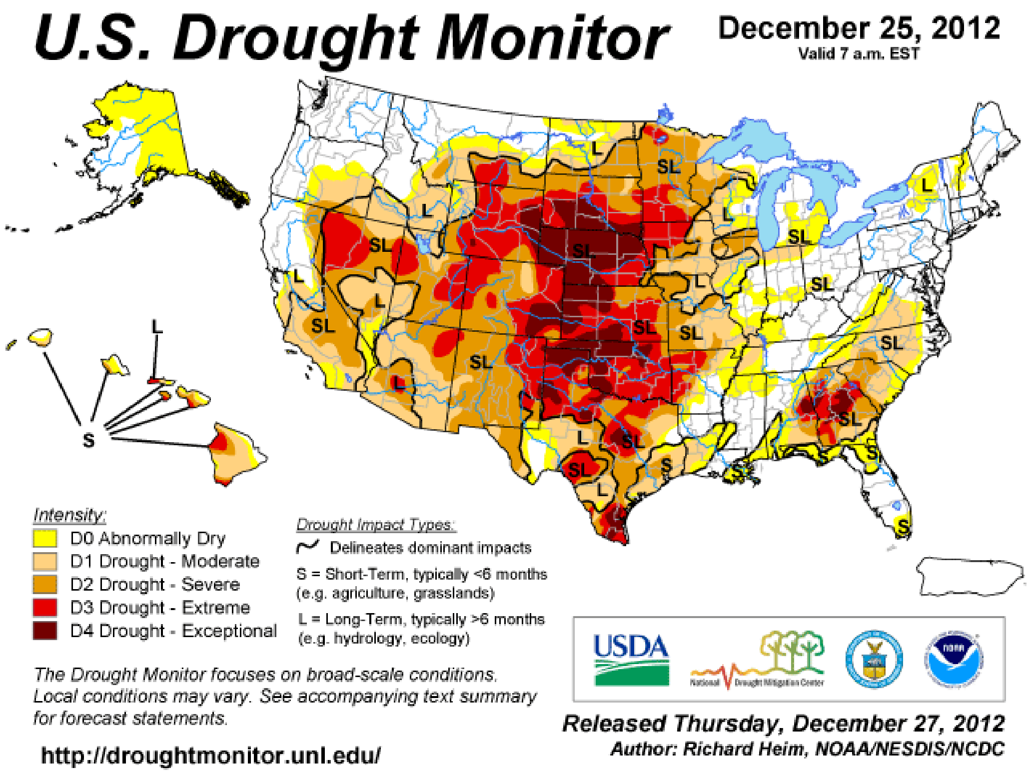

Figure 1. National Drought Mitigation Center U.S. Drought Monitors for December 25, 2012.

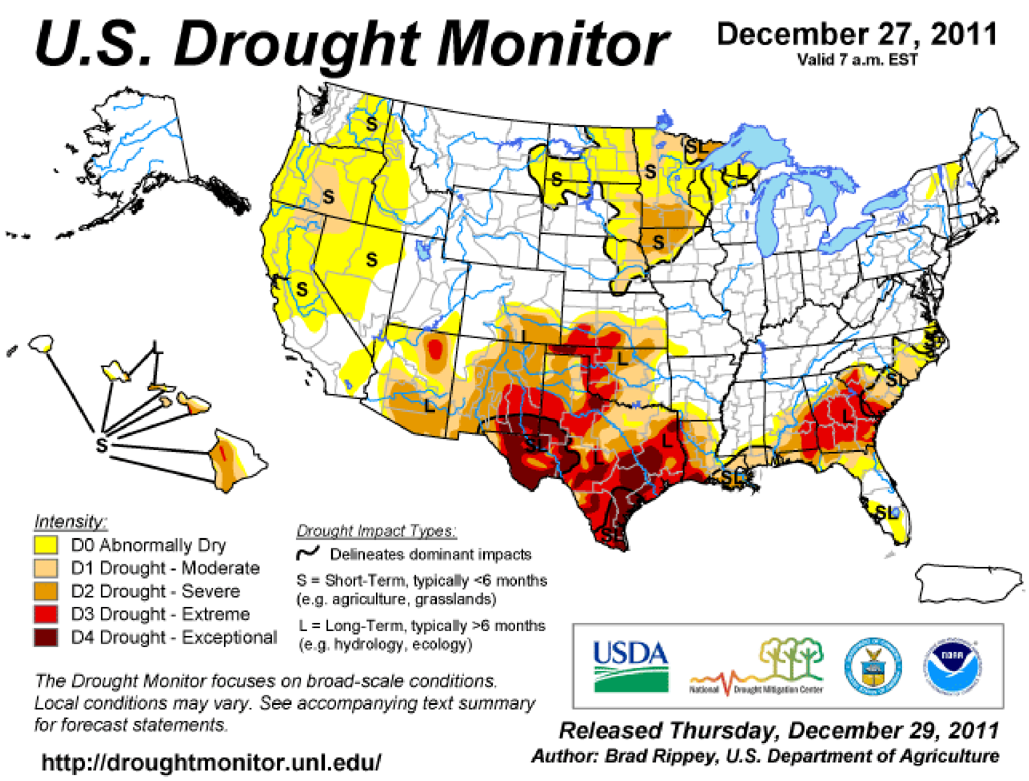

Figure 2. National Drought Mitigation Center U.S. Drought Monitors for December 27, 2011.

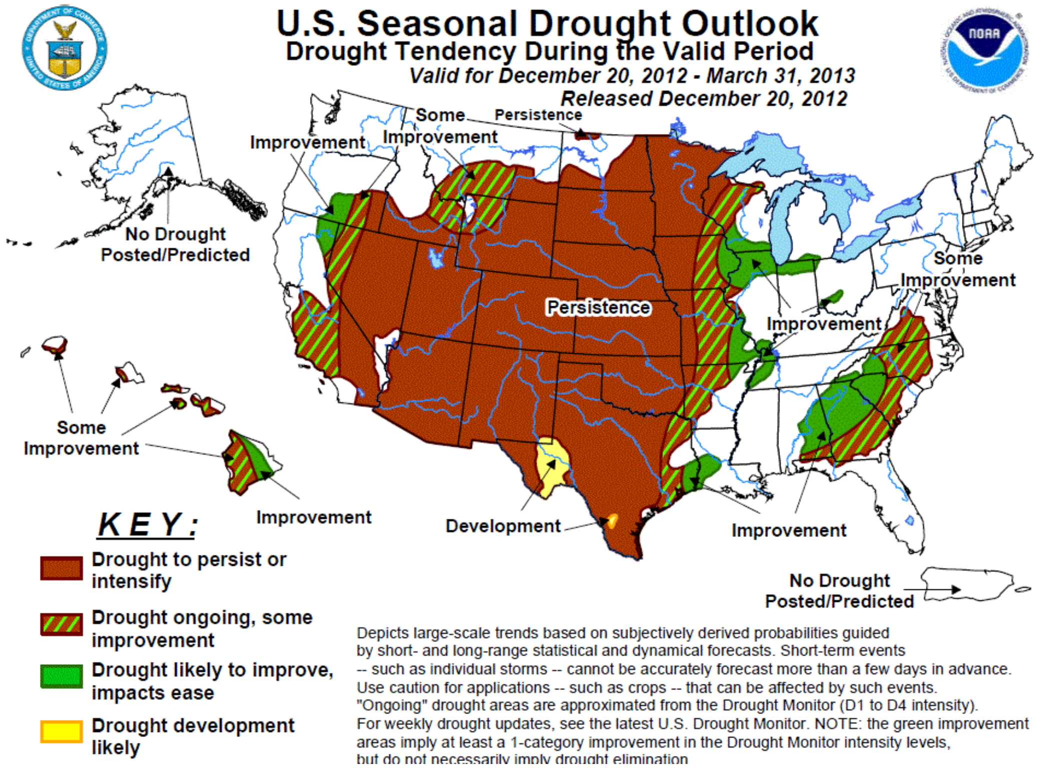

Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of December is shown in Figure 4. While December precipitation generally has limited impact on December runoff since it generally falls as snow and does not result in immediate runoff, it was above normal in many parts of Montana and the Dakotas, while in Wyoming, Nebraska and Iowa, it was mostly below normal except for a few isolated areas. Precipitiation in Montana was greater than 150% of normal across the Rocky Mountain front, in northern and northeast Montana with some areas receiving up to 200% of normal. Similar amounts occurred in southern North Dakota and across South Dakota. Eastern South Dakota received over 200% of normal precipitation in December. Some areas received much less than normal precipitation in December including central and eastern Wyoming and Nebraska where precipitation was as little as 25% of normal.

Accumulated precipitation over the 90-day period ending on December 31, 2012, is shown in Figure 5. Precipitation was well below normal in all states except for Montana and localized areas of Wyoming. Most areas including South Dakota, Nebraska, western Iowa and parts of Wyoming received less than 50% of normal precipitation over the past three months, with some accumulations ranging from 10 to 25% of normal. In contrast large portions of Montana and North Dakota received greater than 150% of normal precipitation. Accumulations in excess of 200% of normal have occurred in northern portions of these states.

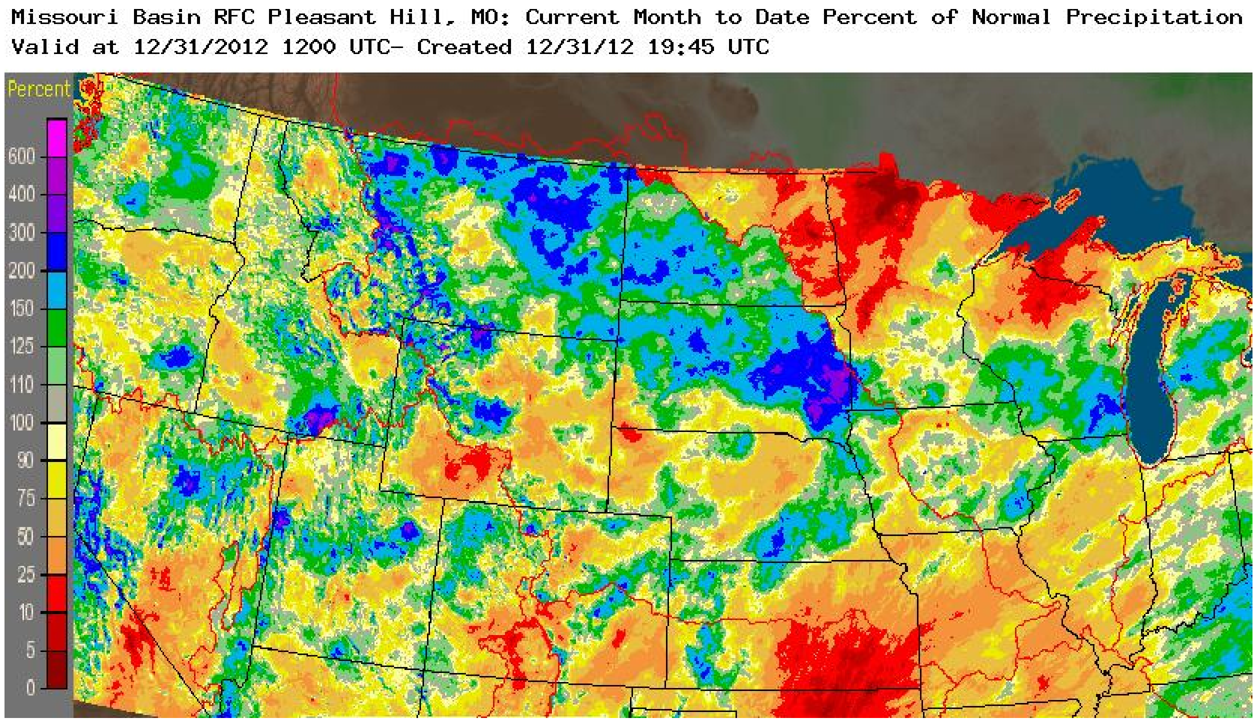

Figure 4. December 2012 Percent of Normal Precipitation.

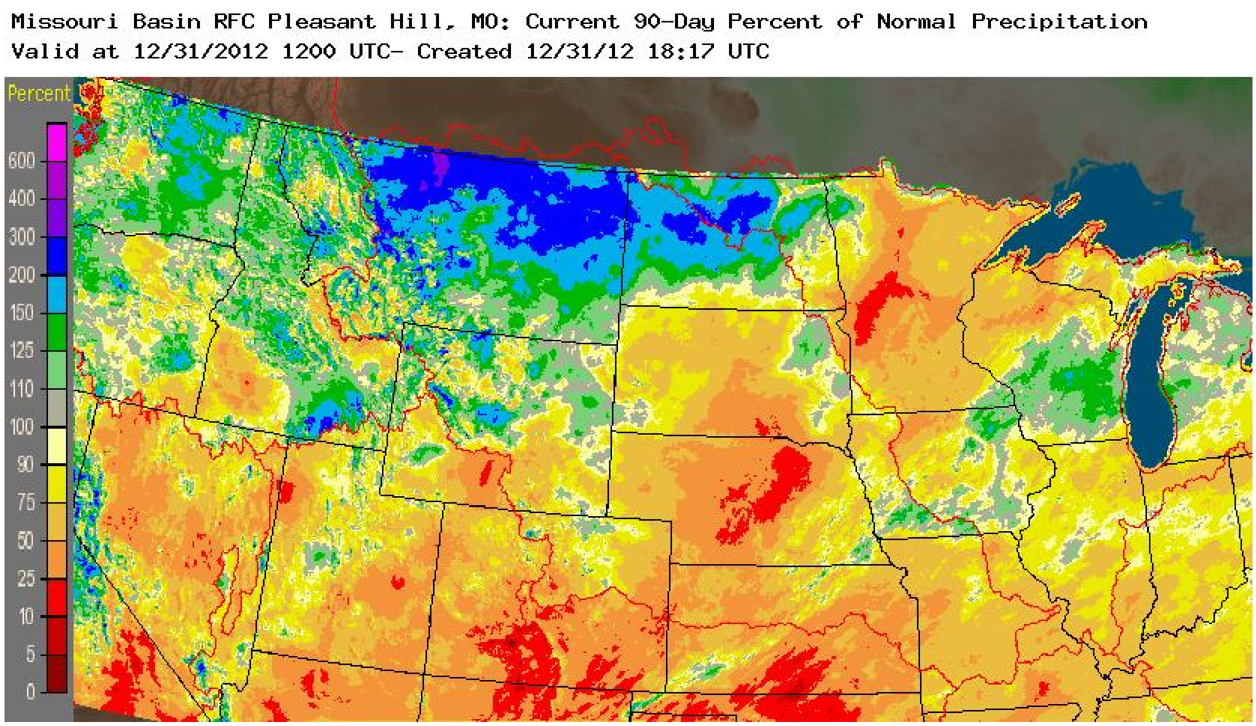

Figure 5. 90-day Percent of Normal Precipitation ending on December 31, 2012.

Temperature

Average temperatures throughout the basin above Sioux City, IA during the month of December 2012 ranged from 3 degrees below normal to 4 degrees above normal (Figure 6). Departures below normal occurred in north central Montana and western North Dakota. Temperatures were near normal in central Montana and throughout western South Dakota, western Nebraska and eastern Wyoming. Temperatures were above normal in all other areas.

Ninety-day (90-day) temperature departures ending on December 31, 2012 are shown in Figure 7. The map in this figure indicates that temperatures in Montana and North Dakota have been 1 to 2 degrees below normal since the beginning of October. In all other areas temperatures were 0 to 2 degrees above normal since the beginning of October.

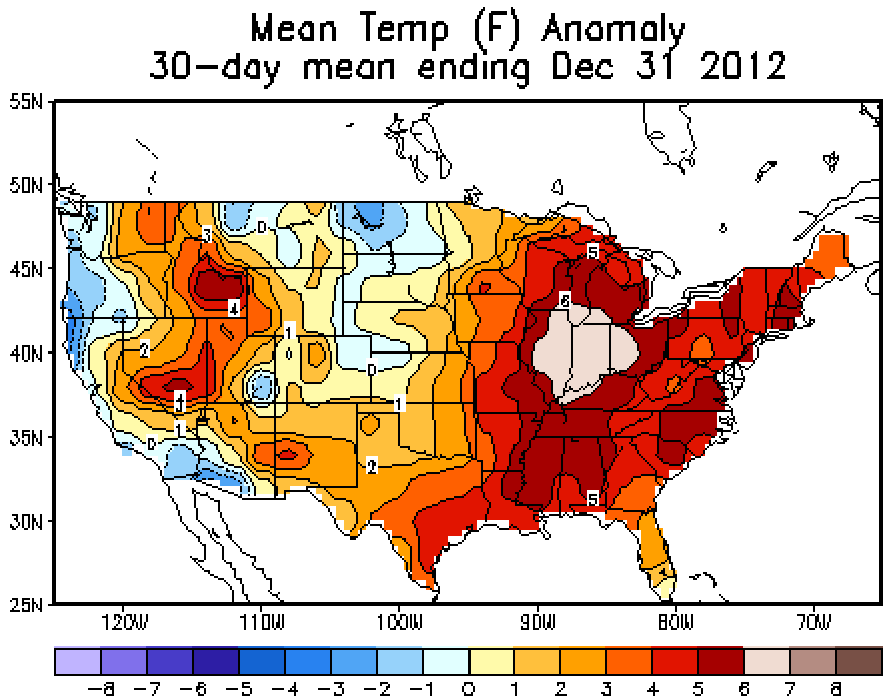

Figure 6. 30-day temperature anomaly (deg F) ending 31 Dec 2012.

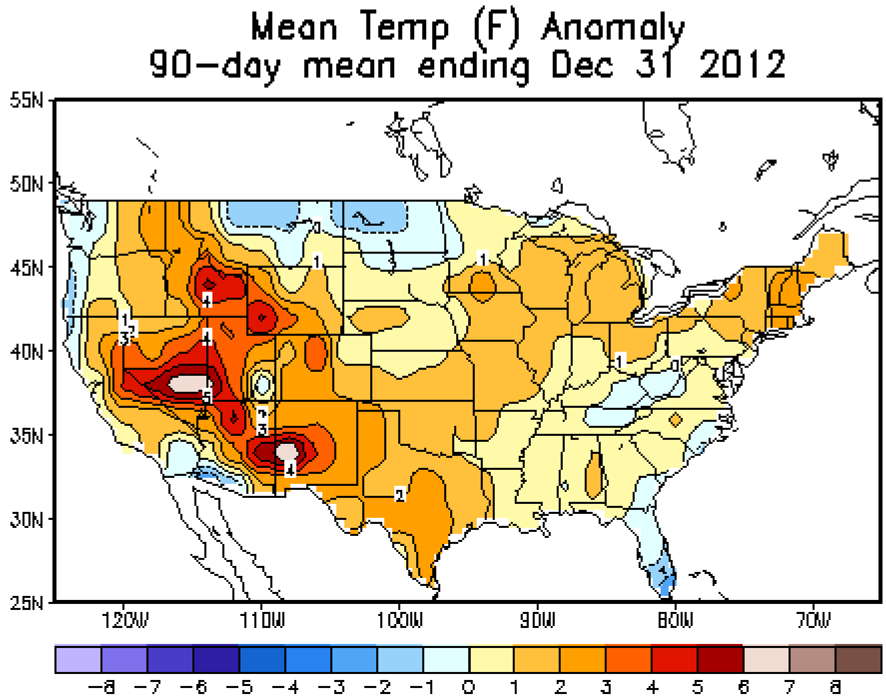

Figure 7. 90-day temperature anomaly (deg F) ending 31 Dec 2012.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Two independent estimates of soil moisture are presented in this report. Figure 8 shows the Climate Prediction Center's calculated soil moisture ranking percentiles for the end of November 2012. Figure 9 shows the Variable Infiltration Capacity model soil moisture percentiles.

Both soil moisture rankings depict very dry soil moisture conditions throughout the upper Missouri River basin, especially in South Dakota, Nebraska, Wyoming and southern Montana. CPC soil moisture conditions in these areas rank from the 5th to the 1st percentile, which are exceptionally dry. In North Dakota and northern Montana, soil moisture ranges from near normal conditions down to the 10th percentile. In comparison, the VIC model depicts very dry soils in the same areas with soil moisture percentiles ranking from the 5th to below the 2nd percentile. In our analysis of the influence of soil moisture on forecast runoff, neither model takes preference over the other. As an indicator of future monthly runoff, soil moisture conditions suggest runoff will be well-below average when considered along with the temperature and precipitation outlooks, which were discussed previously in this forecast discussion.

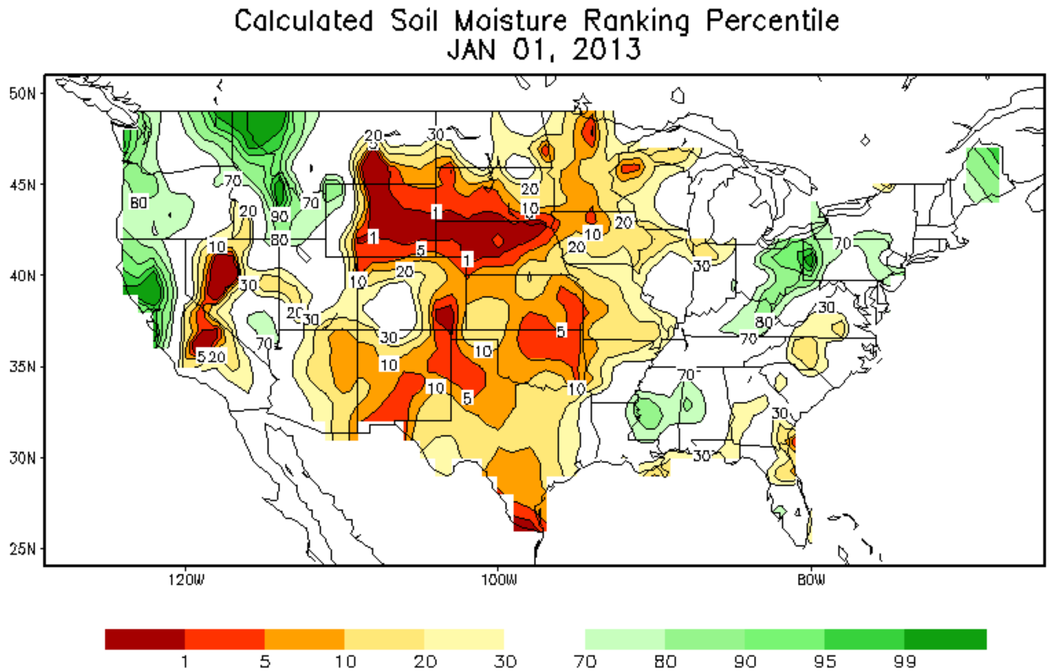

Figure 8. Calculated Soil Moisture Ranking Percentile on 1 January 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

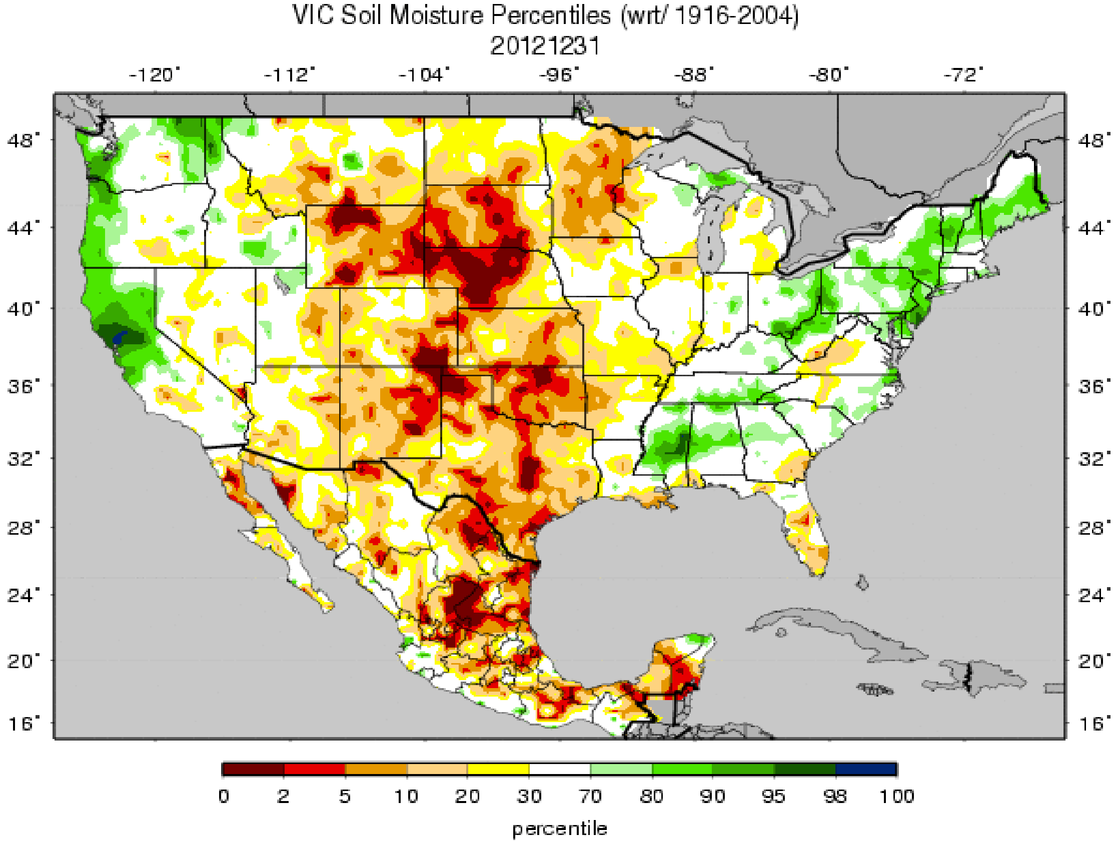

Figure 9. VIC modeled soil moisture percentiles as of December 31, 2012. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

The CPC calculated soil moisture anomaly for the contiguous U.S. on January 1, 2013 is shown in Figure 10. According to the analysis, there are widespread negative soil moisture anomalies in the Missouri River basin; however some areas in Montana and North Dakota have positive anomalies or are normal. Negative anomalies would indicate a soil moisture deficit or negative departure from normal. Negative anomalies range from -20 mm (about 1.0 inch) to –120 mm (about 5 inches) in the upper Missouri River basin.

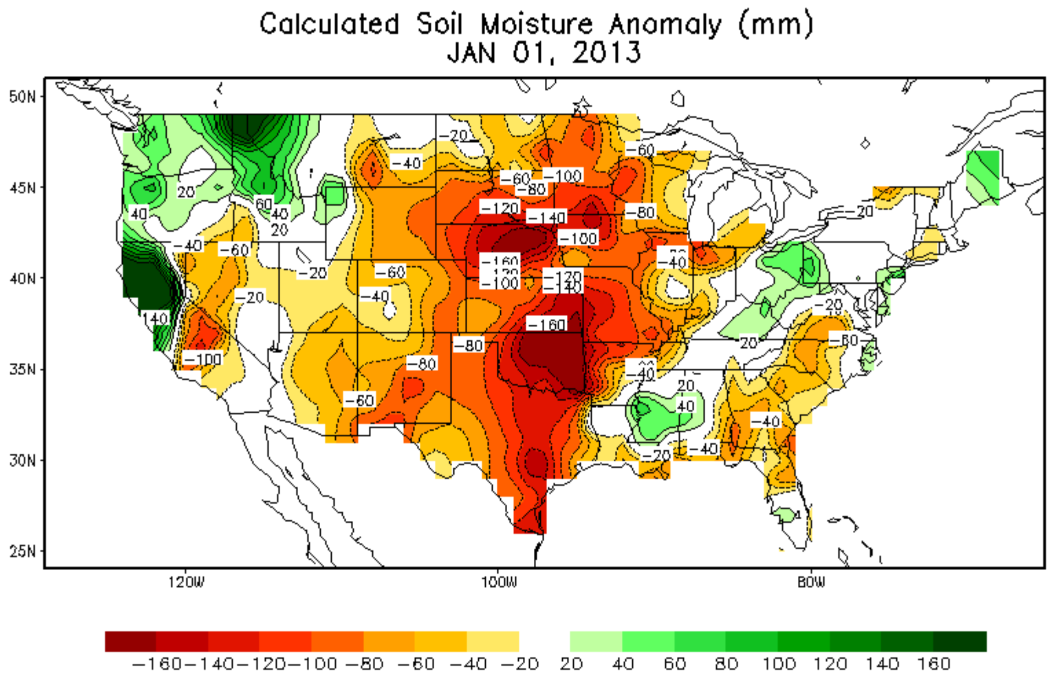

Figure 10. Calculated Soil Moisture Anomaly (bottom) in on 1 January 2013. Source: Climate Prediction Center. **http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#**

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

According to the National Operational Hydrologic Remote Sensing Center (NOHRSC), most plains snow water equivalent (SWE) amounts ranged from trace to 2-inch amounts throughout the upper Missouri River basin. Amounts ranging from 1 to 2 inches cover a majority of eastern

Montana, North Dakota, and less than half of South Dakota. Amounts less than 1 inch cover all remaining plains areas of the basin.

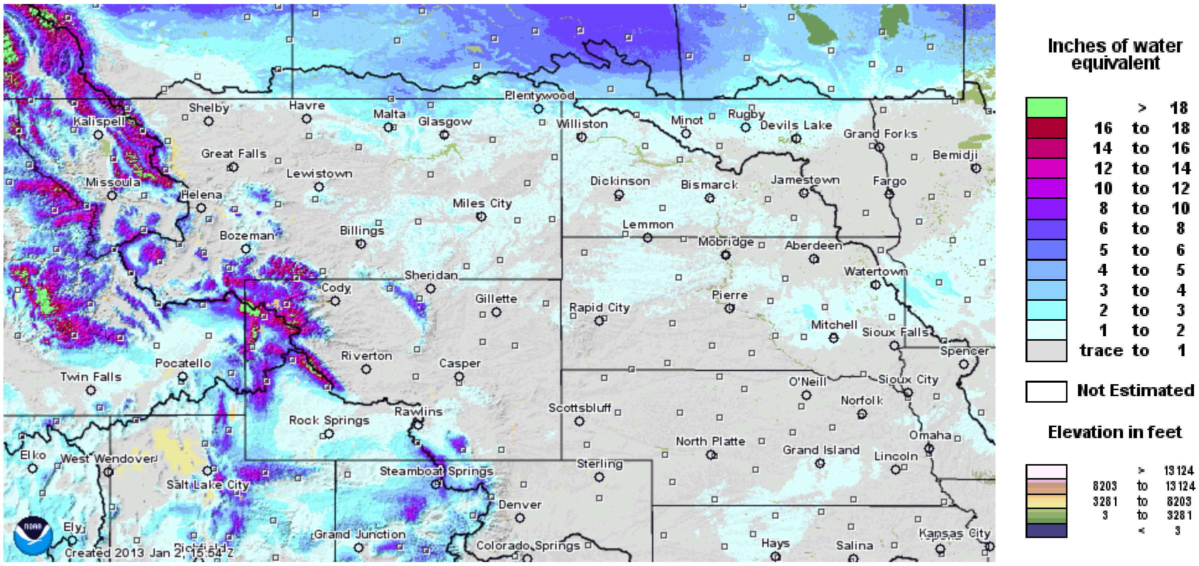

Figure 11. January 1, 2013, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Plains snowpack as of January 1, 2013, was classified as Light across the upper Missouri River basin according to the Corps of Engineers classification methods (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0 to 1 inch of snow water equivalent (SWE) in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins. In the Garrison and Sioux City subbasins, this includes accumulations ranging from 0 to 2 inches of SWE.

Table 1. January 1, 2012 plains snowpack classification for runoff forecasting.

Reservoir Reach	Plains Snowpack Classification
Above Fort Peck	Light (0 – 1 inch SWE)
Fort Peck to Garrison	Light (0 – 2 inch SWE)
Garrison to Oahe	Light (0 – 1 inch SWE)
Oahe to Fort Randall	Light (0 – 1 inch SWE)
Fort Randall to Gavins Point	Light (0 – 1 inch SWE)
Gavins Point to Sioux City	Light (0 – 2 inch SWE)

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month May-July runoff period, about 50% of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. Greater than average mountain snow accumulations are usually associated with greater than average May-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions.

As of January 1, 2013, the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 7.24 inches, which is 101% of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 5.78 inches, which is 91% of normal based on the 1981-2010 average SWE for the Fort Peck to Garrison subbasin. Normally by January 1, 44% of the peak snow accumulation has occurred in the mountains. In comparison, January 1, 2012 mountain snowpack was 6.13 inches in the Fort Peck subbasin and 6.71 inches in the Fort Peck to Garrison subbasin. The average January 1, 2013 SWE is 6.5 inches, while the average January 1, 2012 SWE was 6.4 inches; therefore, 2013 SWE is slightly greater than 2012 SWE.

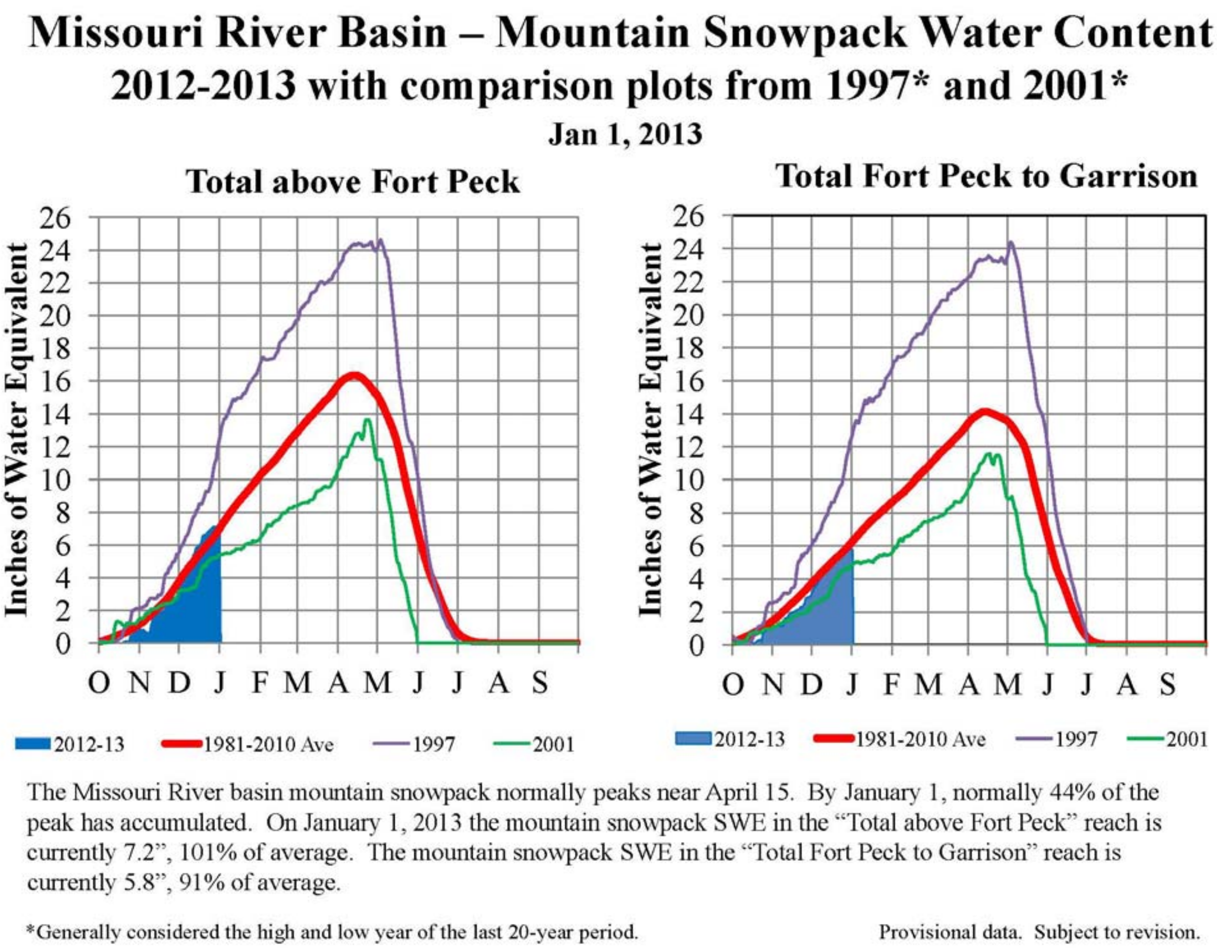

Figure 12. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

The El Nino Southern Oscillation is currently in a neutral phase, which is expected to persist into the spring of 2013. During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The Climate Prediction Center's January outlook (Figure 13) is indicating warmer than normal conditions for all areas of the basin except for Montana, northwest Wyoming, and North Dakota, where there are equal chances for above, below or normal temperatures. With regard to precipitation, there are above normal chances for above normal precipitation in much of Montana and North Dakota, and equal chances for above, below or normal precipitation in all other areas.

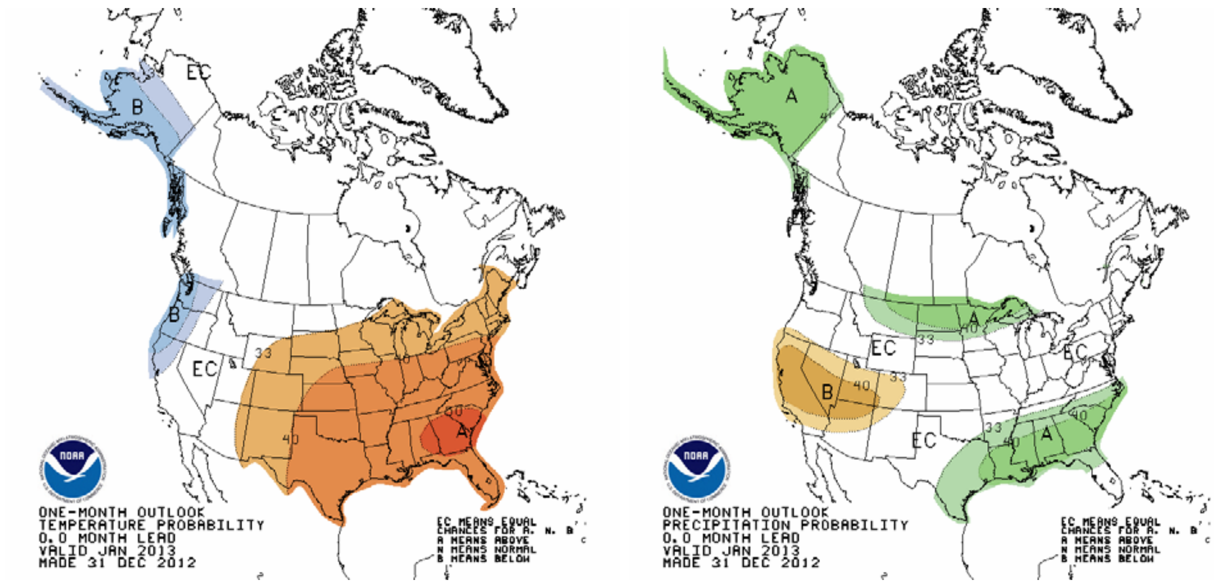

Figure 13. CPC January 2013 temperature and precipitation outlooks.

The three-month climate outlook ending in March 2013 (Figure 14) indicates cooler than normal temperatures in Montana and North Dakota, with equal chances for all other areas. In terms of precipitation, there is an increased chance for precipitation in the Northern Rockies. Looking into further into 2013, the CPC's climate outlook for April-June (Figure 15) is indicating an increased probability for above normal temperatures in much of the upper Missouri River basin with the exception of equal chances for above, below or normal temperatures in Montana, North Dakota, and northern Wyoming. In terms of precipitation, there are equal chances for above, below or normal precipitation throughout the upper Missouri River basin.

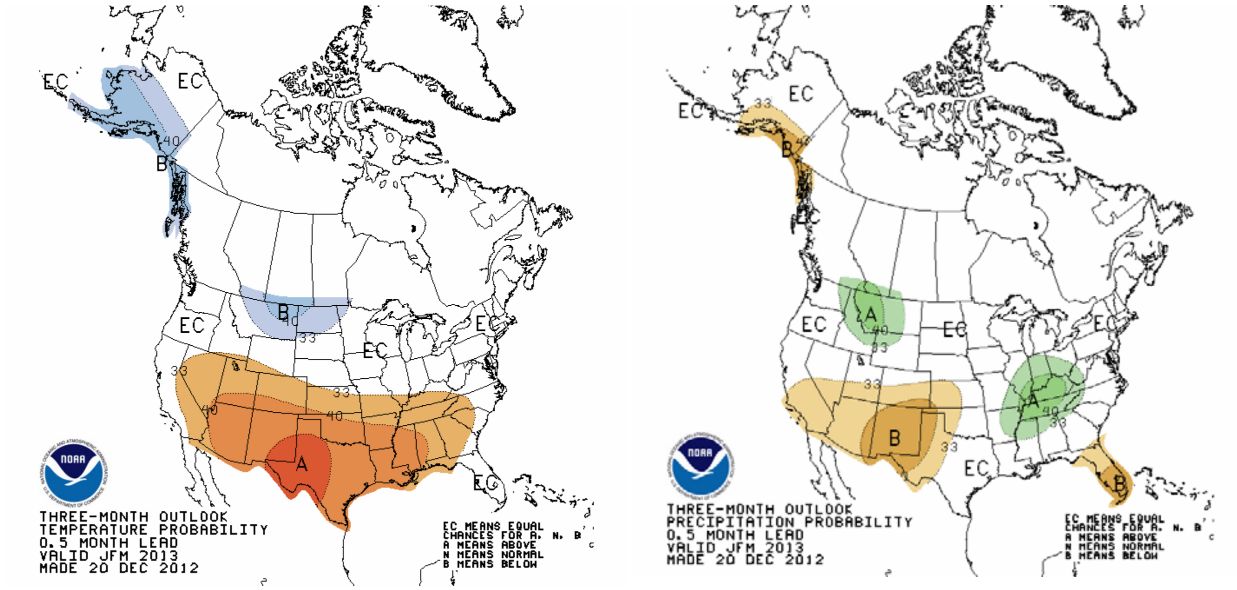

Figure 14. CPC January-February-March 2013 temperature and precipitation outlook.

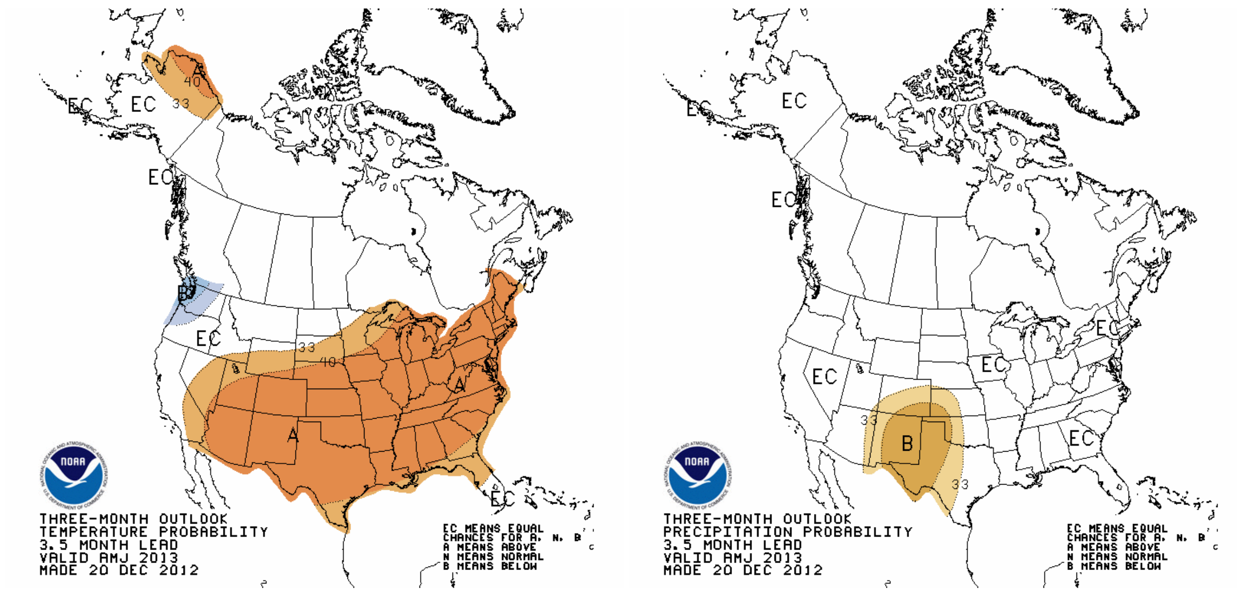

Figure 15. CPC April-May-June 2013 temperature and precipitation outlook.

Climate outlooks for July-September 2013 and October – December 2013 are provided in Figures 16 and 17. The CPC is indicating an increased probability for above normal temperatures in the upper Missouri River basin across Montana, Wyoming, western Nebraska and western South Dakota through September. The precipitation outlook indicates an increased probability for below-normal precipitation in the northern Rocky Mountains while there are equal chances for above, below and normal precipitation in the remainder of the Missouri River basin. Finally, in the October through December outlook, the CPC is indicated mostly equal chances for above, below and normal temperatures with equal chances for above, below and normal precipitation.

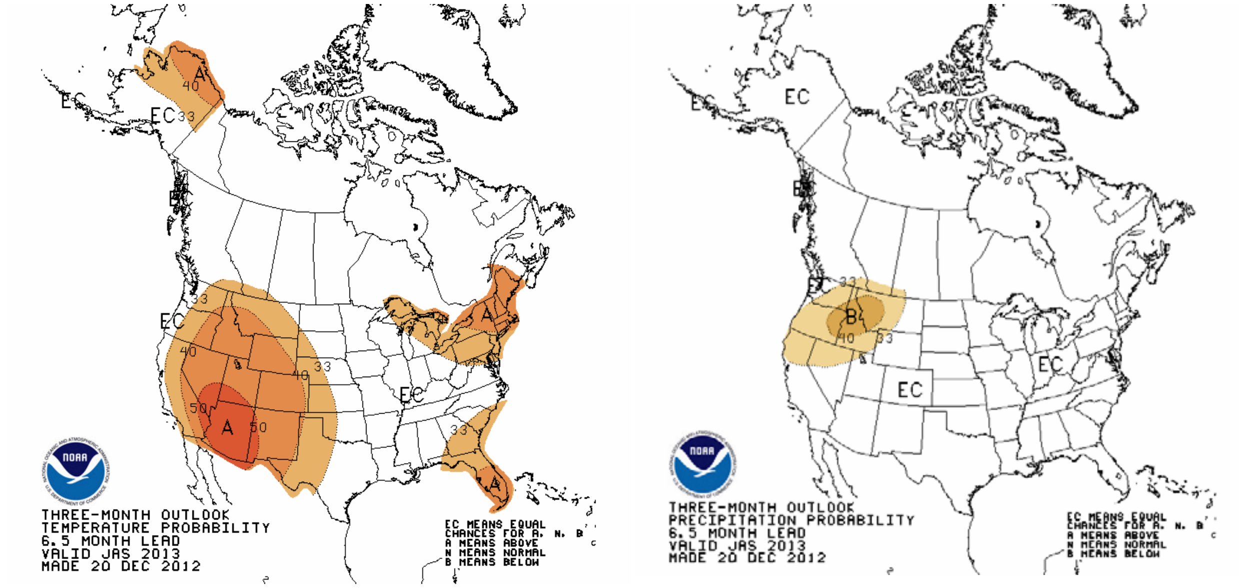

Figure 16. July-August-September 2013 temperature and precipitation outlook.

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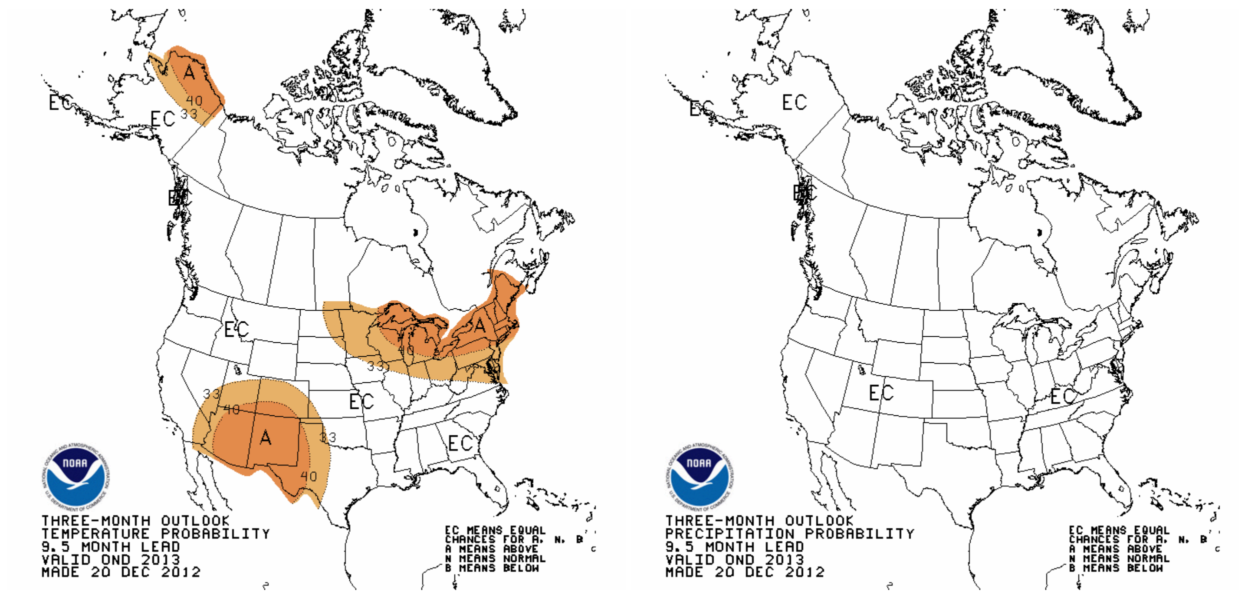


Figure 17. CPC October-November-December 2013 temperature and precipitation outlook.

January 2013 Calendar Year Runoff Forecast

The calendar year runoff forecast is 20.5 MAF (82% of average) above Sioux City and 19.2 MAF (84% of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 28.2 MAF upper basic forecast to the 13.7 MAF lower basic forecast. The upper and lower basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff. It should be noted, however, that it is possible, due to either much higher or much lower than forecasted precipitation occurring, that these ranges may be exceeded on either end.

Factors taken into consideration while preparing the 2013 forecast include: continuing drought conditions in the upper Missouri River basin, soil moisture content, antecedent precipitation, antecedent temperature conditions, plains snowpack, mountain snowpack, and the CPC's monthly and seasonal temperature and precipitation outlooks.

January-February

Runoff in Dec 2012 was 96% of average due to warmer than average temperature, which inhibited ice formation allowing more runoff to occur. During the last week of December, runoff as a percent of average was 45% above Fort Peck, 23% in the Garrison subbasin, negative percents of average in the Oahe and Fort Randall subbains, 61% of average in the Gavins Point subbasin, and 192% of average in the Sioux City subbasin. The average runoff during the last week of December, combining all subbasins, was 50% of average due to colder temperatures that prevented water from entering the system because it was frozen in ice.

Although December runoff was near normal, January-February runoff is expected to be 81 to 83% of average due to the colder conditions that have recently frozen up available tributary water. February runoff volumes are higher than January because there is an inherent chance that some snowmelt runoff will occur near the end of February with intermittent warm periods.

March-April

Plains snowpack is a significant factor influencing the volume of runoff in March and April; however, precipitation during this time period as snow and rainfall are also very important factors that need consideration. Furthermore, antecedent accumulated precipitation and antecedent soil moisture conditions have a significant influence on March-April runoff.

The current plains snowpack is "Light" (0 to 2 inches SWE) across the entire upper Missouri River basin; however, drought conditions are Severe (D2) to Exceptional (D4) in the Oahe, Fort Randall, Gavins Point and Sioux City basins, with lesser impacts in Fort Peck and Garrison subbasins. Under normal soil moisture conditions the March-April runoff under "Light" snowpack conditions would likely be above average; however, the drought conditions and soil moisture deficits are expected to reduce spring runoff.

The CPC's climate outlook indicates colder than normal temperatures from January – March in the Fort Peck, Garrison and Oahe subbasins with a higher probability for above normal precipitation in the Fort Peck and Garrison subbasins. Therefore March-April runoff is forecast to be 91% of average into Fort Peck and 79 to 85% of average into Garrison. The climate outlook is less favorable for runoff in the other reservoir reaches, therefore March-April runoff is forecast to be significantly less into Oahe, Fort Randall, Gavins Point and Sioux City.

May-June-July

During the May-June-July period, the mainstem system receives 50% of its annual runoff as a result of mountain snowmelt and spring and summer precipitation. This is the most active period for precipitation in the Missouri River Basin, so runoff can vary significantly as a result of the above or below normal rainfall.

For this 3-month period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack to runoff. Using the January 1, 2013 mountain snowpack (101% of average in the reach above Fort Peck and 91% of average in the reach between Fort Peck and Garrison) and the CPC 3-month outlooks of spring precipitation and temperatures, the May-June-July runoff is forecast to be 95% of average in the Fort Peck reach and 87% of average in the Garrison reach.

The significance of accurately forecasting the May-June-July runoff for the Fort Peck and Garrison reaches is based on the fact that, historically, an average of 9.2 MAF of runoff occurs during these 3 months into these 2 projects. That is 37% of the total annual runoff into the system.

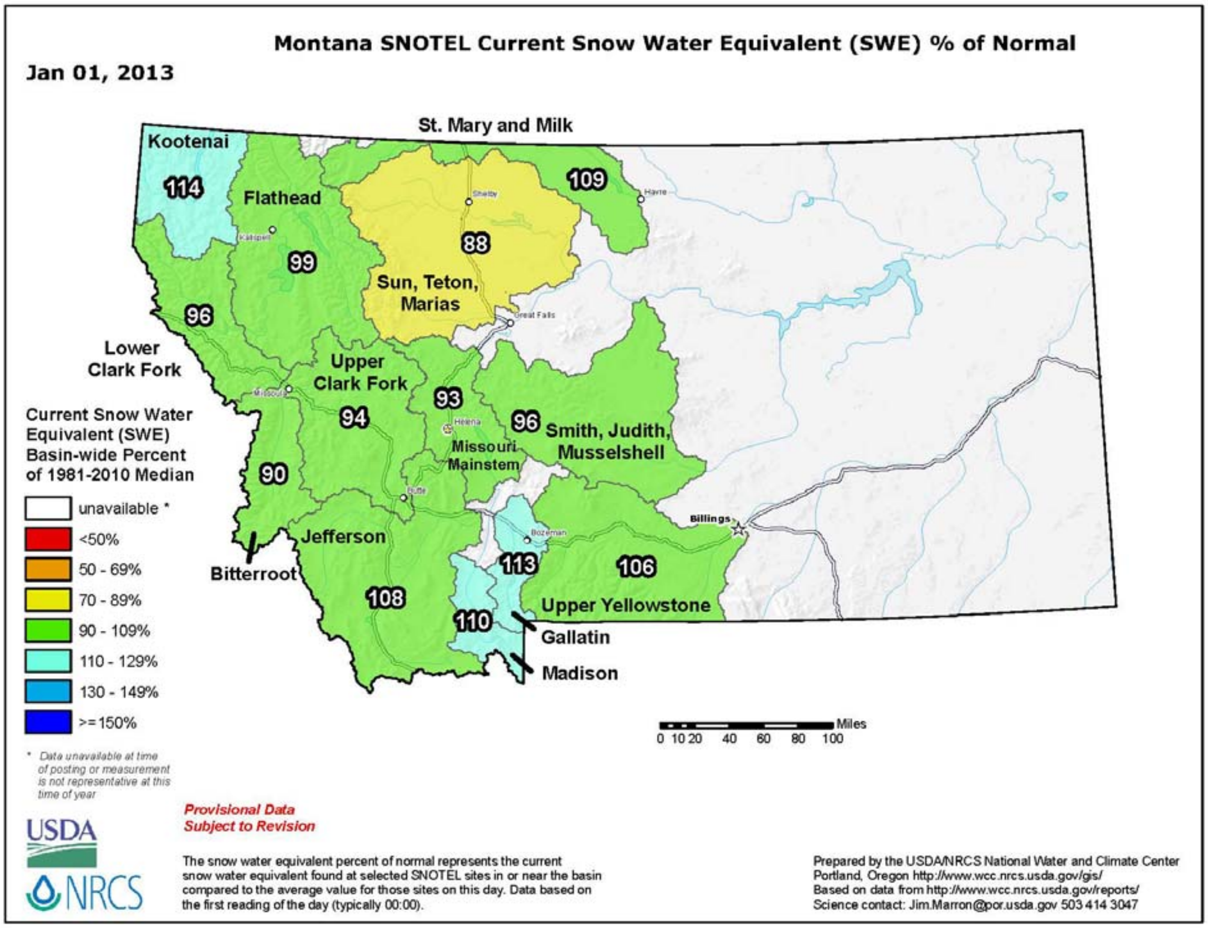
Runoff in the Oahe, Fort Randall and Gavins Point reaches is forecast to be well-below normal as drought conditions are expected to persist into the spring and summer of 2013. Soil moisture conditions will likely remain much drier than normal. The May-June-July temperature outlook indicates above normal temperatures with equal chances for above, below and normal precipitation.

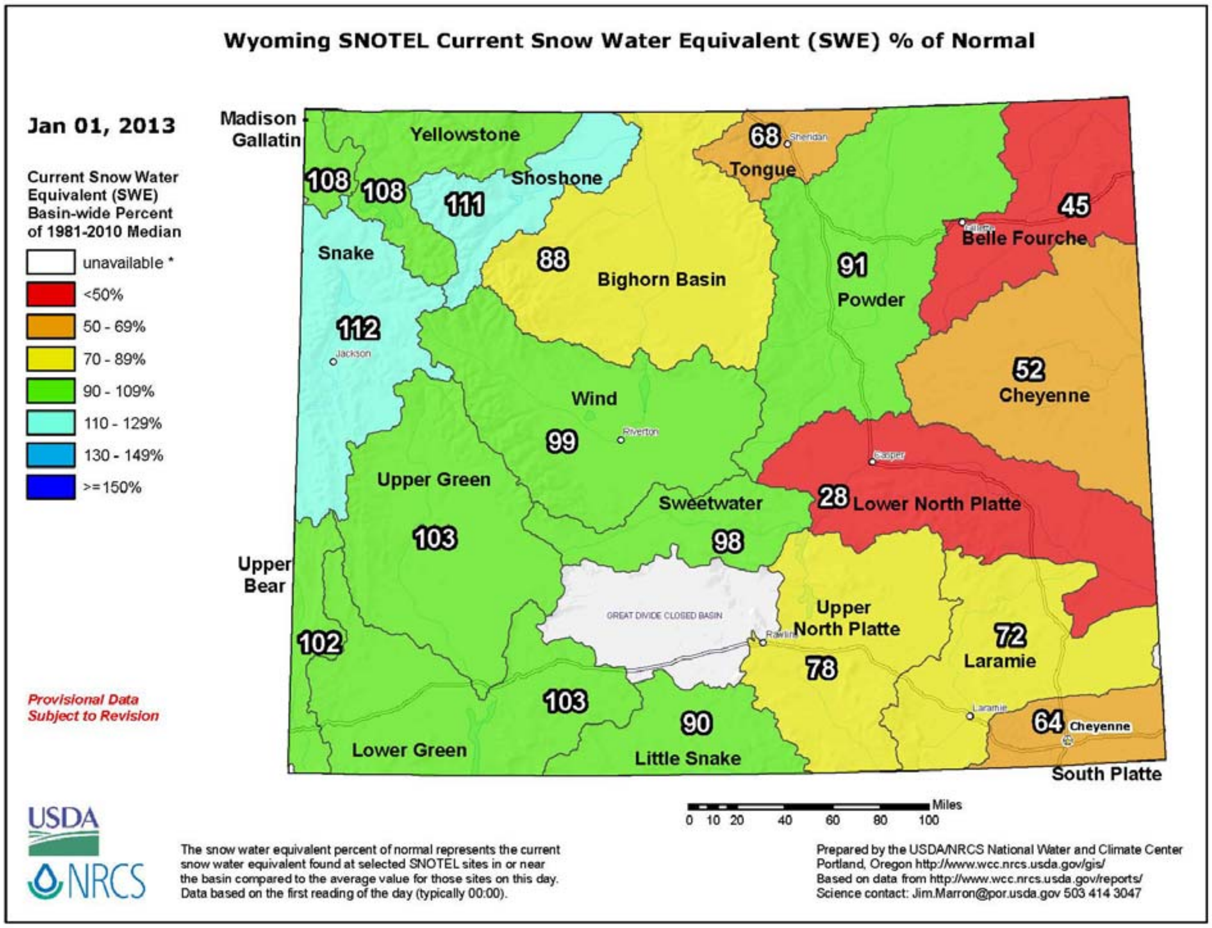
August through December

In the Fort Peck and Garrison subbasins, precipitation chances are below normal while there is an increased probability for above normal temperatures through September according to the CPC long range outlook. In October-November-December, temperature and precipitation outlooks indicate equal chances for above, below and normal conditions. Based on this outlook, runoff into Fort Peck during the August through December period is forecast to be about 87% of normal, while runoff into Garrison is expected to be about 80% of normal.

In the Oahe, Fort Randall, Gavins Point and Sioux City reaches, the precipitation and temperature outlooks indicate equal chances for above, below and normal conditions through December. Given the drought current drought conditions and the expectation that runoff will be well-below normal throughout the summer, runoff during the August through December time period will follow suit. During August through December, runoff is expected to be 81% of normal into Oahe, 82% of normal into Fort Randall, 78% of normal into Gavins Point, and 73% of normal in the Sioux City subbasin.

Additional Figures




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Jan 01, 2013
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1981-2010 Median
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison - Gallatin
Yellowstone
108
108
111
Shoshone
68
Tongue
45
Belle Fourche
Snake
88
Bighorn Basin
91
Powder
112
52
Cheyenne
Wind
99
Upper Green
Sweetwater
28
Lower North Platte
103
98
Upper Bear
GREAT DIVIDE CLOSED BASIN
Upper North Platte
72
Laramie
102
78
103
90
64
Cheyenne
Lower Green
Little Snake
South Platte
Miles
0 10 20 40 60 80 100
USDA
NRCS
The snow water equivalent percent of normal represents the current snow water equivalent found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).
Prepared by the USDA/NRCS National Water and Climate Center Portland, Oregon http://www.wcc.nrcs.usda.gov/gis/
Based on data from http://www.wcc.nrcs.usda.gov/reports/
Science contact: Jim.Marron@por.usda.gov 503 414 3047

Upper Missouri River Basin
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February 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

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2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of February 1, 2013 is 19.9 MAF (80% of normal) above Sioux City, IA. Above Gavins Point, the runoff forecast is 18.6 MAF (82% of normal). For both, this is a decrease of 0.6 MAF from the January forecast. January runoff was 0.9 MAF (114% of normal) in the upper Missouri River Basin (basin) above Sioux City, IA and 0.8 MAF (116% of normal) above Gavins Point. While last month's runoff was greater than both forecasted and normal, the annual forecast total was decreased due to decreasing mountain snowpack.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 11 months, the range of expected inflow is quite large and ranges from the 27.0 MAF upper basic forecast to the 13.6 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or "bracket" for each reach, and thus, for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

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ENSO-neutral conditions continue in the equatorial Pacific, and equatorial sea surface temperatures are near average across most of the Pacific Ocean. ENSO-neutral conditions are favored in the Northern Hemisphere through the winter of 2012-2013 and into spring 2013; therefore, there is not a strong indication of future winter temperature and precipitation conditions in the basin based on ENSO conditions.

Drought Analysis

According to the National Drought Mitigation Center (Figure 1), drought conditions impacted a large majority of the upper basin with the exception of the northern half of Montana. Abnormally Dry (D0) conditions transitioned to Severe (D2) and Extreme (D3) drought conditions in southern Montana and the Dakotas. Exceptional (D4) drought, which is the worst classification of drought according to the drought monitor, is present in southern South Dakota, eastern Wyoming and a very large portion of Nebraska. These conditions developed as a result of the record warmest calendar year and very low precipitation accumulations as indicated in Figures 2 and 3.

The U.S. Seasonal Drought Outlook shown in Figure 4 indicates drought conditions impacting the basin will persist through winter and early spring 2013. Areas that will experience drought persistence include most of Wyoming, Nebraska and western Iowa. There is potential for some improvement in eastern North Dakota, northern South Dakota, southern Montana, and northern Wyoming, where one-category improvement could occur. The Drought Outlook, though, does forecast likely improvement in eastern and southern North Dakota and some improvement in southern Montana and northern South Dakota.

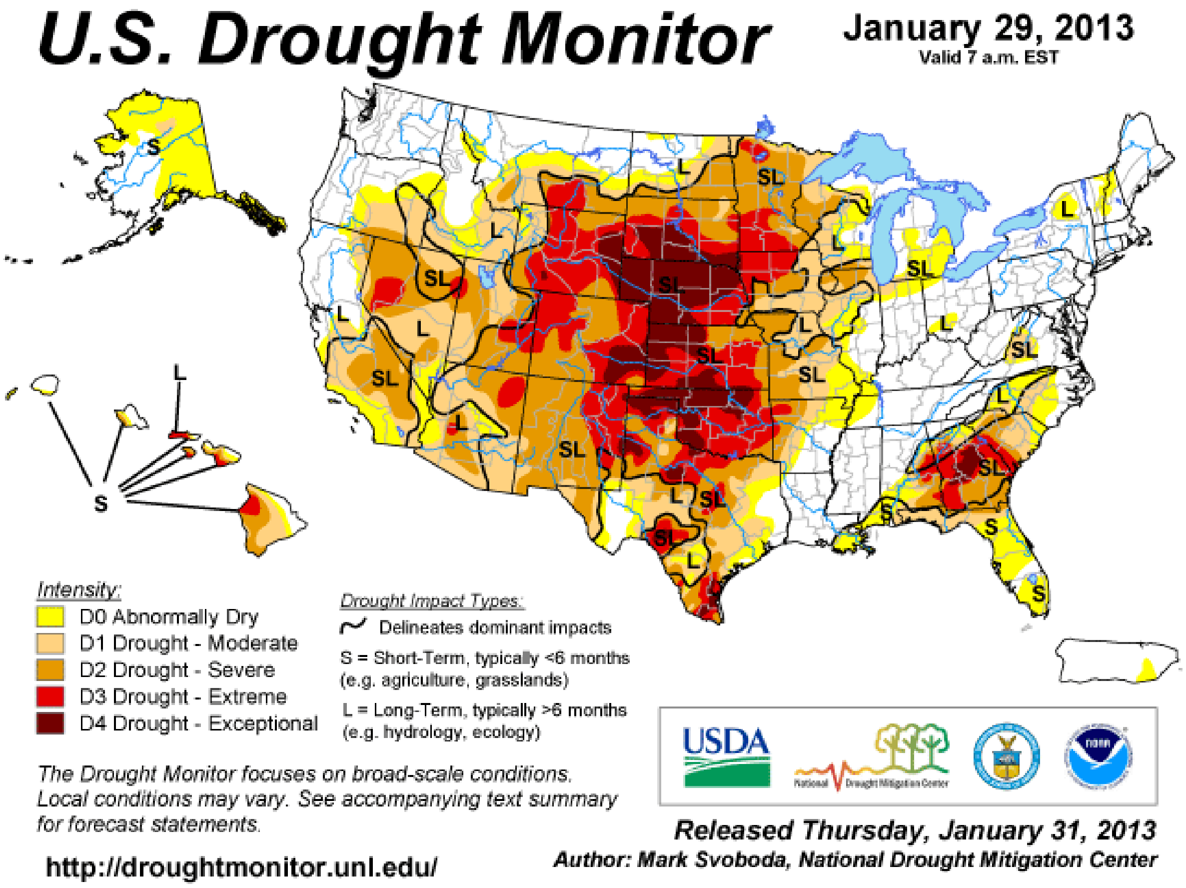


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for December 25, 2012.

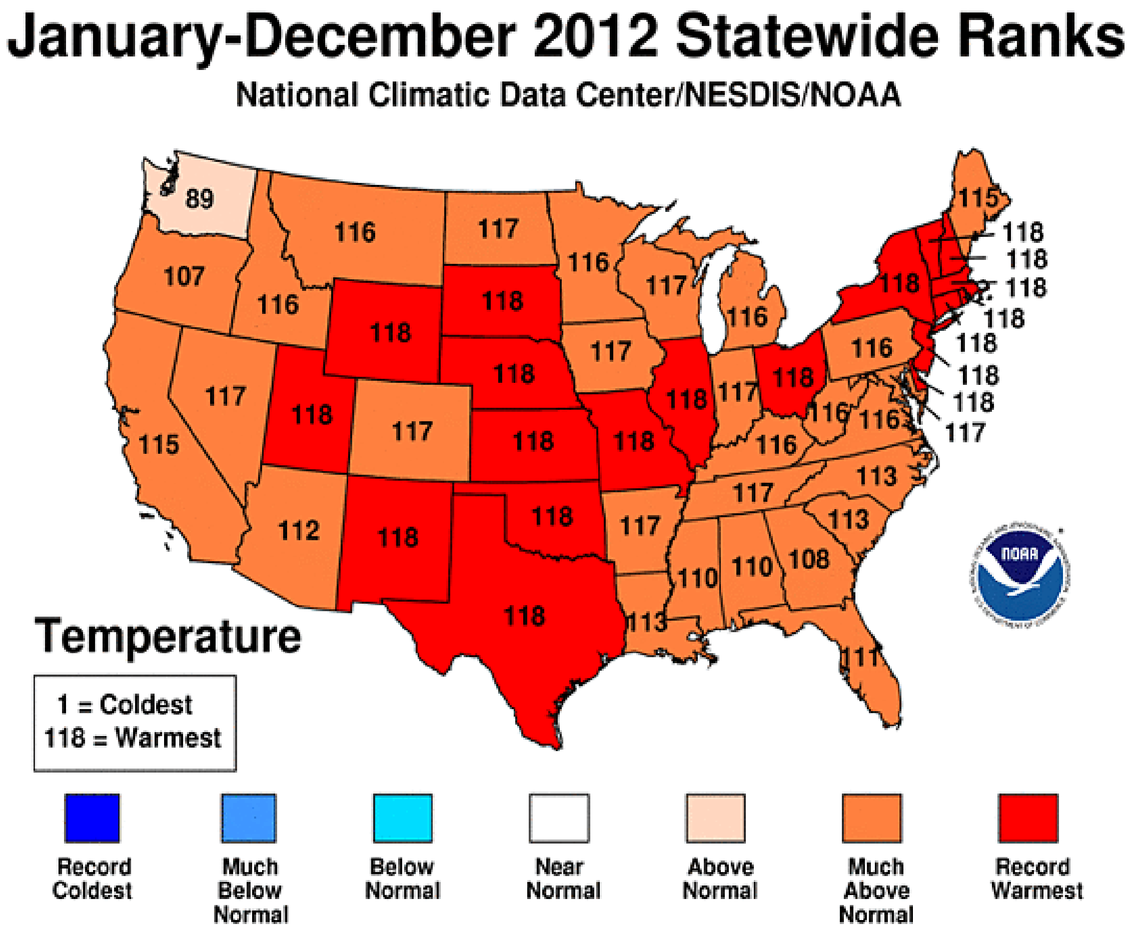


Figure 2. 2012 Temperature – Statewide Ranks

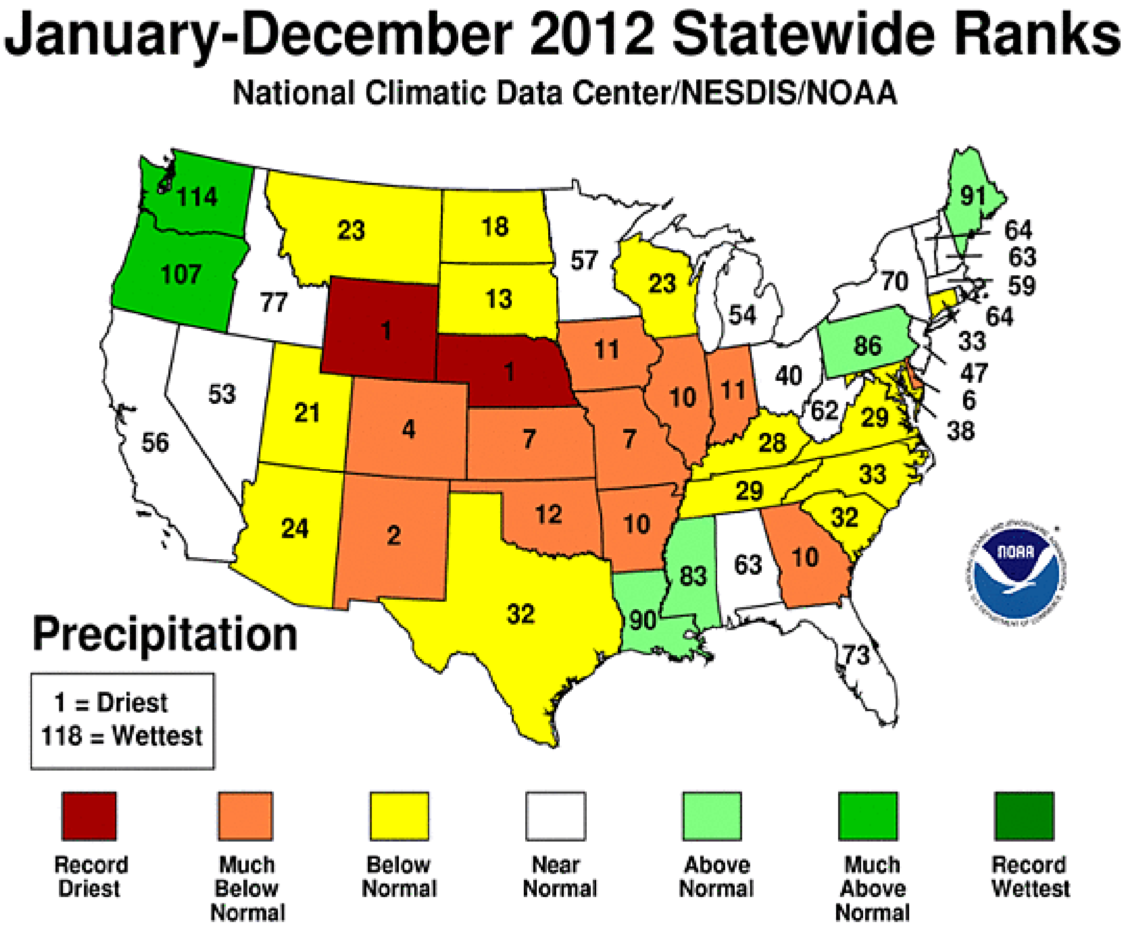


Figure 3. 2012 Precipitation – Statewide Ranks.

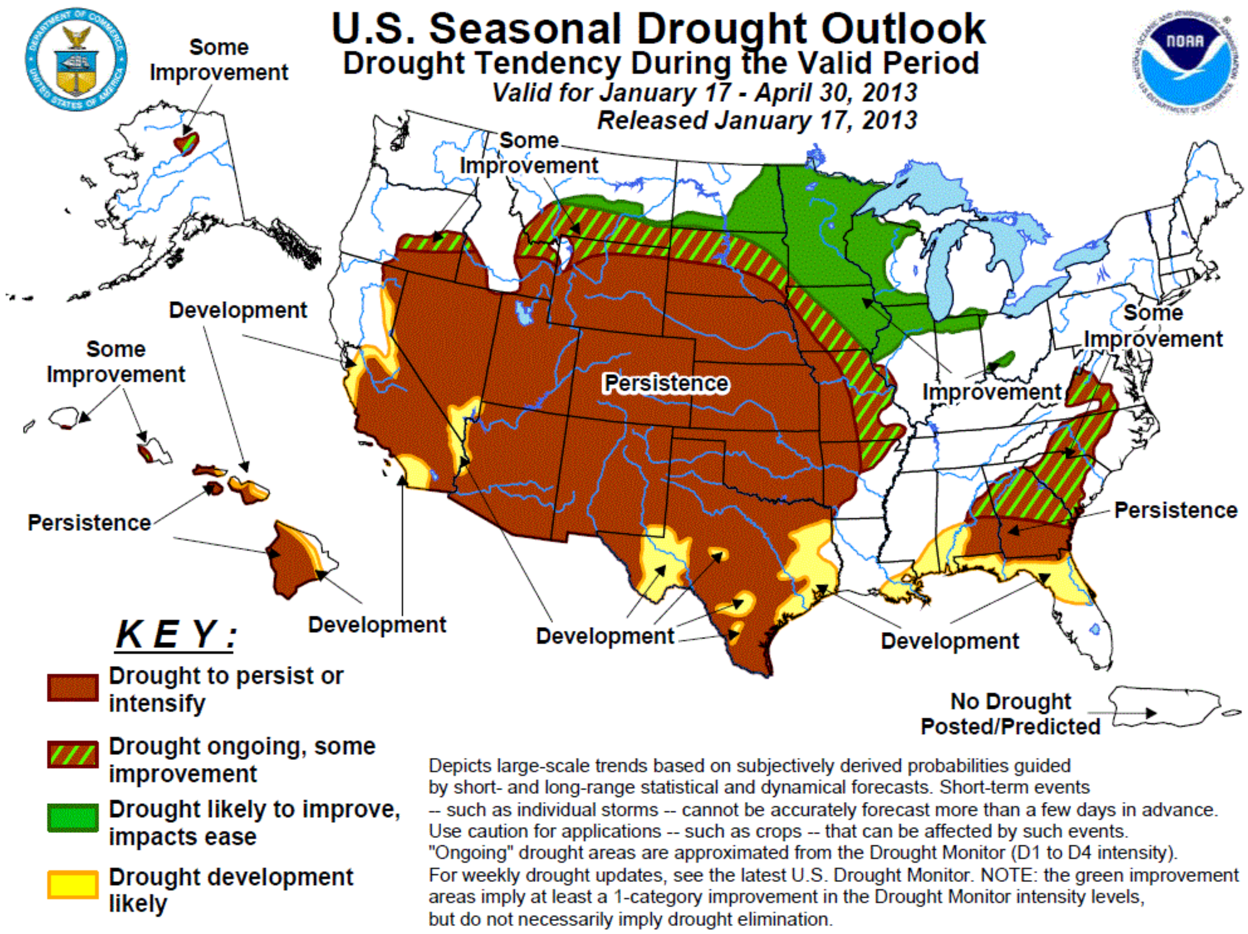


Figure 4. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of January is shown in Figure 5. While January precipitation generally has limited impact on January runoff since it generally falls as snow and does not result in immediate runoff, it was above normal in many parts of Montana and the Dakotas. In Wyoming, Nebraska and Iowa, it was mostly below normal except for a few isolated areas. Precipitation in Montana was greater than 150% of normal across the Rocky Mountain front, in northern and northeast Montana with some areas receiving up to 200% of normal. Similar amounts occurred in southern North Dakota and across South Dakota. Eastern South Dakota received over 200% of normal precipitation in January. Some areas received much less than normal precipitation in January including central and eastern Wyoming and Nebraska where precipitation was as little as 25% of normal.

Accumulated precipitation over the 90-day period ending on December 31, 2012, is shown in Figure 6. Precipitation was well below normal in all states except for Montana and localized areas of Wyoming. Most areas including South Dakota, Nebraska, western Iowa and parts of Wyoming received less than 50% of normal precipitation over the past three months, with some accumulations ranging from 10 to 25% of normal. In contrast large portions of Montana and North Dakota received greater than 150% of normal precipitation. Accumulations in excess of 200% of normal occurred in northern portions of these states.

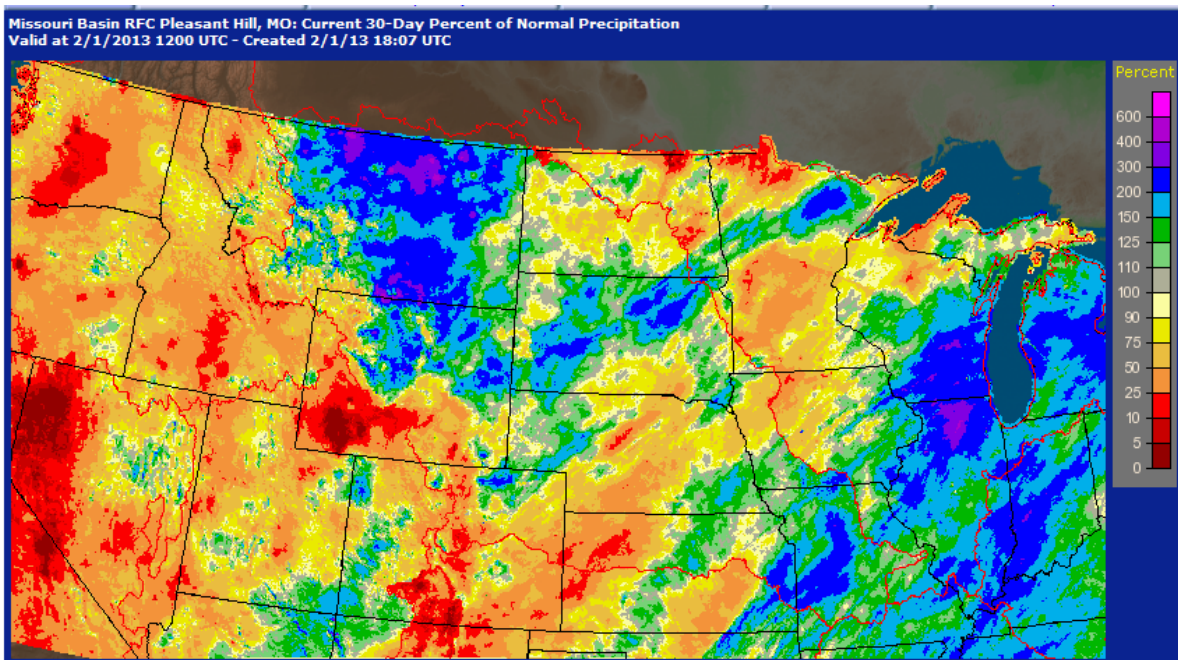


Figure 5. January 2013 Percent of Normal Precipitation.

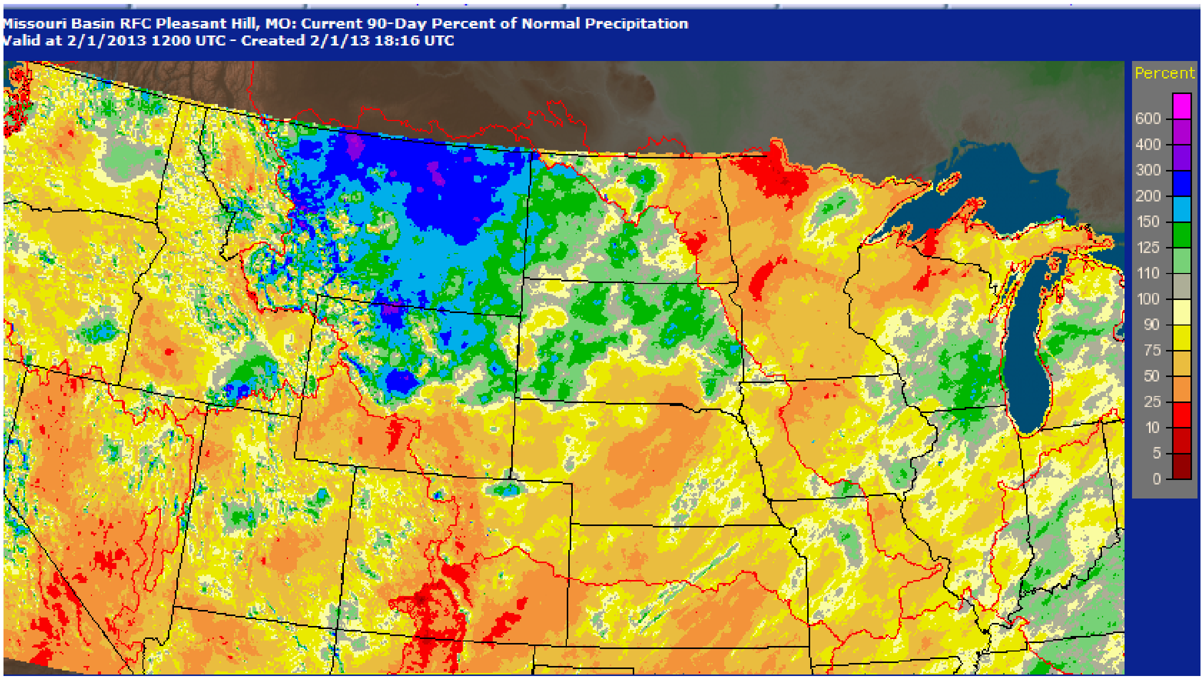


Figure 6. 90-day Percent of Normal Precipitation ending on January 31, 2013.

Temperature

Average temperatures throughout the basin above Sioux City, IA during the month of January 2013 generally ranged from 2 to 3 degrees F above normal (Figure 7).

Ninety-day (90-day) temperature departures ending on February 1, 2013 are shown in Figure 8. The map in this figure indicates that temperatures in Montana and North Dakota have generally ranged from 1 degree F below normal to 2 degrees F above normal for the basin.

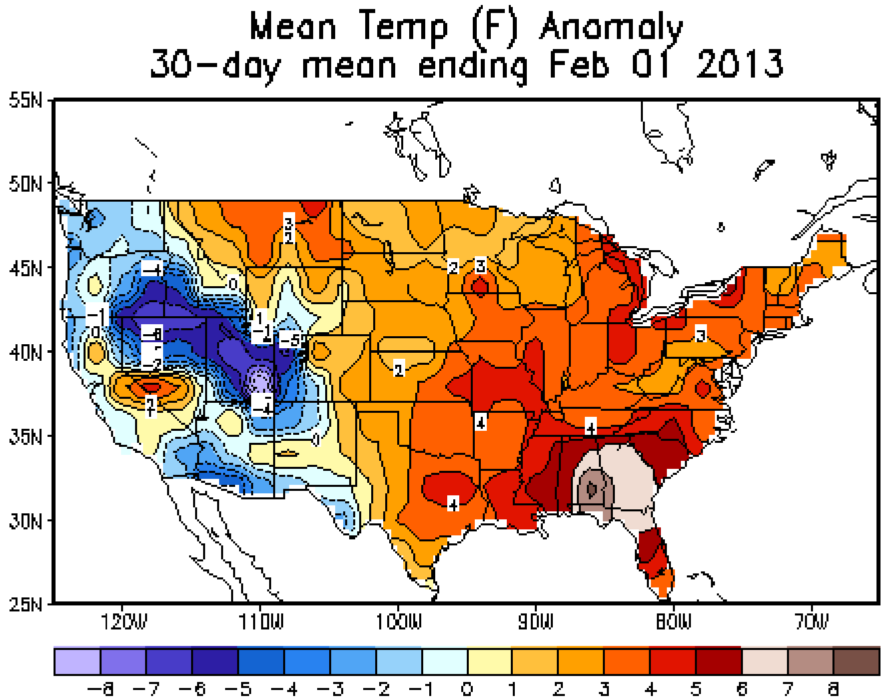


Figure 5. 30-day temperature anomaly (deg F) ending January 31, 2013.

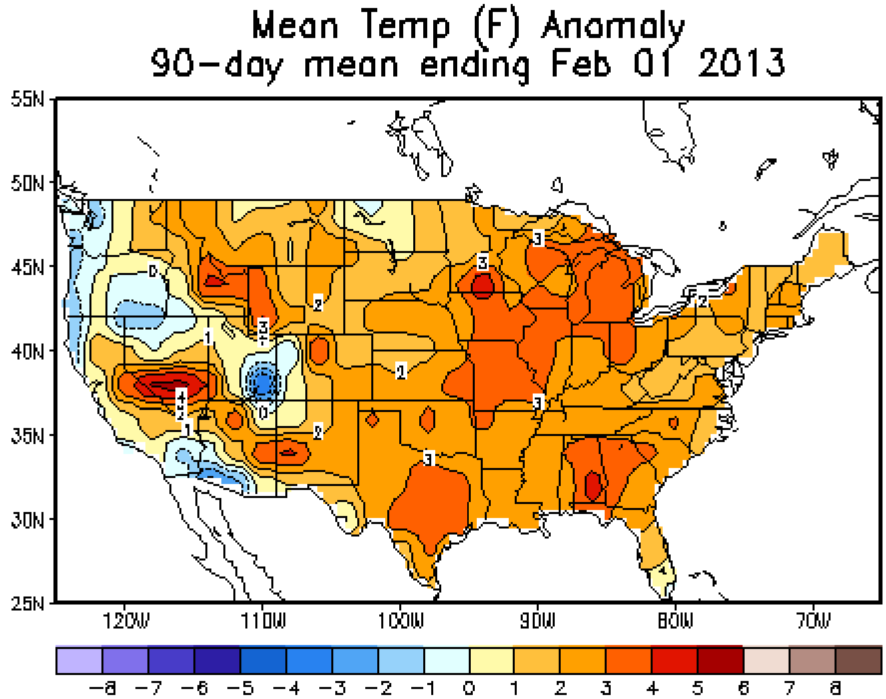


Figure 8. 90-day temperature anomaly (deg F) ending February 1, 2013.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff (e.g. baseflow).

Two independent estimates of soil moisture are presented in this report. Figure 9 shows the NOAA Climate Prediction Center's (CPC) calculated soil moisture ranking percentiles for the end of November 2012. Figure 10 shows the University of Washington's Variable Infiltration Capacity (VIC) model soil moisture percentiles.

Both soil moisture rankings depict very dry soil moisture conditions throughout the upper basin, especially in South Dakota, Nebraska, Wyoming and southern Montana. CPC soil moisture conditions in these areas rank from the 5^{th} to the 1^{st} percentile, which are exceptionally dry. In North Dakota and northern Montana, soil moisture ranges from near normal conditions down to the 10^{th} percentile. In comparison, the VIC model depicts very dry soils in the same areas with soil moisture percentiles ranking from the 5^{th} to below the 2^{nd} percentile. In our analysis of the influence of soil moisture on forecast runoff, neither model takes preference over the other. As an indicator of future monthly runoff, soil moisture conditions suggest runoff will be well-below average when considered along with the temperature and precipitation outlooks, which were discussed previously in this forecast discussion.

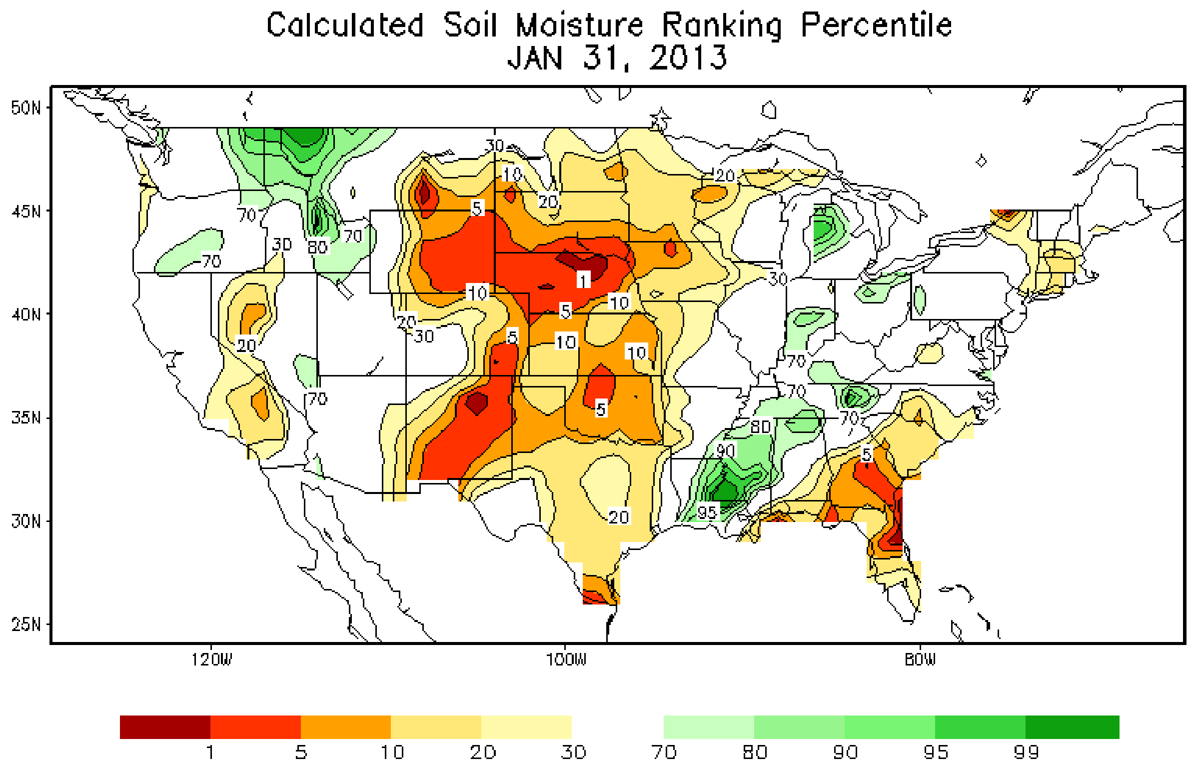


Figure 9. Calculated Soil Moisture Ranking Percentile on January 31, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

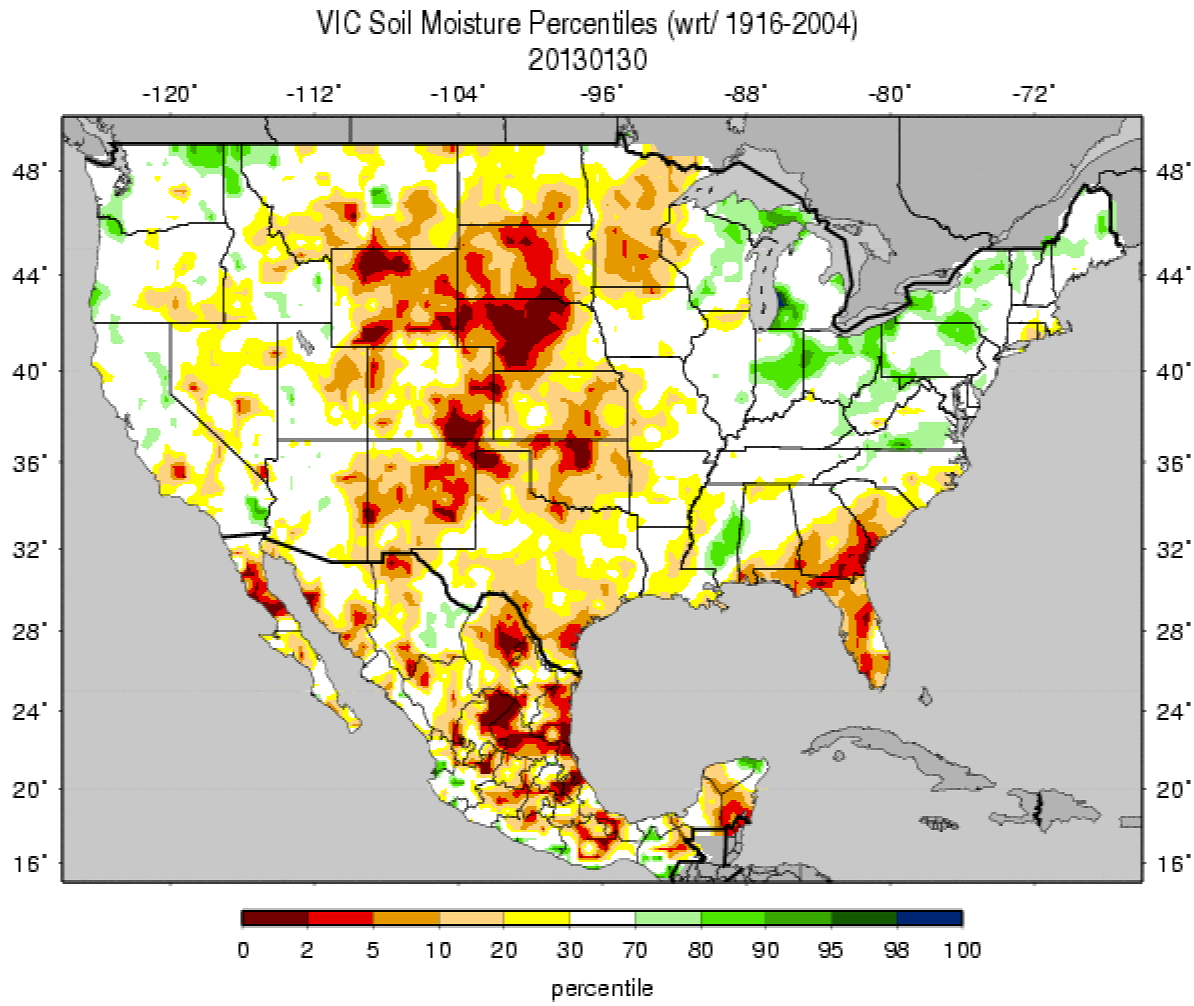


Figure 10. VIC modeled soil moisture percentiles as of December 31, 2012. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

The CPC calculated soil moisture anomaly for the contiguous U.S. on January 31, 2013 is shown in Figure 11. According to the analysis, there are widespread negative soil moisture anomalies in the basin; however some areas in Montana and North Dakota have positive anomalies or are normal. Negative anomalies would indicate a soil moisture deficit or negative departure from normal. Negative anomalies range from -20 mm (about 1.0 inch) to –120 mm (about 5 inches) in the upper basin.

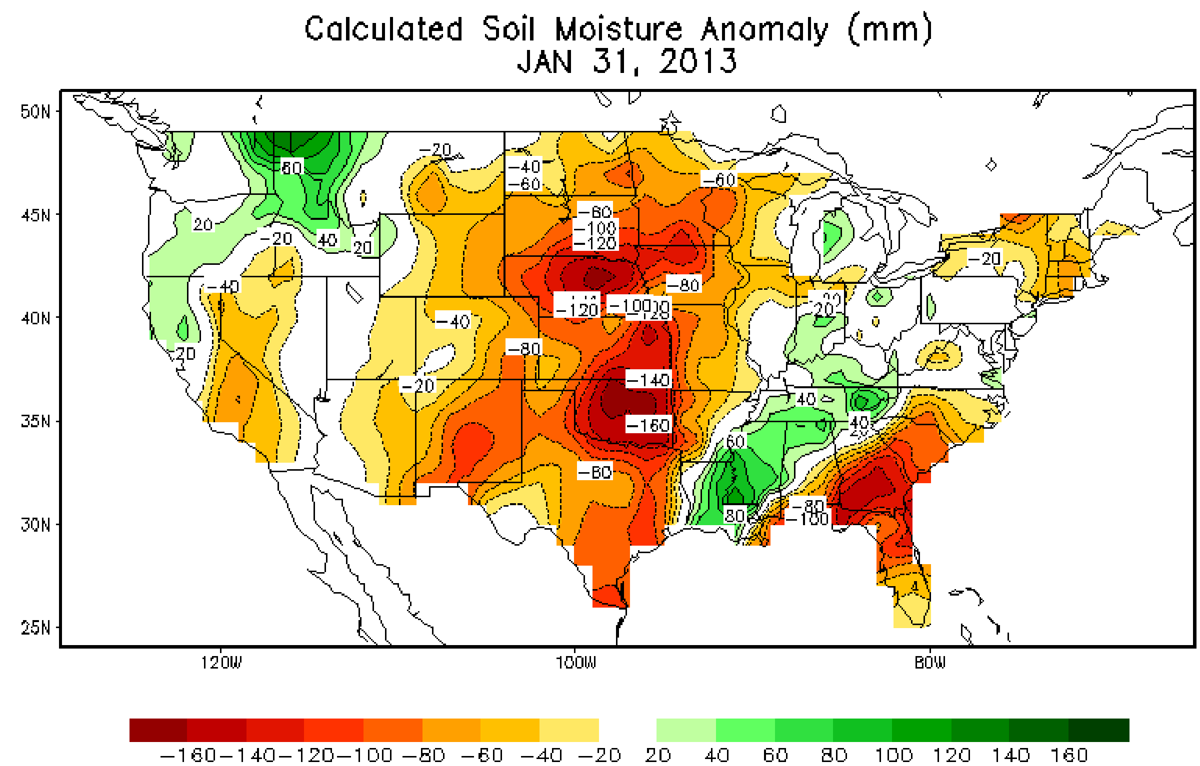


Figure 11. Calculated Soil Moisture Anomaly (bottom) in on 1 January 2013. Source: Climate Prediction Center. [**http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#**](http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#)

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

According to the NOAA National Operational Hydrologic Remote Sensing Center (NOHRSC), most plains snow water equivalent (SWE) amounts ranged from trace to 4-inch amounts throughout the upper basin. Amounts ranging from 1 to 2 inches cover a majority of eastern

Montana, North Dakota, and less than half of South Dakota. Amounts less than 1 inch cover all remaining plains areas of the basin, as shown on Figure 12.

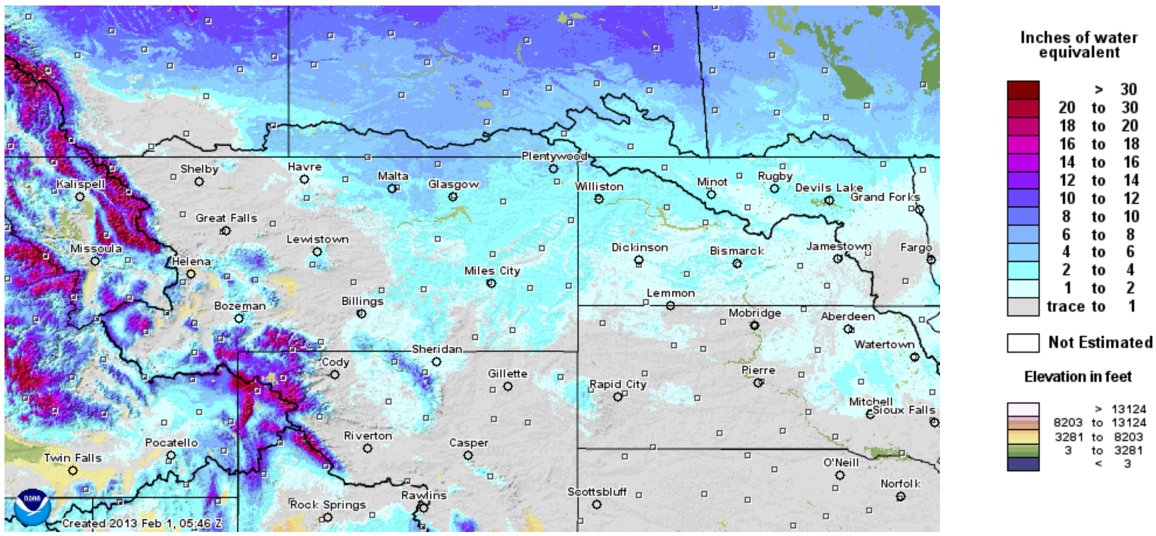


Figure 12 February 1, 2013, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Plains snowpack as of February 1, 2013 was classified as predominantly Light across the upper Missouri River basin according to the Corps of Engineers classification methods (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0 to 1 inch of snow water equivalent (SWE) in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins. In the Garrison and Sioux City subbasins, this includes accumulations ranging from 0 to 2 inches of SWE.

Table 1. January 1, 2012 plains snowpack classification for runoff forecasting.

Reservoir Reach	Plains Snowpack Classification
Above Fort Peck	Light (0 – 1 inch SWE)
Fort Peck to Garrison	Light (0 – 2 inch SWE)
Garrison to Oahe	Light (0 – 1 inch SWE)
Oahe to Fort Randall	Light (0 – 1 inch SWE)
Fort Randall to Gavins Point	Light (0 – 1 inch SWE)
Gavins Point to Sioux City	Light (0 – 2 inch SWE)

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50% of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. As of February 1, 2013, (see Figure 13) the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 9.4 inches, which is 92% of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 7.3 inches, which is 84% of normal based on the 1981-2010 average SWE for the Fort Peck to Garrison subbasin. Normally by February 1, 64% of the peak snow accumulation has occurred in the mountains.

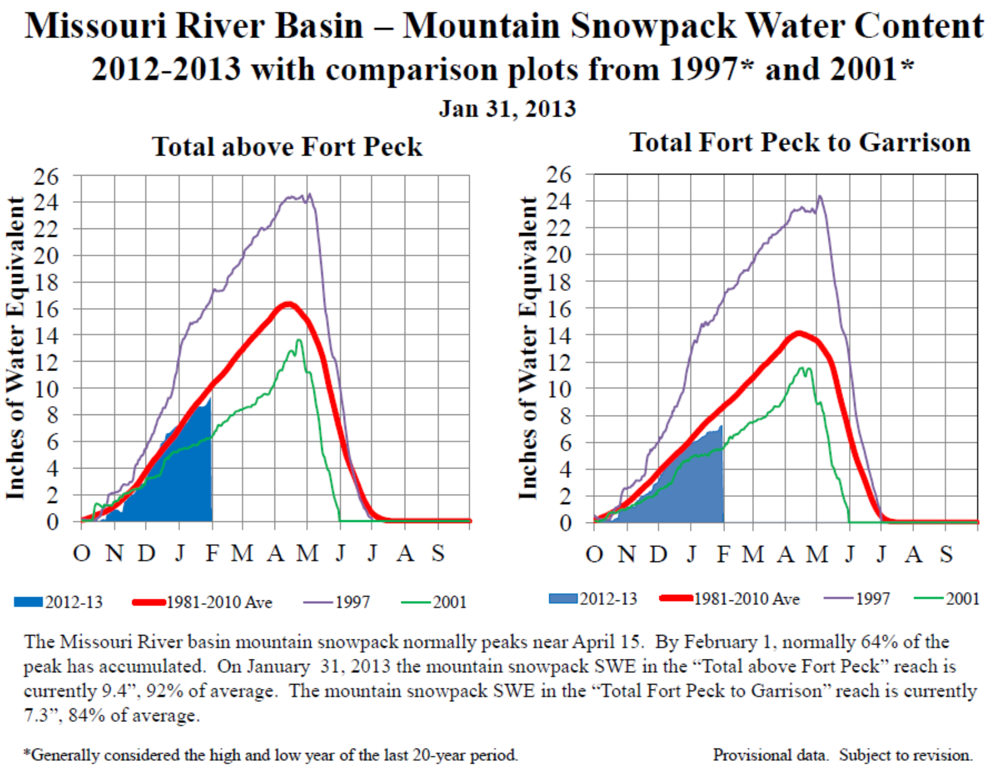


Figure 12. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

The El Nino Southern Oscillation is currently in a neutral phase, which is expected to persist into the spring of 2013. During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The CPC's February outlook (Figure 14) is indicating are equal chances for above, below or normal temperatures warmer than normal throughout the upper basin. With regard to precipitation, there are above normal chances for above normal precipitation in much of North Dakota, and equal chances for above, below or normal precipitation in all other areas.

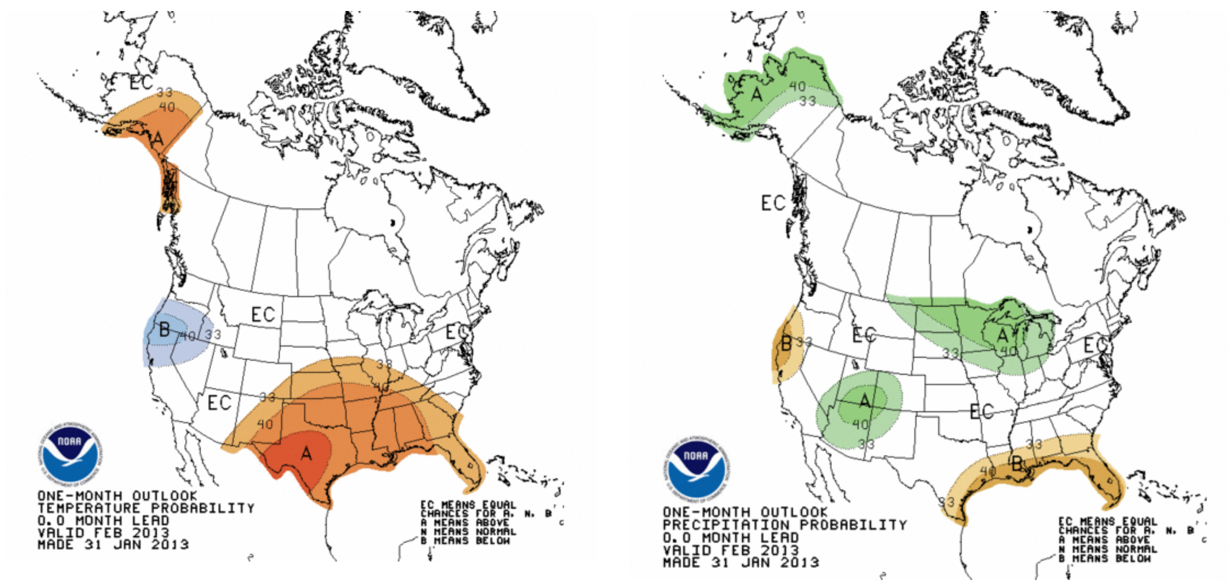


Figure 14. CPC February 2013 temperature and precipitation outlooks.

The CPC's 3-month outlooks (see Figure 15 and 16) are indicating below normal temperatures in eastern Montana and North Dakota and above chances of precipitation for the eastern two-thirds of the upper basin. For the remainder of 2013, the outlook indicates warmer temperatures throughout the basin combined with equal chances of above/below/normal precipitation.

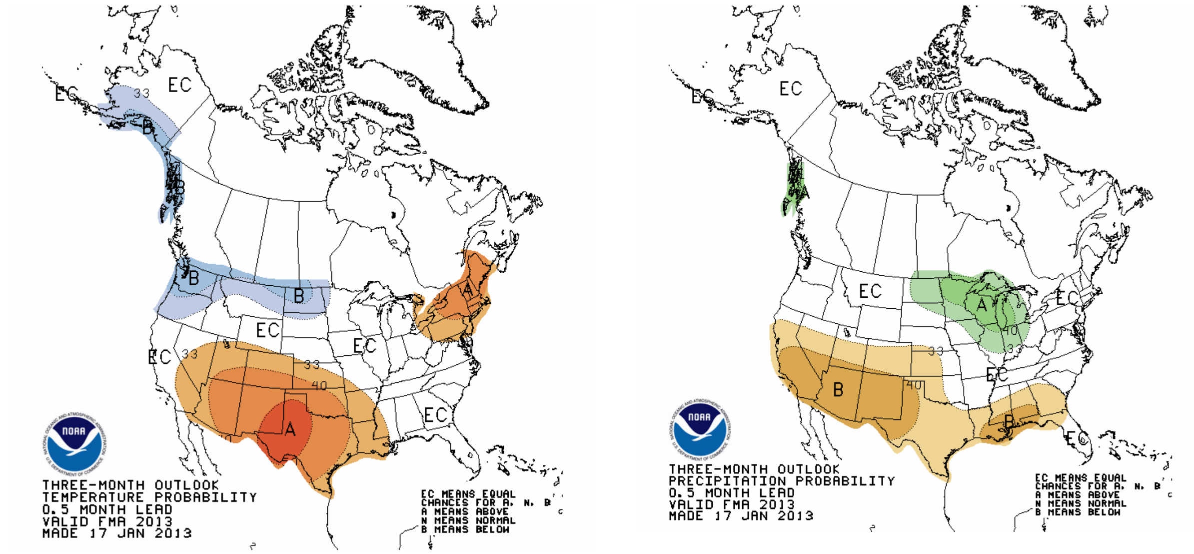


Figure 15. CPC February-March-April 2013 temperature and precipitation outlook.

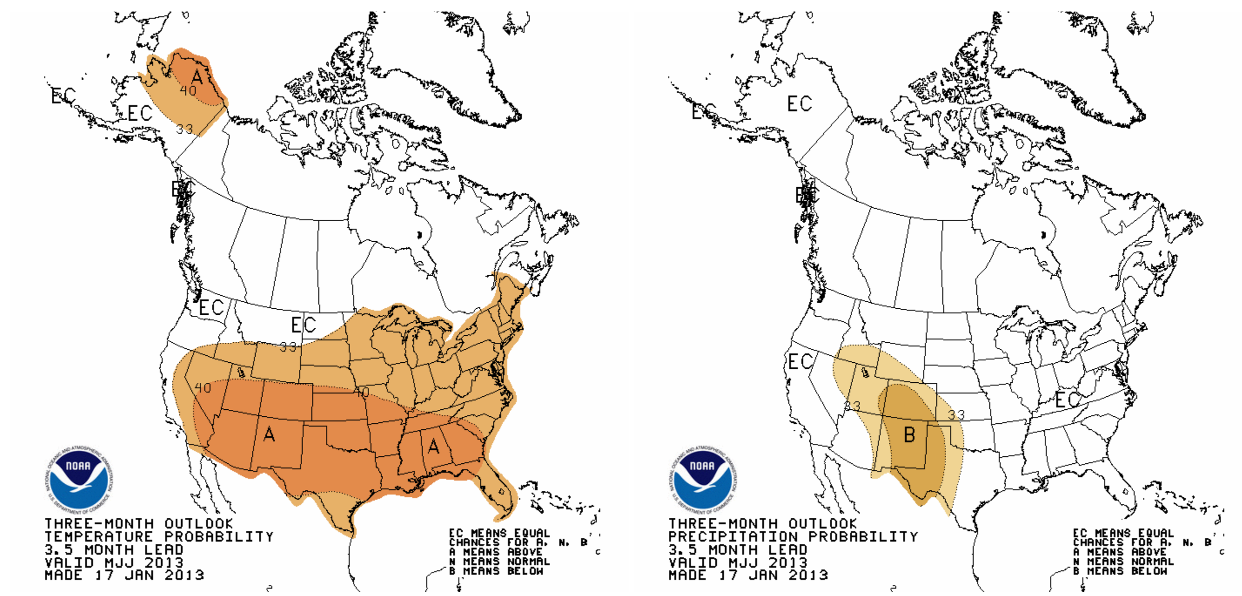


Figure 16. CPC May-June-July 2013 temperature and precipitation outlook.

February 2013 Calendar Year Runoff Forecast

The calendar year runoff forecast is 19.9 MAF (80% of average) above Sioux City and 18.6 MAF (82% of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 27.0 MAF upper basic forecast to the 13.6 MAF lower basic forecast. The upper and lower basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff. It should be noted, however, that it is possible, due to either much higher or much lower than forecasted precipitation occurring, that these ranges may be exceeded on either end.

Factors taken into consideration while preparing the 2013 forecast include continuing drought conditions in the upper Missouri River basin, soil moisture content, antecedent precipitation, antecedent temperature conditions, plains snowpack, mountain snowpack, and the CPC's monthly and seasonal temperature and precipitation outlooks.

USDA NRCS National Water & Climate Center

* - DATA CURRENT AS OF: February 04, 2013 07:46:24 PM

- Based on February 01, 2013 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	97	100	112	103	91	82	97
	APR-SEP	114	102	129	120	108	99	112
St. Mary R at Int'l Boundary (2)	APR-JUL	440	101	540	480	400	340	435
	APR-SEP	500	99	600	540	460	400	505
Lima Reservoir Inflow (2)	APR-JUL	84	102	117	97	71	51	82
	APR-SEP	91	102	129	107	75	53	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	101	100	188	136	66	13.7	101
	APR-SEP	121	101	215	159	83	26	120
Jefferson R nr Three Forks (2)	APR-JUL	650	88	1030	800	500	275	740
	APR-SEP	695	87	1120	865	525	275	800
Hebgen Reservoir Inflow (2)	APR-JUL	360	97	430	390	330	290	370
	APR-SEP	460	98	545	495	425	375	470
Ennis Reservoir Inflow (2)	APR-JUL	595	95	745	655	535	445	625
	APR-SEP	735	95	910	805	665	560	775
Missouri R at Toston (2)	APR-JUL	1690	94	2330	1950	1430	1050	1790
	APR-SEP	1940	94	2700	2250	1630	1180	2070
Smith R bl Eagle Ck (2)	APR-JUL	110	104	163	131	89	57	106
	APR-SEP	122	105	183	147	97	61	116
Gibson Reservoir Inflow (2)	APR-JUL	380	96	475	420	340	285	395
	APR-SEP	420	95	520	460	380	320	440
Marias R nr Shelby (2)	APR-JUL	340	99	520	410	270	161	345
	APR-SEP	345	96	535	420	270	156	360
Milk R at Western Crossing	MAR-JUL	38	103	63	48	28	13.3	37
	MAR-SEP	41	105	68	52	30	14.1	39
	APR-JUL	31	100	53	40	22	9.1	31
	APR-SEP	34	103	58	44	24	9.9	33
Milk R at Eastern Crossing	MAR-JUL	60	107	126	87	33	1.50	56
	MAR-SEP	69	110	141	98	40	1.50	63
	APR-JUL	47	104	101	69	25	1.50	45
	APR-SEP	59	107	120	84	34	1.50	55

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	53	90	61	56	50	45	59
	APR-SEP	68	92	79	72	64	57	74
Wind R ab Bull Lake Ck (2)	APR-JUL	360	90	495	415	305	225	400
	APR-SEP	440	90	580	495	385	300	490
Bull Lake Ck nr Lenore	APR-JUL	126	91	158	139	113	94	139
	APR-SEP	155	92	196	171	139	114	169
Boysen Reservoir Inflow (2)	APR-JUL	495	81	900	660	330	90	610
	APR-SEP	540	81	975	715	365	103	665
Greybull R nr Meeteetse	APR-JUL	122	93	157	136	108	87	131

	APR-SEP	167	94	210	184	150	124	177
Shell Ck nr Shell	APR-JUL	48	87	63	54	42	33	55
	APR-SEP	60	91	76	67	53	44	66
Bighorn R at Kane (2)	APR-JUL	685	82	1200	895	475	167	840
	APR-SEP	735	81	1290	960	510	179	905
NF Shoshone R at Wapiti	APR-JUL	445	97	530	480	410	360	460
	APR-SEP	495	96	585	530	460	405	515
SF Shoshone R nr Valley	APR-JUL	200	93	240	215	183	158	215
	APR-SEP	230	94	275	250	210	183	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	635	94	775	690	580	495	675
	APR-SEP	700	94	850	760	640	550	745
Bighorn R nr St. Xavier (2)	APR-JUL	1180	86	1790	1430	930	565	1380
	APR-SEP	1250	86	1930	1520	975	570	1460
Little Bighorn R nr Hardin	APR-JUL	65	66	113	84	46	17.1	98
	APR-SEP	73	66	126	94	52	20	111
Tongue R nr Dayton (2)	APR-JUL	65	76	96	78	52	34	86
	APR-SEP	74	76	107	87	61	41	98
Tongue River Reservoir Inflow (2)	APR-JUL	125	65	230	168	82	17.9	193
	APR-SEP	141	66	255	186	96	29	215
NF Powder R nr Hazelton	APR-JUL	10.0	110	12.5	11.0	9.0	7.5	9.1
	APR-SEP	10.9	110	13.5	12.0	9.8	8.3	9.9
Powder R at Moorhead	APR-JUL	152	86	250	193	111	52	177
	APR-SEP	174	89	275	215	132	71	196
Powder R nr Locate	APR-JUL	171	86	295	220	121	47	199
	APR-SEP	195	89	330	250	141	62	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAR-JUL	5.3	85	9.4	7.0	3.6	1.20	6.2
	APR-JUL	4.3	83	7.6	5.5	3.2	1.94	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	21	84	40	29	13.4	2.2	25
	APR-JUL	17.1	78	35	24	11.6	5.5	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

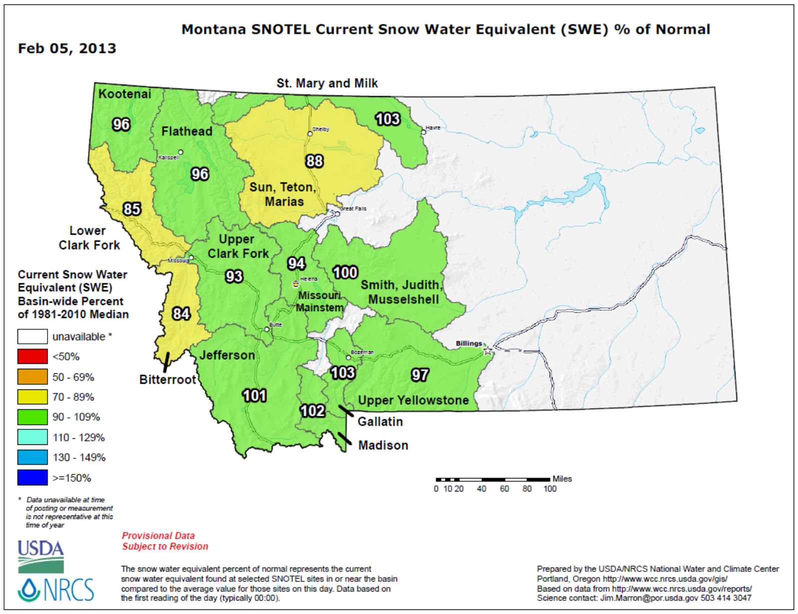
Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate	APR-JUL	112	50	230	159	65	15.0	225
	APR-SEP	123	49	250	175	71	20	250
Encampment R nr Encampment	APR-JUL	97	75	143	116	78	51	129
	APR-SEP	103	75	151	122	84	55	138
Rock Ck nr Arlington	APR-JUL	35	71	52	42	28	18.2	49
	APR-SEP	37	71	55	44	30	18.9	52
Seminoe Reservoir Inflow (2)	APR-JUL	395	55	805	560	230	158	715
	APR-SEP	425	55	865	600	250	170	770
Sweetwater R nr Alcova	APR-JUL	31	53	67	46	16.3	2.5	59
	APR-SEP	36	56	75	52	20	4.2	64
North Platte R-Alcova to Orin Gain	APR-JUL	-4.0	-3	134	52	-23	-60	136
	APR-SEP	-1.00	-1	142	57	-23	-59	144
North Platte R bl Glendo Res (2)	APR-JUL	385	47	650	490	280	150	820
	APR-SEP	385	45	665	495	275	150	850
North Platte R bl Guernsey Res (2)	APR-JUL	375	46	705	510	240	150	820
	APR-SEP	390	46	730	530	250	150	850
Laramie R nr Woods	APR-JUL	80	70	119	96	64	41	115
	APR-SEP	88	70	130	105	71	46	126
Little Laramie R nr Filmore	APR-JUL	33	65	52	41	25	14.3	51

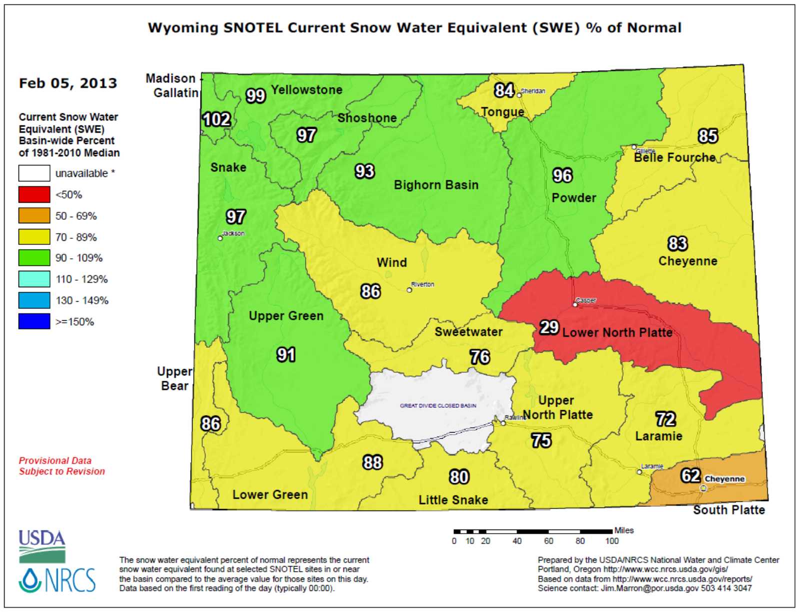
APR-SEP	36	65	57	44	28	15.2	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Additional Figures





Upper Missouri River Basin
Calendar Year Runoff Forecast
March 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of March 1, 2013 is 20.0 MAF (81 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 18.7 MAF (82 percent of normal). For both, this is an increase of 0.1 MAF from the February forecast. February runoff was 1.1 MAF (97 percent of normal) in the upper Missouri River Basin (Basin) above Sioux City, IA and 1.0 MAF (106 percent of normal) above Gavins Point Dam.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 10 months, the range of expected inflow is quite large and ranges from the 26.9 MAF upper basic forecast to the 13.8 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

According to the National Drought Mitigation Center's (NDMC) U.S. Drought Monitor (Figure 1), drought conditions impact much of the upper Basin with the exception of the northern half of Montana and northwest North Dakota. Abnormally Dry (D0) conditions transition to Severe (D2) and Extreme (D3) drought conditions in southern Montana and the Dakotas. Exceptional (D4) drought, which is the worst classification of drought, is present in southern South Dakota, eastern Wyoming and a very large portion of Nebraska. These conditions developed as a result of the record warmest calendar year and very low precipitation accumulations as indicated in Figures 2 and 3 of the February 2013 calendar year forecast narrative. Compared to the January 29, 2013 drought conditions shown in Figure 2, February 26, 2013 conditions improved in southern Montana, northeast South Dakota, eastern Kansas and western Missouri due to above normal precipitation in these areas. The U.S. Seasonal Drought Outlook shown in Figure 3 indicates drought conditions impacting the Basin will persist through spring 2013; however, areas in Montana, North Dakota, South Dakota, Iowa and Missouri are expected to have some limited improvement.

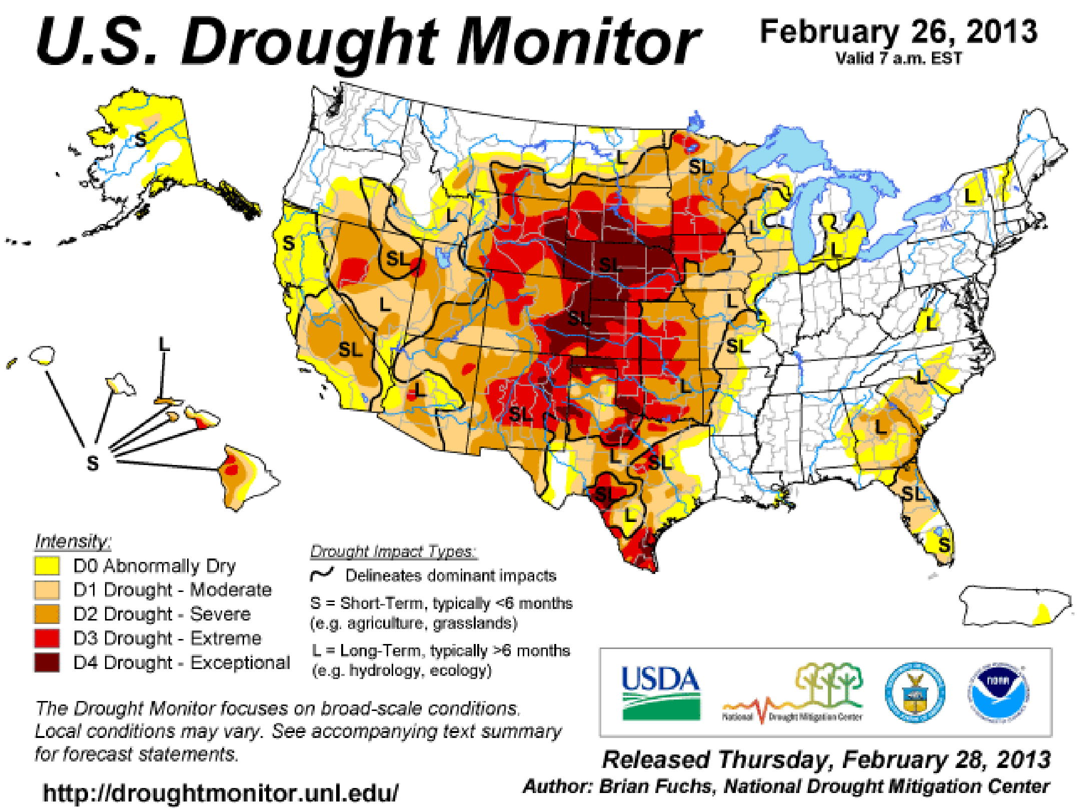


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for February 26, 2013.

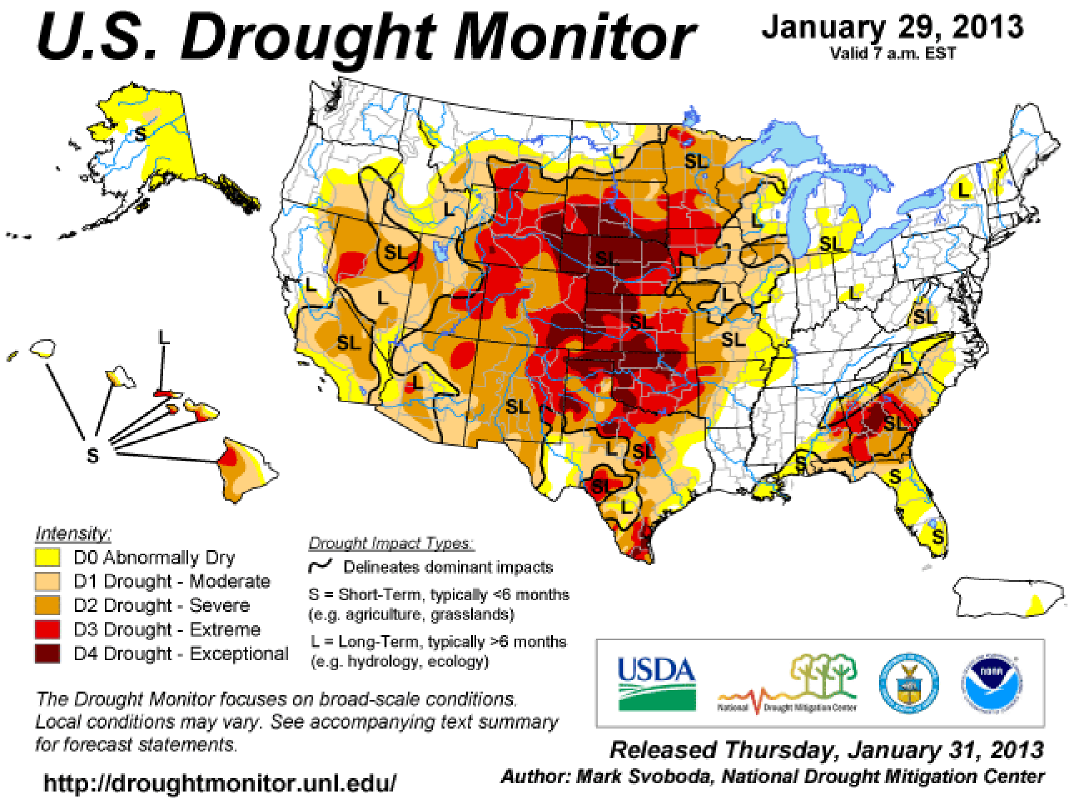


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for January 29, 2013.

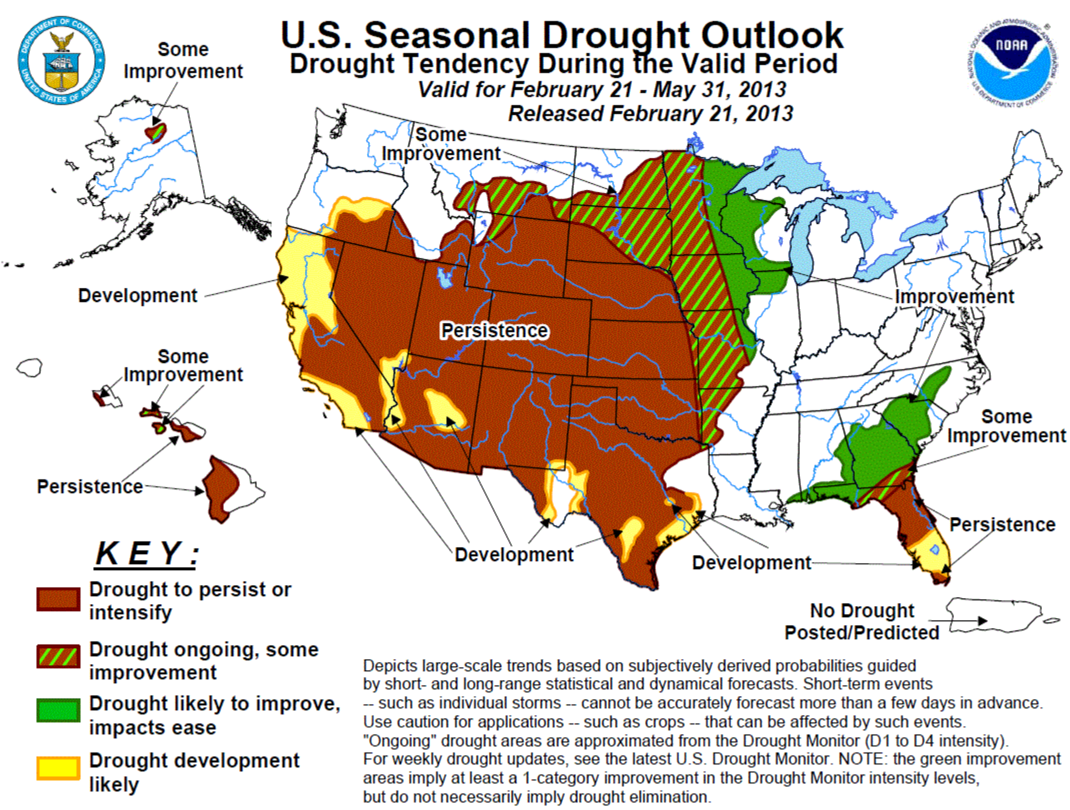


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of February is shown in Figure 4. While February precipitation generally has limited impact on February runoff since it usually falls as snow and does not result in immediate runoff, it was above normal in much of Nebraska, eastern South Dakota, central Wyoming and parts of Montana. Precipitation accumulations were in excess of 200 percent of normal in these areas, though actual departures ranged from 0.5 – 1.0 inches. Although precipitation in the lower Basin is not considered in this forecast, it is worth noting that Kansas, Missouri and Iowa experienced very high precipitation accumulations as a result of two powerful winter storms that occurred February 21-22 and February 25-27. Many locations throughout Kansas and Missouri set near-record daily and monthly snowfall accumulations that produced 1.5 – 2.5 inches of SWE.

Accumulated precipitation over the 90-day period ending on February 28 is shown in Figure 5. Precipitation was near to slightly-above normal in most of the Missouri River Basin. As a percent of normal, accumulations were greater than 150 percent of normal across Montana and eastern South Dakota. In most other areas, precipitation was greater than 125 percent of normal. Departures in some locations in eastern Kansas and Missouri were greater than 2.0 inches above normal.

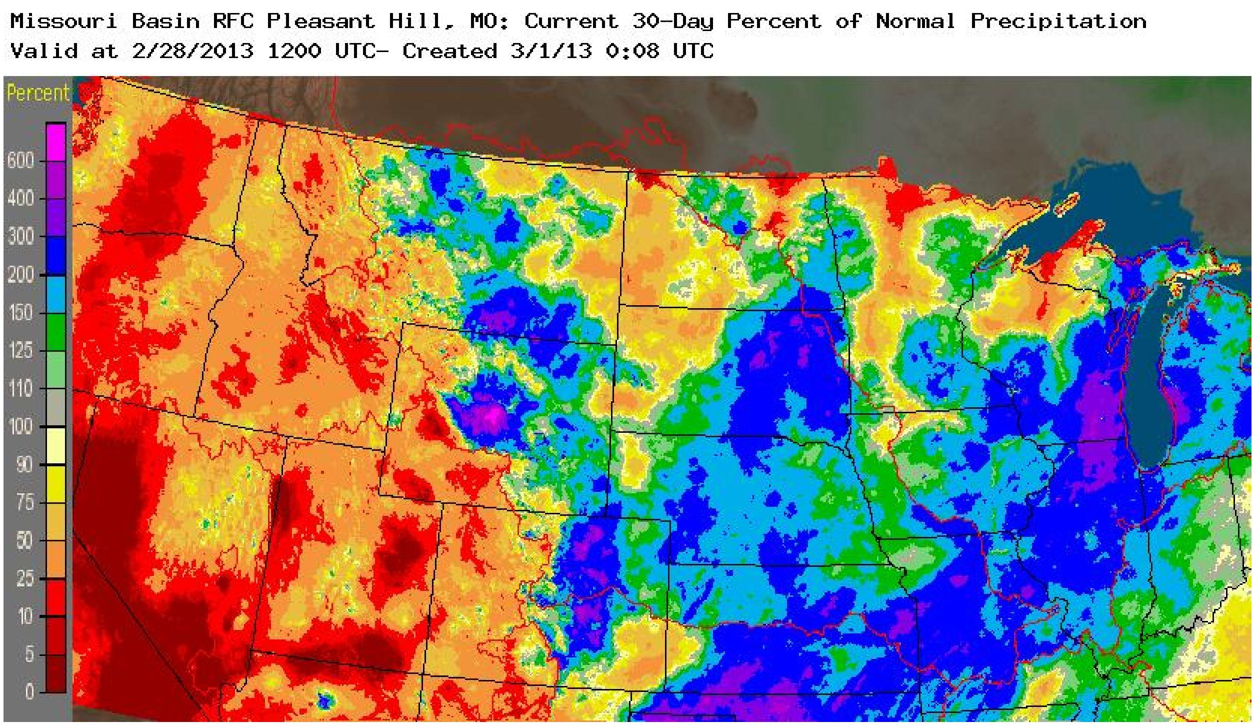


Figure 4. February 2013 Percent of Normal Precipitation.

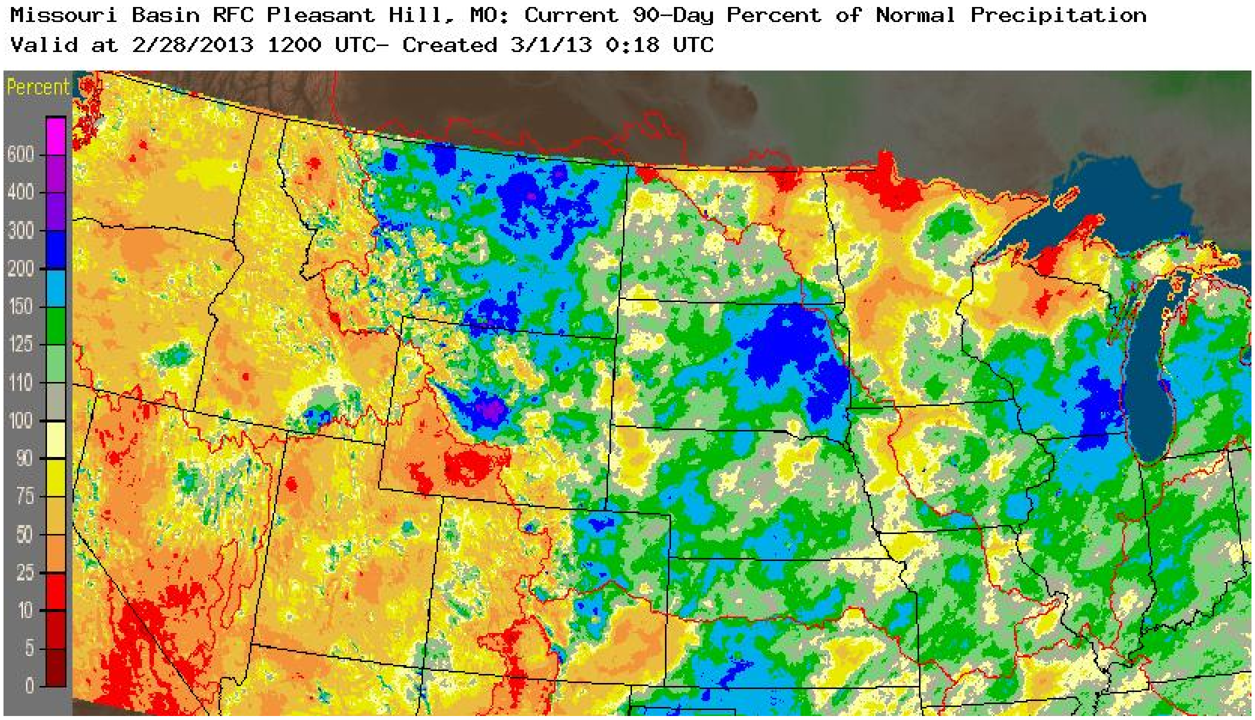


Figure 5. 90-day Percent of Normal Precipitation ending on February 28, 2013.

Temperature

Average temperatures throughout most of the upper Basin above Sioux City, IA during the month of February 2013 generally were 1 - 4 degrees F above normal (Figure 7). Temperatures were below normal in Wyoming and near normal in eastern North and South Dakota, Iowa, and Nebraska. Ninety-day (90-day) temperature departures ending on February 28 are shown in Figure 8. The above normal temperature trend is reflected in this 90-day temperature departure map, indicating temperatures were 1 – 3 degrees F above normal with some areas experiencing 90-day departures of 3 – 4 degrees F above normal. Near normal average 90-day temperatures occurred over Wyoming, southeast North Dakota and northeast North Dakota.

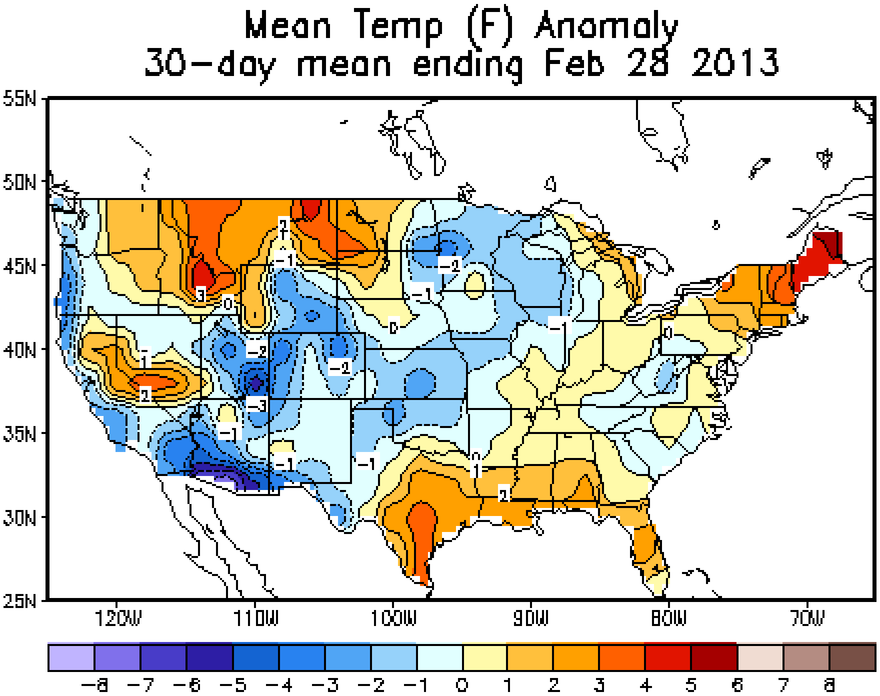


Figure 6. 30-day temperature anomaly (deg F) ending February28, 2013.

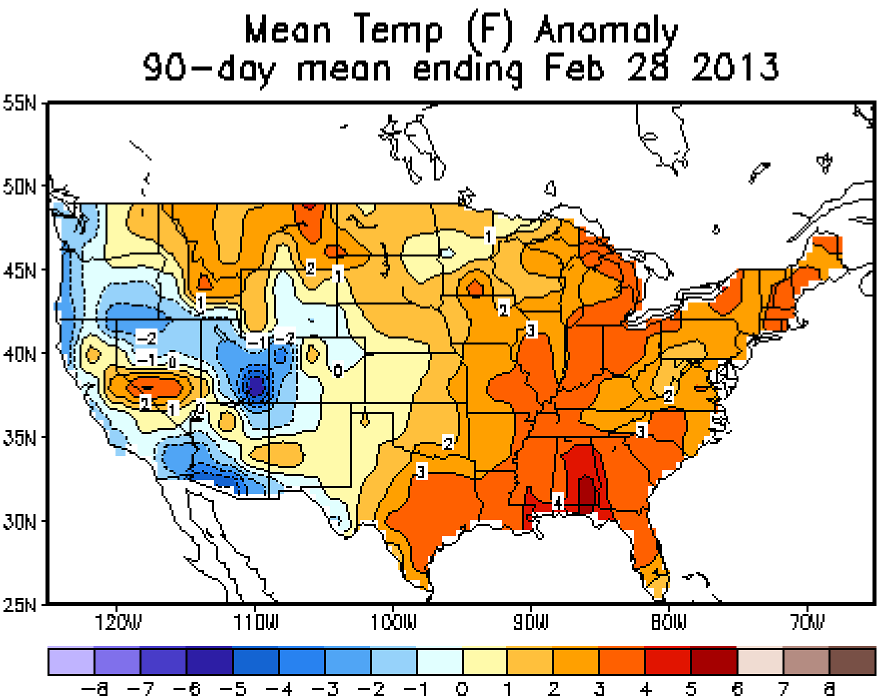


Figure 7. 90-day temperature anomaly (deg F) ending February 28, 2013.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff (e.g. baseflow).

Two independent estimates of soil moisture are presented in this report. Figure 8 shows the NOAA Climate Prediction Center's (CPC) calculated soil moisture ranking percentiles for the end of February. Figure 9 shows the University of Washington's Variable Infiltration Capacity (VIC) model soil moisture percentiles.

Both soil moisture rankings depict very dry soil moisture conditions throughout the upper Basin, especially in South Dakota, Nebraska, Wyoming and southern Montana. CPC soil moisture conditions in these areas rank below the 5th to the 1st percentile, which are exceptionally dry. In North Dakota and northern Montana, soil moisture ranges from near normal conditions down to the 10th percentile. In comparison, the VIC model depicts very dry soils in the same areas with soil moisture percentiles ranking from the 5th to below the 2nd percentile. In our analysis of the influence of soil moisture on forecast runoff, neither model takes preference over the other. As an indicator of future monthly runoff, soil moisture conditions suggest runoff will be well-below average when considered along with the temperature and precipitation outlooks, which were discussed previously in this forecast discussion.

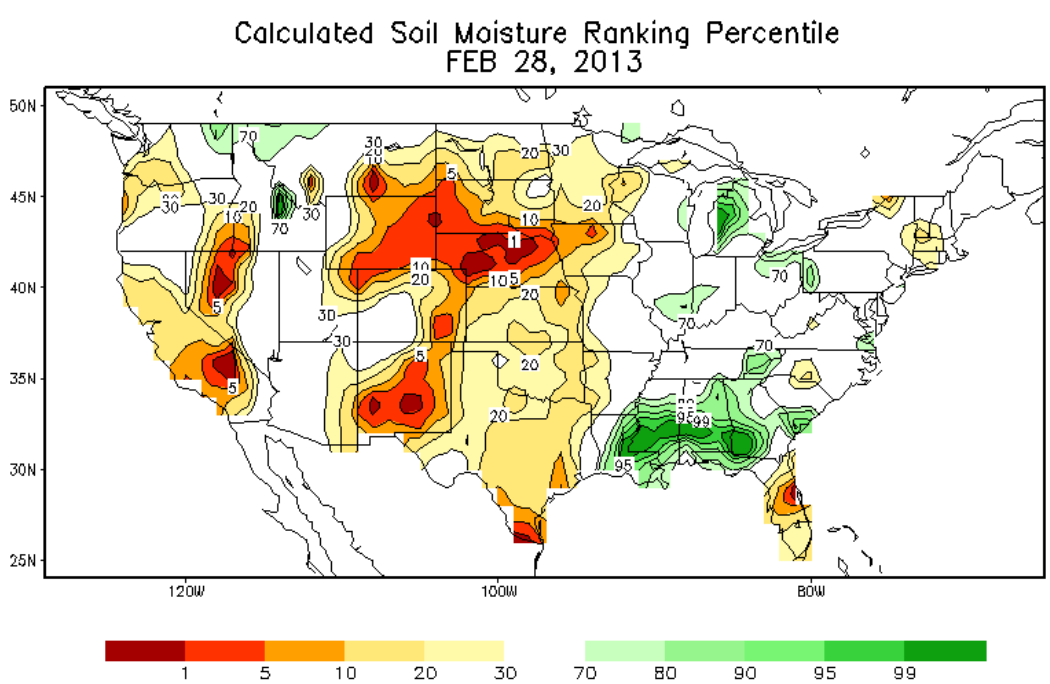


Figure 8. Calculated Soil Moisture Ranking Percentile on February 28, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

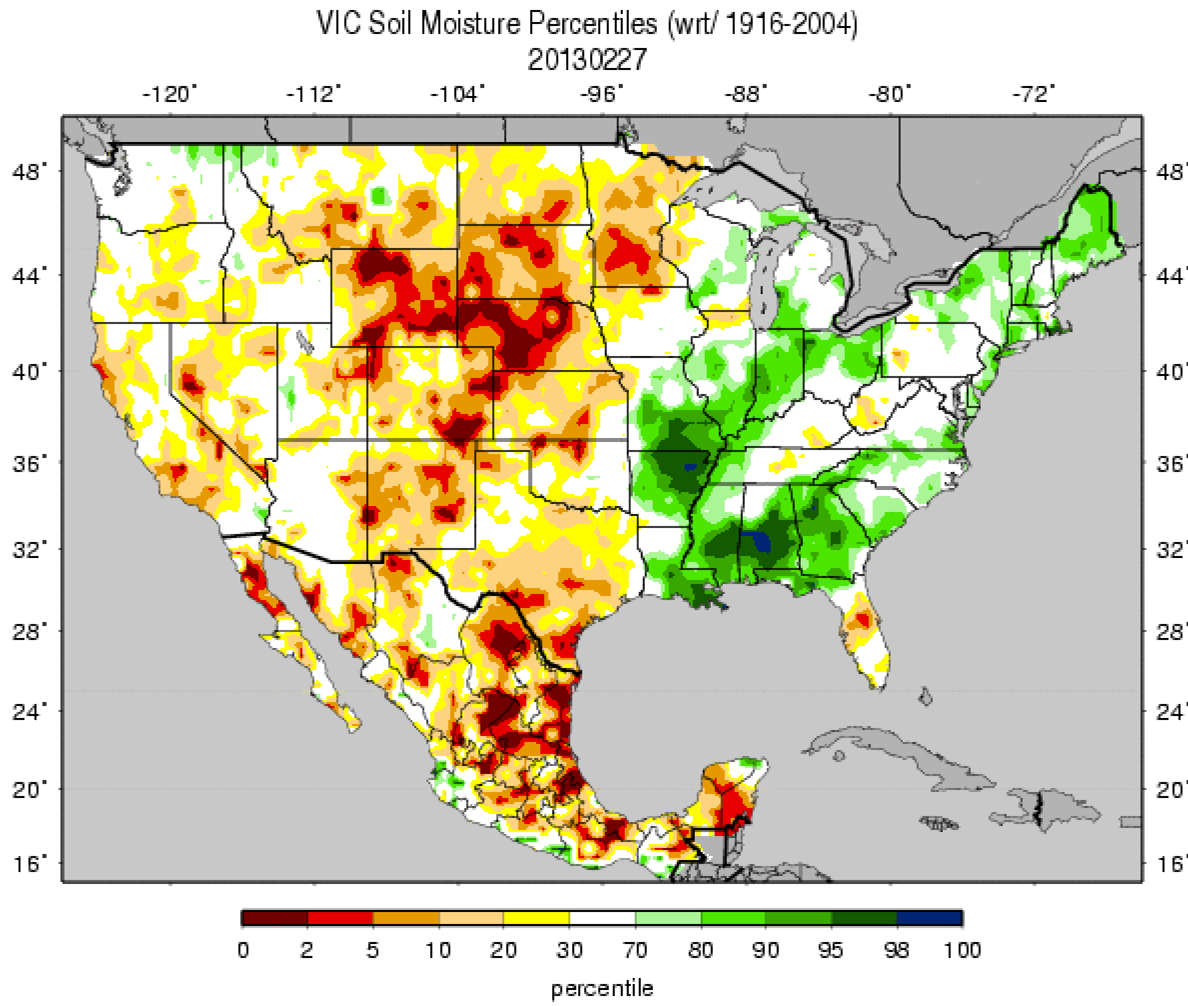


Figure 9. VIC modeled soil moisture percentiles as of February 27, 2013. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

The CPC calculated soil moisture anomaly for the contiguous U.S. on February 28 is shown in Figure 10. According to the analysis, there are widespread negative soil moisture anomalies in the Basin; however, some areas in western Montana have positive anomalies or are normal. Negative anomalies would indicate a soil moisture deficit or negative departure from normal. Negative anomalies range from -20 mm (about 1.0 inch) to -120 mm (about 5.0 inches) in the upper Basin spanning from Montana and North Dakota to northern Nebraska.

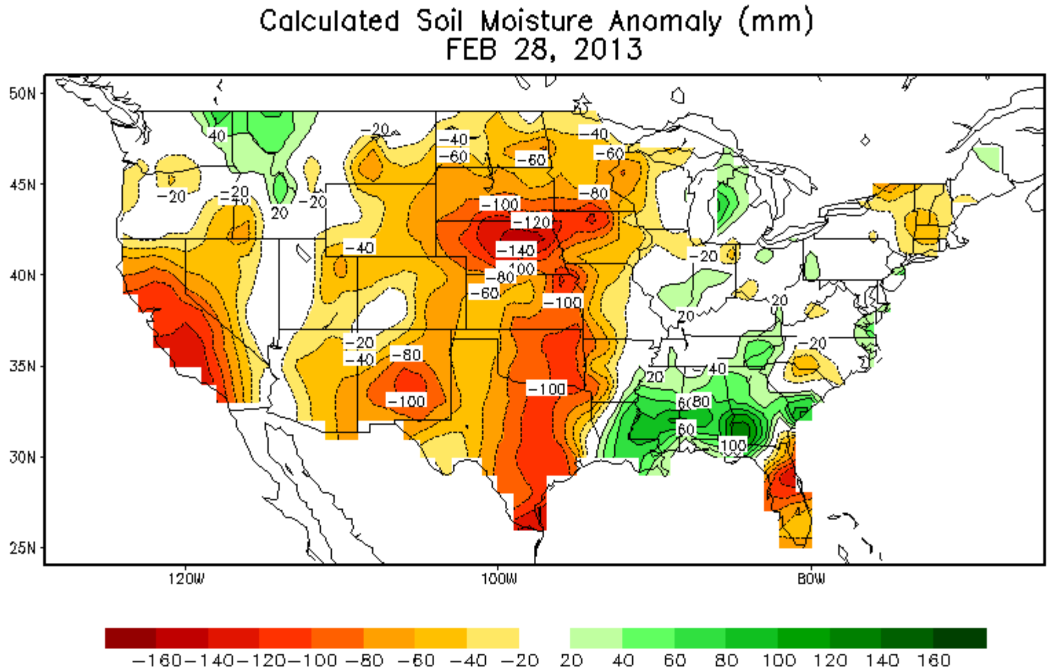


Figure 10. Calculated Soil Moisture Anomaly in on February 28, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25 percent of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

According to the National Weather Service (NWS) National Operational Hydrologic Remote Sensing Center (NOHRSC), the upper Basin is less than 50 percent snow covered with a majority of the snow located north and east of the Missouri River (Figure 11). SWE ranged from 0 – 2.0 inches with an average of about 1.0 inch of SWE. Field measurements indicate the heaviest areas of snow in and along the northern watershed boundary of the Basin range from 2.0 – 3.0 inches of SWE.

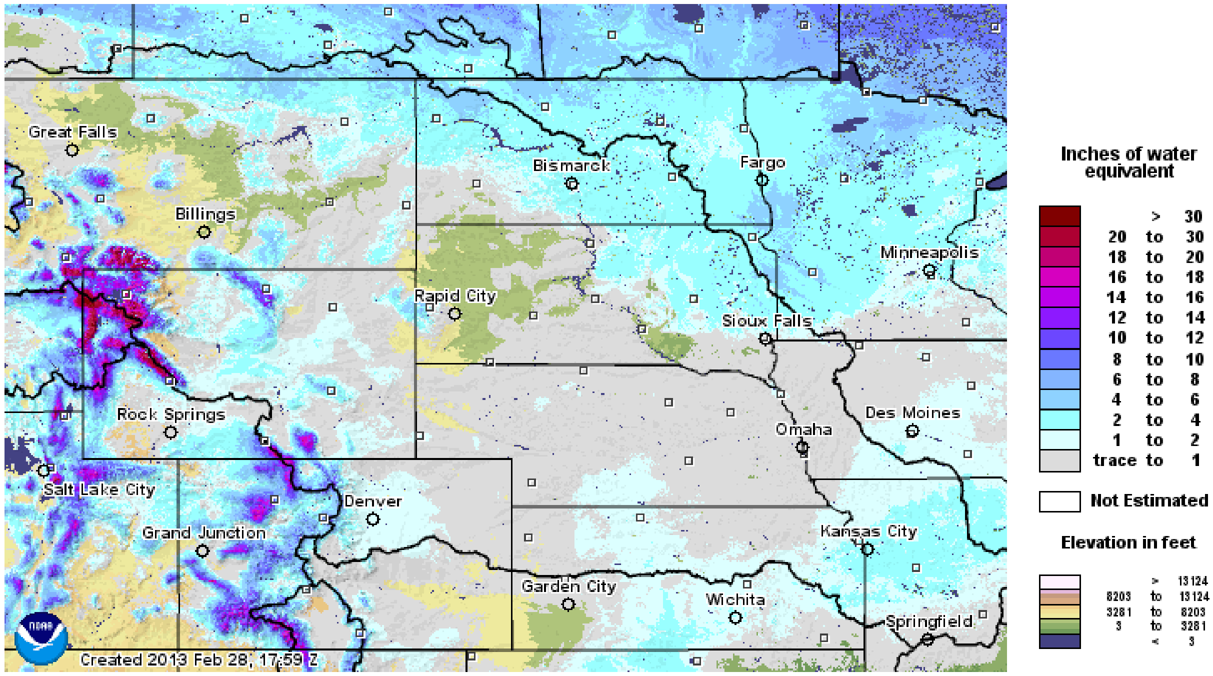


Figure 11. March 1, 2013, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Overall plains snowpack as of March 1 was classified as "Light" across the upper Basin according to the Corps of Engineers classification methods (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0.0 – 1.0 inch of SWE in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins. In the Garrison and Sioux City subbasins, this includes accumulations ranging from 0.0 - 2.0 inches of SWE.

Table 1. March 1, 2013 plains snowpack classification for runoff forecasting.

Reservoir Reach	Average Classification	Approximate Maximum
Above Fort Peck	Light (0 – 1 inch SWE)	2 inches
Fort Peck to Garrison	Light (0 – 2 inch SWE)	3 inches
Garrison to Oahe	Light (0 – 1 inch SWE)	2 inches
Oahe to Fort Randall	Light (0 – 1 inch SWE)	1 inch
Fort Randall to Gavins Point	Light (0 – 1 inch SWE)	1 inch
Gavins Point to Sioux City	Light (0 – 2 inch SWE)	3 inches

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. As of February 28 (see Figure 13) the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 11.9 inches, which is 93 percent of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 9.3 inches, which is 86 percent of normal based on the 1981-2010 average SWE for the Fort

Peck to Garrison subbasin. Normally by March 1, 79 percent of the peak snow accumulation has occurred in the mountains.

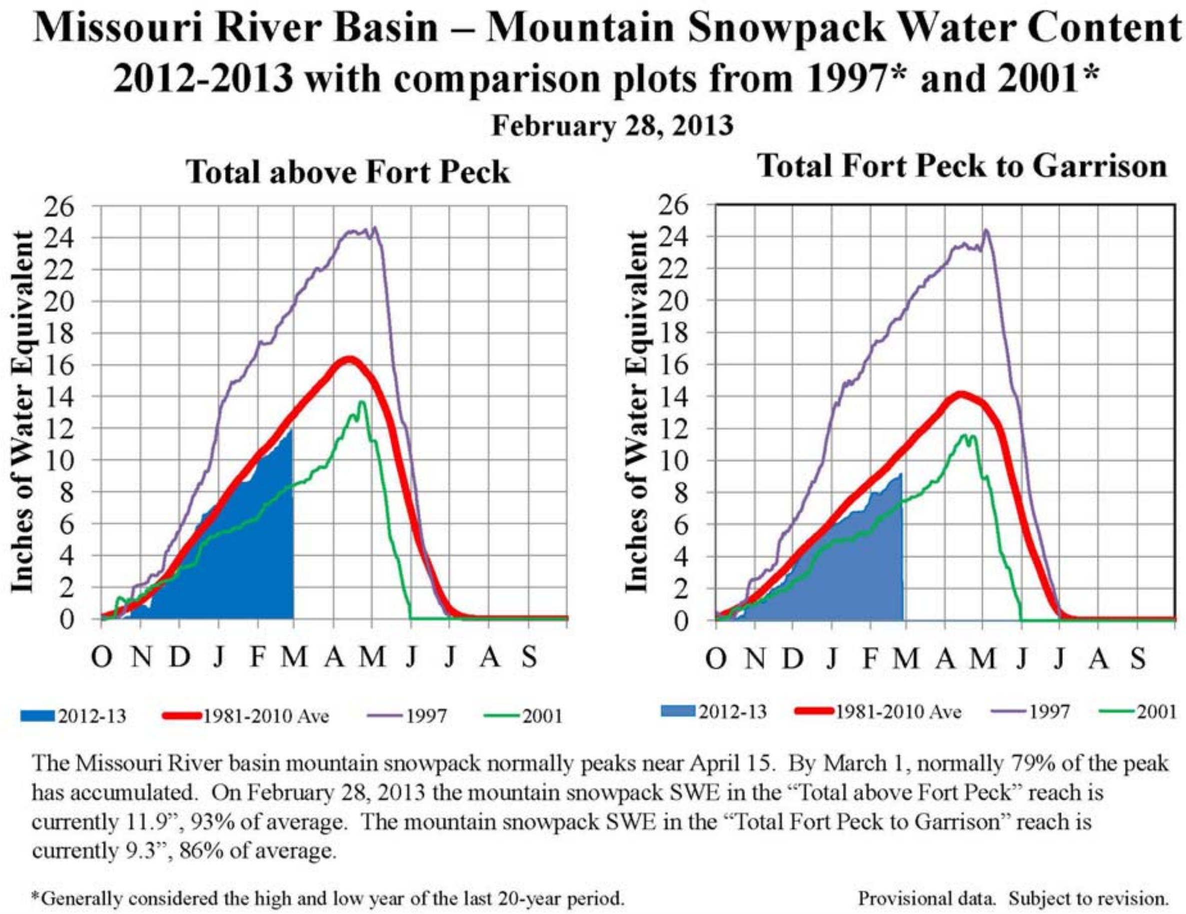


Figure 12. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific, and equatorial sea surface temperatures are near average to below average across most of the Pacific Ocean. ENSO-neutral conditions are favored in the Northern Hemisphere through spring 2013.   During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The CPC's March outlook (Figure 13) is indicating increased chances for below-normal temperatures in the entire upper Basin. With regard to precipitation, there are equal chances for above-normal, normal and below-normal precipitation. The CPC's 3-month outlook for March-April-May (Figure 14) indicates probabilities ranging from increased chances for below-normal temperatures in western Montana to increased chances for above-normal temperatures in the lower Basin. The 3-month temperature outlook for June-July-August (Figure 15) indicates an increased probability for above-normal temperatures throughout most of the upper Missouri

River Basin. The March-April-May precipitation outlook (Figure 14) indicates equal chances for above-normal, normal, and below-normal precipitation in much of the upper Missouri River Basin. The June-July-August precipitation outlook (Figure 15) indicates equal chances for above-normal, normal, and below-normal precipitation in the entire upper Missouri River Basin with the exception of increased chances for above-normal precipitation in western Montana. The September-October-November temperature outlook (Figure 16) indicates an increased probability for above-normal temperatures, while the precipitation outlook indicates equal chances for above-normal, normal, and below-normal precipitation.

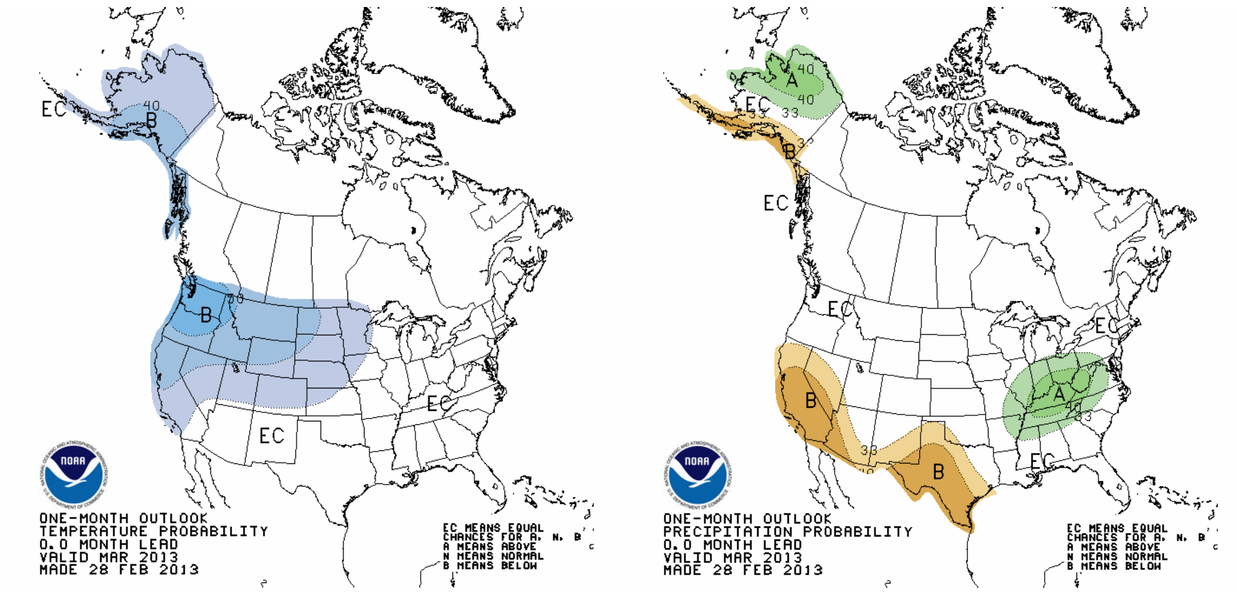


Figure 13. CPC March 2013 temperature and precipitation outlooks.

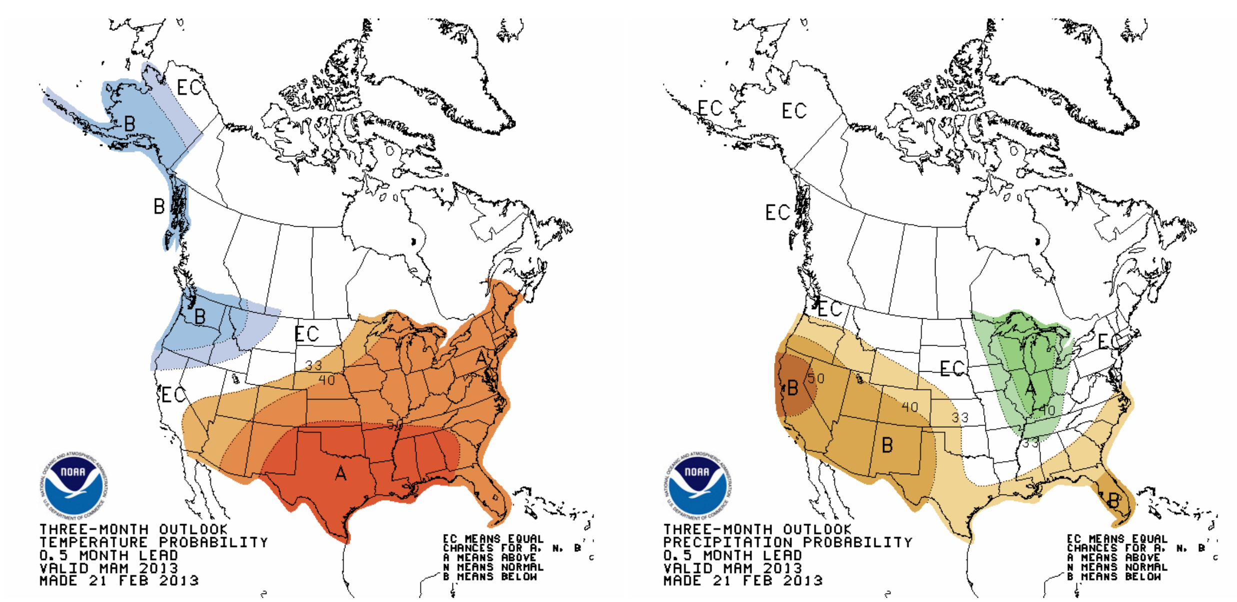


Figure 14. CPC March-April-May 2013 temperature and precipitation outlook.

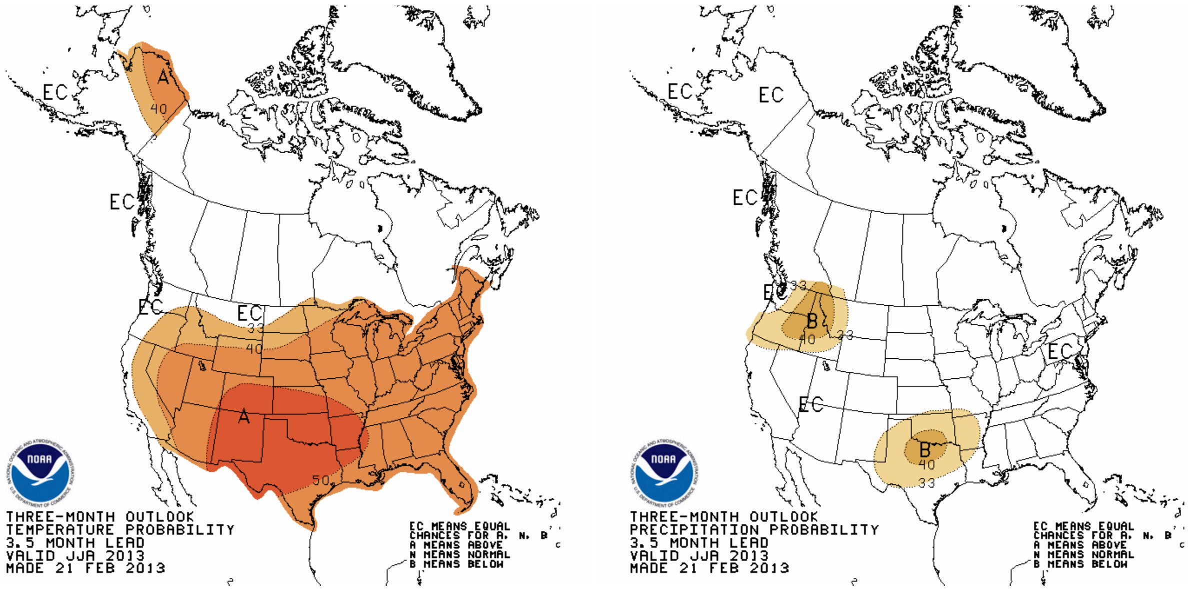


Figure 15. CPC June-July-August 2013 temperature and precipitation outlook.

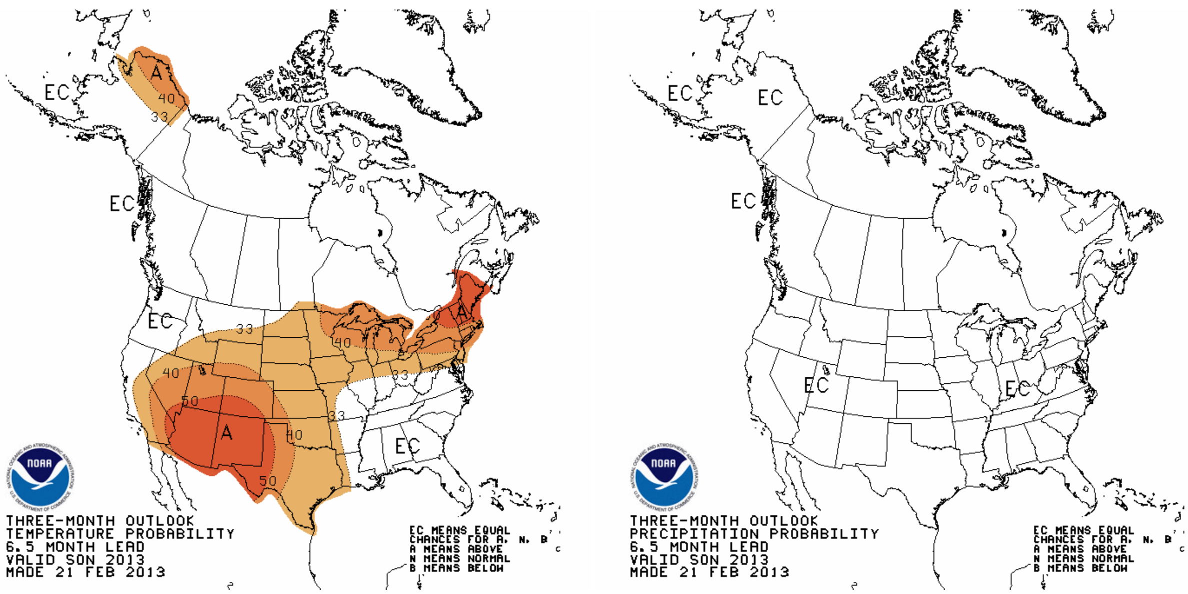


Figure 16. CPC September-October-November 2013 temperature and precipitation outlook.

March 2013 Calendar Year Runoff Forecast

The calendar year runoff forecast is 20.0 MAF (81 percent of average) above Sioux City and 18.7 MAF (82 percent of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 26.9 MAF upper basic forecast to the 13.8 MAF lower basic forecast. The upper and lower basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions.

Factors taken into consideration while preparing the 2013 forecast include continuing drought conditions in the upper Missouri River Basin, soil moisture content, antecedent precipitation, antecedent temperature conditions, plains snowpack, mountain snowpack, and the CPC's long range climate outlook.

February

During February runoff was near normal due to much warmer than normal temperatures across much of the upper Missouri River Basin. Runoff was about 0.1 MAF greater than forecast or about 1.1 MAF.

March-April

Plains snow is a significant factor influencing the volume of runoff in March and April; however, precipitation and air temperature during this time period are also very important factors that need consideration. Factors taken into consideration in updating the March and April runoff forecast were: 1) the lack of plains snow cover; 2) an equal chance probability for above, normal, and below-normal precipitation; and, 3) drier than normal soil moisture in the Dakotas and southeast Montana.

Based on the CPC's March outlook, temperatures are expected to be below normal while precipitation chances are expected to be equal for above, normal or below-normal precipitation accumulations. There is a similar climate outlook in April. The overall plains snowpack in the Fort Peck, Garrison and Oahe subbasins is classified as Light according to the Corps of Engineers snowpack classification (0-1 inches in the Fort Peck and Oahe subbasins and 0-2 inches in the Garrison subbasin). Soil moisture is considered dry to very dry in much of the plains region with the exception of northern Montana and northwestern North Dakota.

Plains snowpack increased slightly in some areas since February 1, but the change was not significant. February runoff was slightly greater than forecast due to some snowmelt and ice melt in upper Missouri River tributaries; therefore, the March-April runoff forecast was reduced slightly to account for a reduction in runoff that would normally occur in March. The March forecast is 2.0 MAF (71 percent of normal) while the April forecast is 2.1 MAF (71 percent of normal).

May-June-July

During the May-June-July period, the mainstem system receives 50 percent of its annual runoff as a result of mountain snowmelt and spring and summer precipitation. This is the most active period for precipitation in the Basin, so runoff can vary significantly as a result of the above or below normal rainfall.

The significance of accurately forecasting the May-June-July runoff for the Fort Peck and Garrison reaches is based on the fact that, historically, an average of 9.2 MAF of runoff occurs during these 3 months into these 2 projects, which is 37 percent of the total annual runoff into the System.

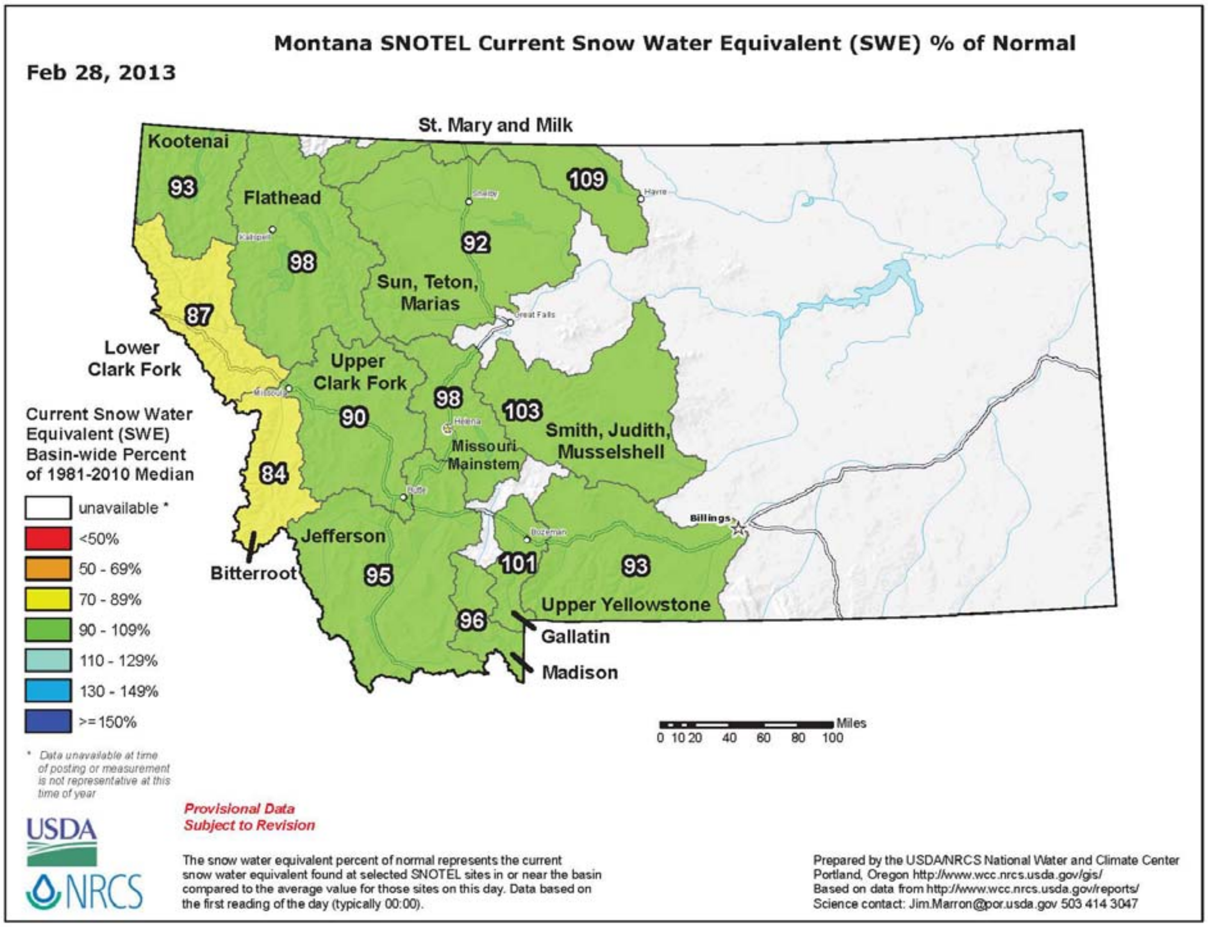
May-June-July runoff in the Fort Peck and Garrison subbasins was determined based on linear regression relationships between mountain snowpack as a percent of normal and runoff. Based on these relationships, May-June-July runoff is forecast to be 88 percent of normal above Fort Peck and 79 percent of normal in the Fort Peck to Garrison reach.

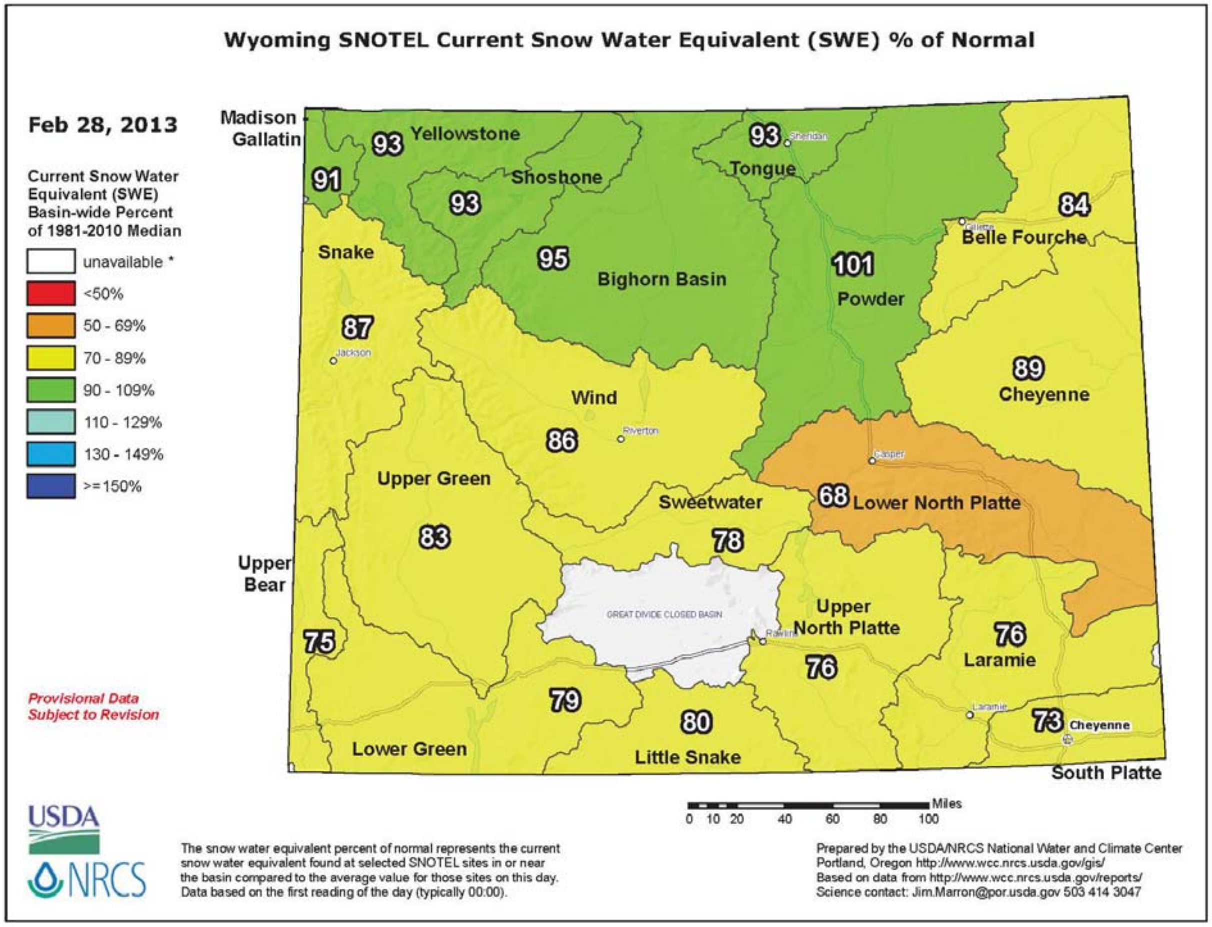
Runoff in the Oahe, Fort Randall and Gavins Point reaches is forecast to be below normal based on the fact that there is no strong climate signal that will influence the weather during the time. The already dry soil moisture and drought conditions in the plains are expected to persist at least into summer.

August-December

Runoff during the August-December period is expected to persist at comparable percent of normal runoff levels in all reaches. The runoff summation above Sioux City, IA ranges from 81-83 percent of normal during the August-December period. The long-lead temperature outlooks indicate increased probabilities for above-normal temperatures in the Basin, which may provide a barrier for drought recovery and the return to more runoff conditions closer to normal. The long-lead precipitation outlooks indicate precipitation chances will be equal, though there is very limited skill in long-lead precipitation forecasts.

Additional Figures




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Feb 28, 2013
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1981-2010 Median
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison - Gallatin
91
93 Yellowstone
93
Shoshone
95
Bighorn Basin
93
Tongue
101
Powder
84
Belle Fourche
89
Cheyenne
Snake
87
Wind
86
Upper Green
83
Sweetwater
78
68 Lower North Platte
Upper Bear
75
GREAT DIVIDE CLOSED BASIN
Upper North Platte
76
76
Laramie
79
80
Little Snake
Lower Green
73 Cheyenne
South Platte
Miles
0 10 20 40 60 80 100
USDA
NRCS
The snow water equivalent percent of normal represents the current snow water equivalent found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).
Prepared by the USDA/NRCS National Water and Climate Center Portland, Oregon http://www.wcc.nrcs.usda.gov/gis/
Based on data from http://www.wcc.nrcs.usda.gov/reports/
Science contact: Jim.Marron@por.usda.gov 503 414 3047

USDA NRCS National Water & Climate Center
* - DATA CURRENT AS OF: March 04, 2013 05:04:27 PM
- Based on March 01, 2013 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	97	100	112	103	91	82	97
	APR-SEP	114	102	131	121	107	97	112
St. Mary R at Int'l Boundary (2)	APR-JUL	440	101	540	480	400	340	435
	APR-SEP	500	99	605	540	460	395	505
Lima Reservoir Inflow (2)	APR-JUL	74	90	108	88	60	40	82
	APR-SEP	79	89	120	95	63	38	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	94	93	179	128	60	9.3	101
	APR-SEP	113	94	205	151	75	20	120
Jefferson R nr Three Forks (2)	APR-JUL	615	83	1040	785	445	189	740
	APR-SEP	665	83	1140	855	475	195	800
Hebgen Reservoir Inflow (2)	APR-JUL	330	89	395	355	305	265	370
	APR-SEP	430	91	510	460	400	350	470
Ennis Reservoir Inflow (2)	APR-JUL	550	88	690	605	495	410	625
	APR-SEP	695	90	860	760	630	530	775
Missouri R at Toston (2)	APR-JUL	1610	90	2300	1890	1330	915	1790
	APR-SEP	1870	90	2680	2200	1540	1060	2070
Smith R bl Eagle Ck (2)	APR-JUL	112	106	168	135	89	56	106
	APR-SEP	124	107	190	151	97	58	116
Gibson Reservoir Inflow (2)	APR-JUL	365	92	470	405	325	260	395
	APR-SEP	405	92	515	450	360	295	440
Marias R nr Shelby (2)	APR-JUL	335	97	515	405	265	156	345
	APR-SEP	345	96	535	425	265	153	360
Milk R at Western Crossing	MAR-JUL	32	86	58	42	22	6.4	37
	MAR-SEP	34	87	62	45	23	5.8	39
	APR-JUL	27	87	50	36	17.8	4.2	31
	APR-SEP	29	88	54	39	18.7	3.6	33
Milk R at Eastern Crossing	MAR-JUL	62	111	129	89	35	1.00	56
	MAR-SEP	70	111	144	100	40	10.0	63
	APR-JUL	50	111	106	73	27	1.50	45
	APR-SEP	61	111	125	87	35	10.0	55

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	51	86	60	55	47	42	59
	APR-SEP	65	88	77	70	60	53	74
Wind R ab Bull Lake Ck (2)	APR-JUL	335	84	445	380	290	225	400
	APR-SEP	415	85	545	465	365	285	490
Bull Lake Ck nr Lenore	APR-JUL	126	91	157	138	114	95	139
	APR-SEP	154	91	192	170	138	116	169
Boysen Reservoir Inflow (2)	APR-JUL	435	71	820	590	280	50	610
	APR-SEP	485	73	915	660	310	54	665
Greybull R nr Meeteetse	APR-JUL	121	92	158	136	106	84	131
	APR-SEP	164	93	210	183	145	116	177
Shell Ck nr Shell	APR-JUL	50	91	65	56	44	35	55
	APR-SEP	62	94	79	69	55	45	66
Bighorn R at Kane (2)	APR-JUL	635	76	1160	845	425	115	840
	APR-SEP	685	76	1250	915	455	119	905
NF Shoshone R at Wapiti	APR-JUL	420	91	520	460	380	320	460
	APR-SEP	470	91	580	515	425	360	515
SF Shoshone R nr Valley	APR-JUL	190	88	235	210	171	144	215
	APR-SEP	220	90	270	240	197	166	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	600	89	760	665	535	440	675
	APR-SEP	665	89	840	735	595	490	745
Bighorn R nr St. Xavier (2)	APR-JUL	1100	80	1730	1360	845	465	1380
	APR-SEP	1160	79	1870	1450	875	450	1460
Little Bighorn R nr Hardin	APR-JUL	77	79	124	96	58	30	98
	APR-SEP	89	80	141	110	68	37	111

Tongue R nr Dayton (2)	APR-JUL	73	85	104	86	60	42	86
	APR-SEP	84	86	118	98	70	50	98
Tongue River Reservoir Inflow (2)	APR-JUL	145	75	255	189	101	35	193
	APR-SEP	165	77	280	210	118	49	215
NF Powder R nr Hazelton	APR-JUL	9.6	105	12.8	10.9	8.3	6.4	9.1
	APR-SEP	10.4	105	13.8	11.8	9.0	7.0	9.9
Powder R at Moorhead	APR-JUL	157	89	270	205	111	43	177
	APR-SEP	178	91	295	225	130	60	196
Powder R nr Locate	APR-JUL	177	89	310	230	122	42	199
	APR-SEP	200	91	345	260	141	55	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow	MAR-JUL	5.6	90	9.4	7.2	4.0	1.78	6.2
	APR-JUL	4.7	90	7.7	5.8	3.7	2.4	5.2
Pactola Reservoir Inflow	MAR-JUL	23	92	41	30	15.8	5.2	25
	APR-JUL	19.5	89	36	25	14.3	8.2	22

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
Calendar Year Runoff Forecast
April 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of April 1, 2013 is 20.5 MAF (81 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 18.9 MAF (82 percent of normal). Above Sioux City, this is an increase of 0.5 MAF from the March forecast. March runoff was 1.6 MAF (55 percent of normal) in the upper Missouri River Basin (Basin) above Sioux City, IA and 1.4 MAF (55 percent of normal) above Gavins Point Dam.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 9 months, the range of expected inflow is quite large and ranges from the 27.0 MAF upper basic forecast to the 14.8 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

According to the National Drought Mitigation Center's (NDMC) U.S. Drought Monitor (Figure 1), drought conditions impact much of the upper Basin with the exception of the northern half of Montana and northwest North Dakota. Abnormally Dry (D0) conditions transition to Severe (D2) and Extreme (D3) drought conditions in southern Montana and the Dakotas. Exceptional (D4) drought, which is the worst classification of drought, is present in southern South Dakota, eastern Wyoming and a very large portion of Nebraska. Compared to the February 26, 2013 drought conditions shown in Figure 2, March 26, 2013 conditions have not changed much in the past month. The U.S. Seasonal Drought Outlook shown in Figure 3 indicates drought conditions impacting the Basin will improve in across most of the Basin; however, drought impacts will be ongoing in much of Nebraska, Wyoming and southern Montana.

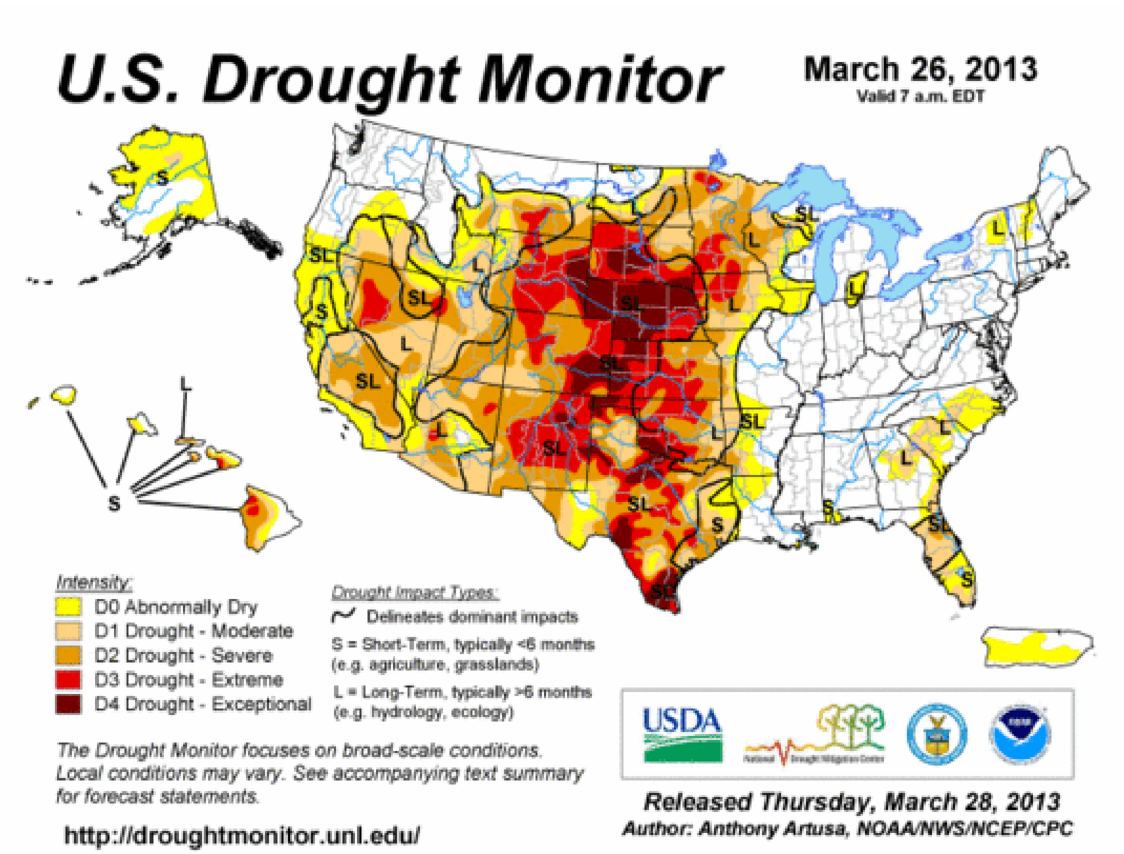


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for March 26, 2013.

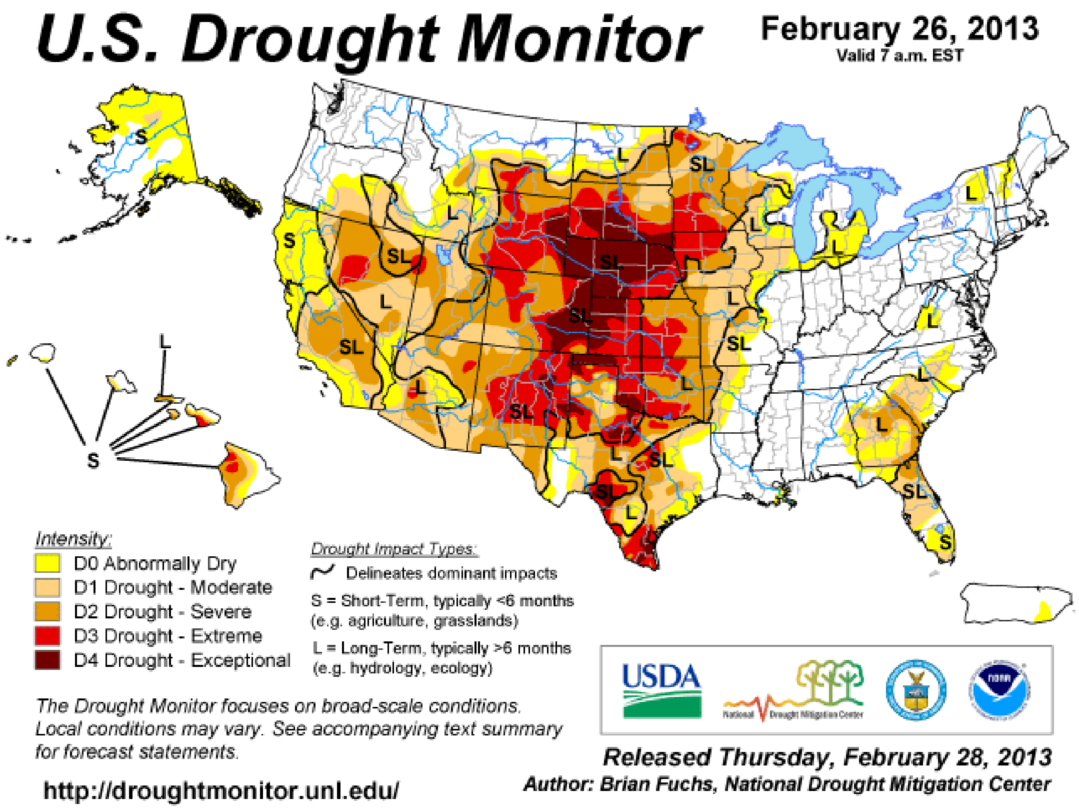


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for February 26, 2013.

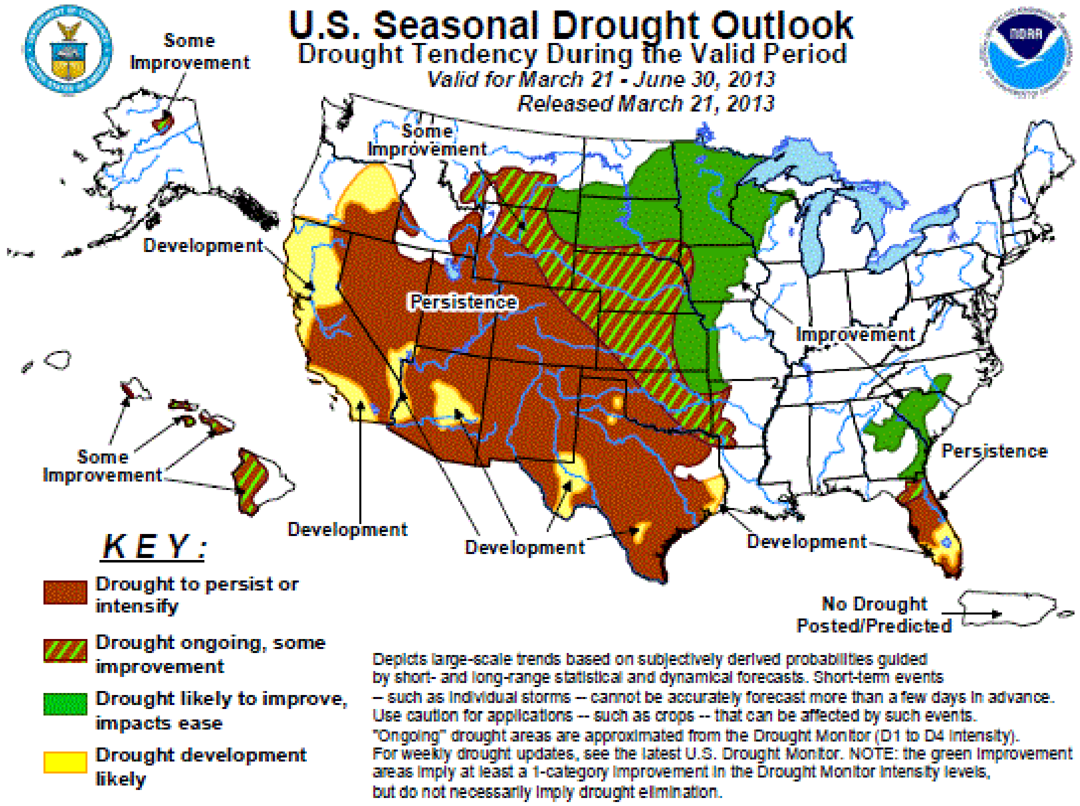


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of March is shown in Figure 4. March precipitation falls as snow and rain. Therefore, the runoff response is sometimes delayed until late March and April. Precipitation was above normal in northeast Montana, much of North Dakota, in portions of eastern South Dakota, Nebraska and western Iowa. Precipitation accumulations were in excess of 300 percent of normal in northeast Montana with actual departures ranging from 1.0 – 2.0 inches.

Accumulated precipitation over the 90-day period ending on April 2 is shown in Figure 5. Precipitation was near to slightly-below normal in most of the Missouri River Basin, except for northeast Montana and northeast South Dakota, which have precipitation amounts approximately 200 percent of normal.

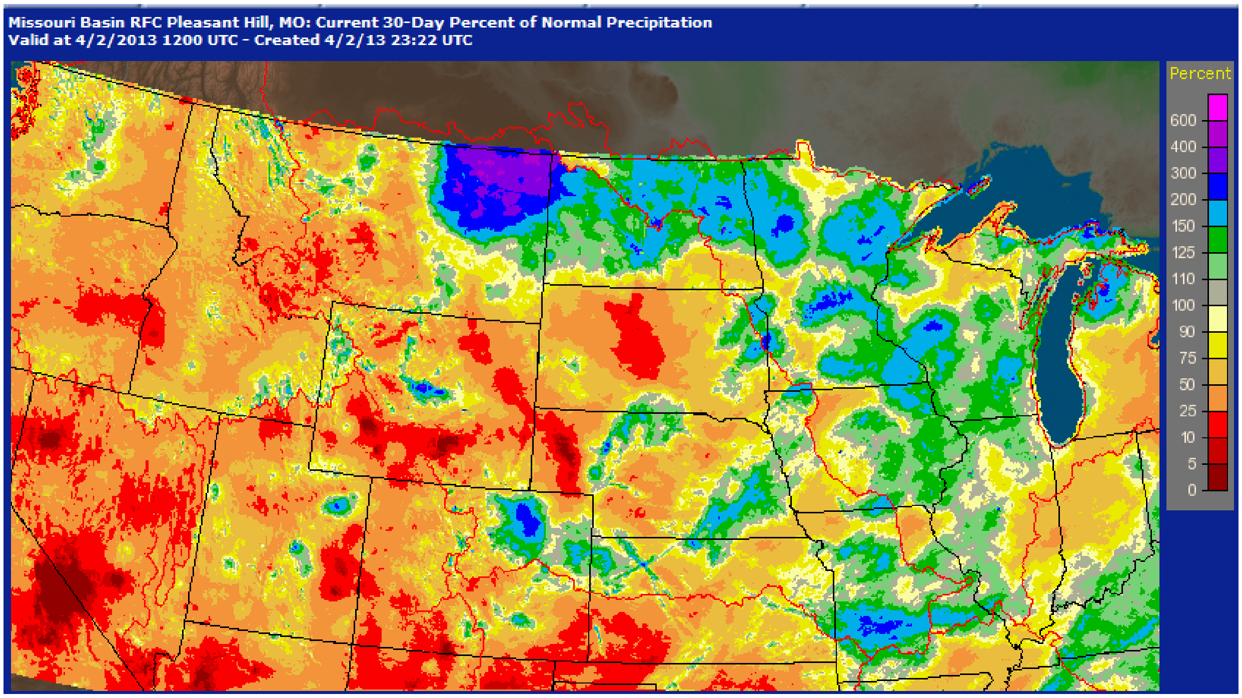


Figure 4. March 2013 Percent of Normal Precipitation.

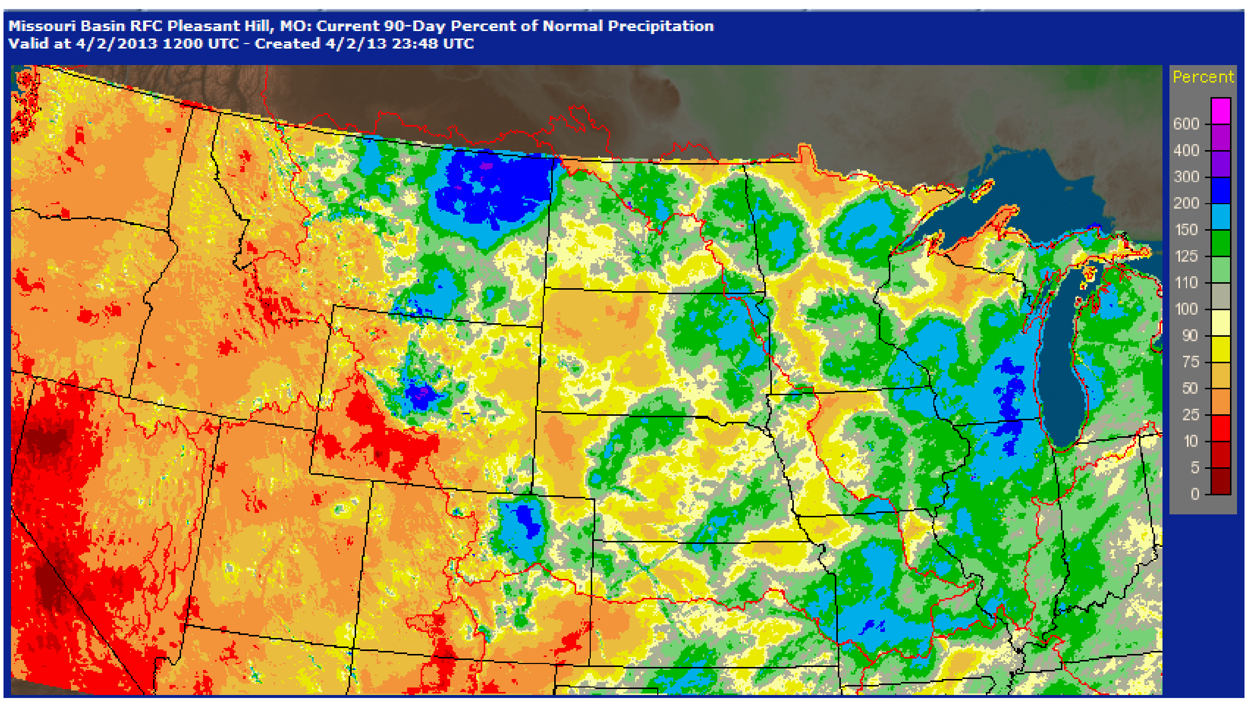


Figure 5. 90-day Percent of Normal Precipitation ending on April 2, 2013.

Temperature

Average temperatures throughout most of the upper Basin above Sioux City, IA during the month of March 2013 generally were 3-8 degrees F below normal (Figure 6). Ninety-day (90-day) temperature departures ending on April 1 are shown in Figure 7. The 90-day temperature departure map shows slightly above normal temperatures in the western portion of the Basin and slightly below normal temperatures in the eastern portion of the Basin.

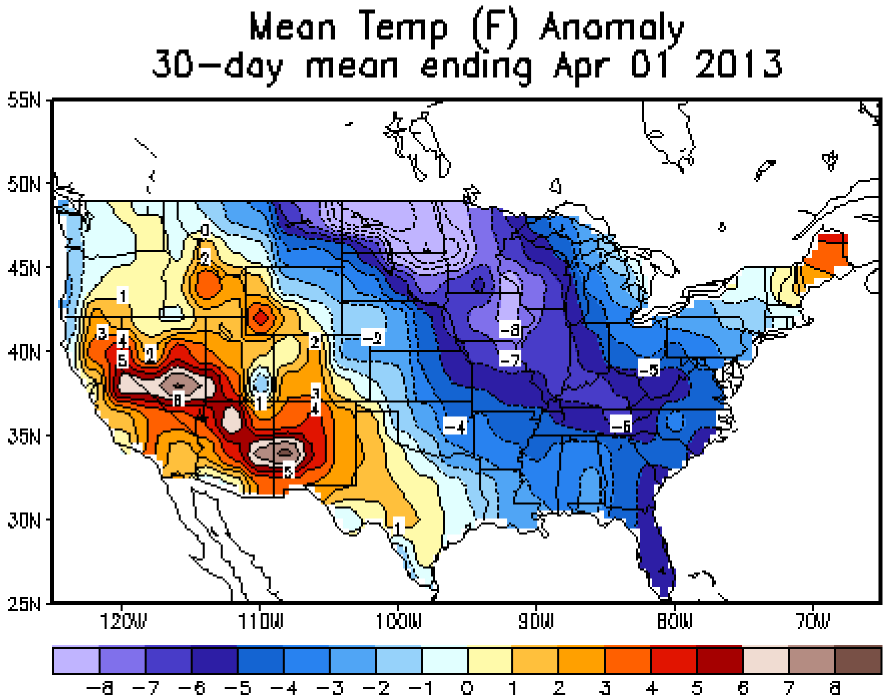


Figure 6. 30-day temperature anomaly (deg F) ending April 1, 2013.

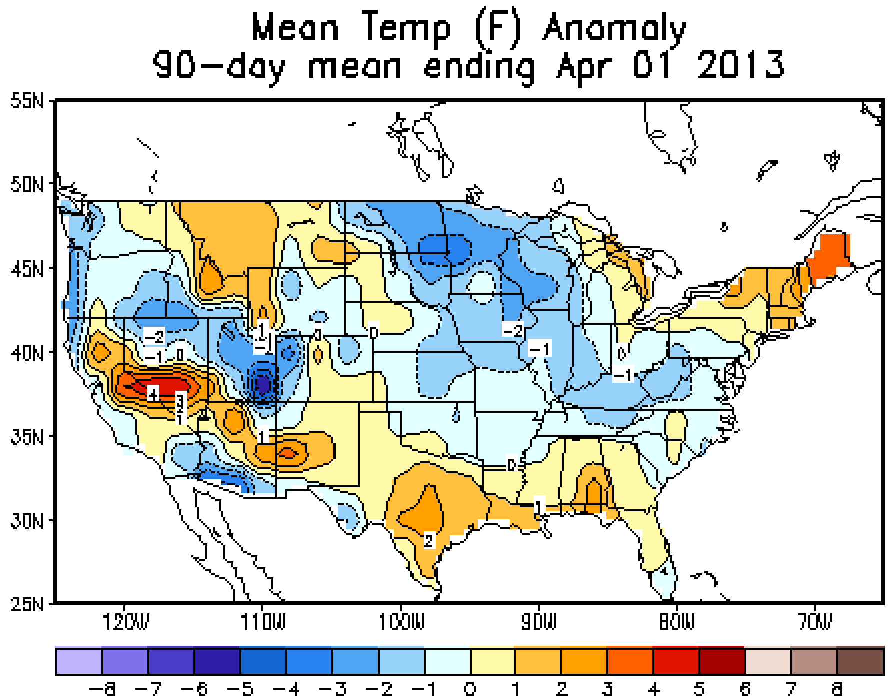


Figure 7. 90-day temperature anomaly (deg F) ending April 1, 2013.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff (e.g. baseflow).

Two independent estimates of soil moisture are presented in this report. Figure 8 shows the NOAA Climate Prediction Center's (CPC) calculated soil moisture ranking percentiles for the end of February. Figure 9 shows the University of Washington's Variable Infiltration Capacity (VIC) model soil moisture percentiles.

Both soil moisture rankings depict very dry soil moisture conditions throughout the upper Basin, especially in South Dakota, Nebraska, Wyoming and southern Montana. CPC soil moisture conditions in these areas rank below the 5th to the 1st percentile, which are exceptionally dry. In North Dakota and northern Montana, soil moisture ranges from near normal conditions down to the 10th percentile in southern portions of both states. In comparison, the VIC model depicts very dry soils in the same areas with soil moisture percentiles ranking from the 5th to below the 2nd percentile. In our analysis of the influence of soil moisture on forecast runoff, neither model takes preference over the other. As an indicator of future monthly runoff, soil moisture conditions suggest runoff will be well-below average when considered along with the temperature and precipitation outlooks, which were discussed previously in this forecast discussion.

The CPC calculated soil moisture anomaly for the contiguous U.S. on March 31 is shown in Figure 10. According to the analysis, there are widespread negative soil moisture anomalies in the Basin; however, some areas in western Montana have positive anomalies or are normal. Negative anomalies would indicate a soil moisture deficit or negative departure from normal. Negative anomalies range from -20 mm (about 1.0 inch) to -120 mm (about 5.0 inches) in the upper Basin spanning from Montana and North Dakota to central Nebraska.

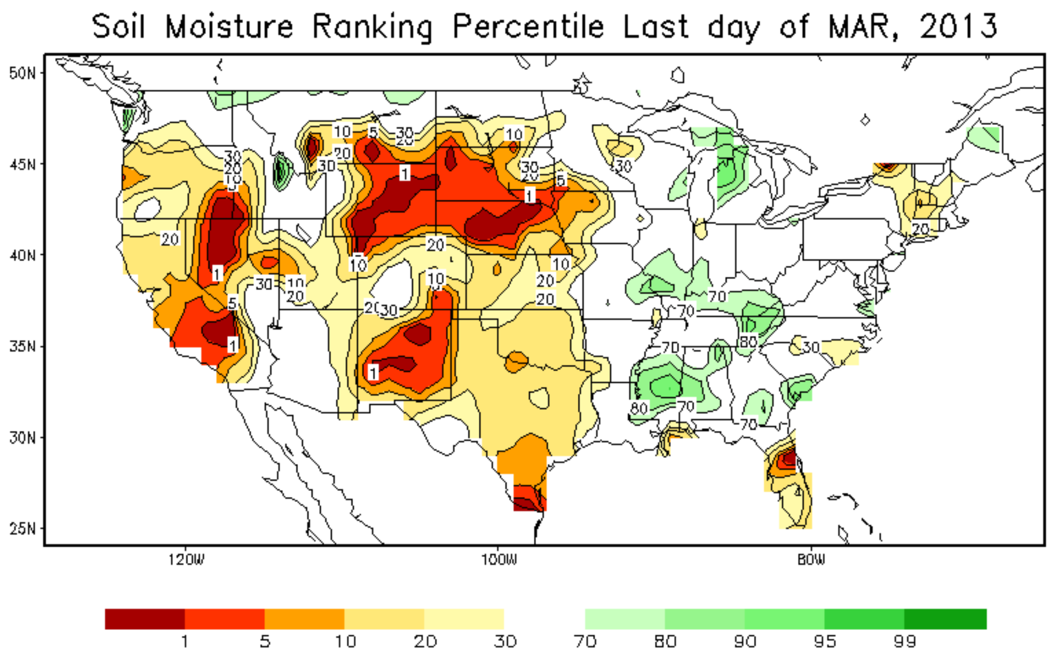


Figure 8. Calculated Soil Moisture Ranking Percentile on March 31, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

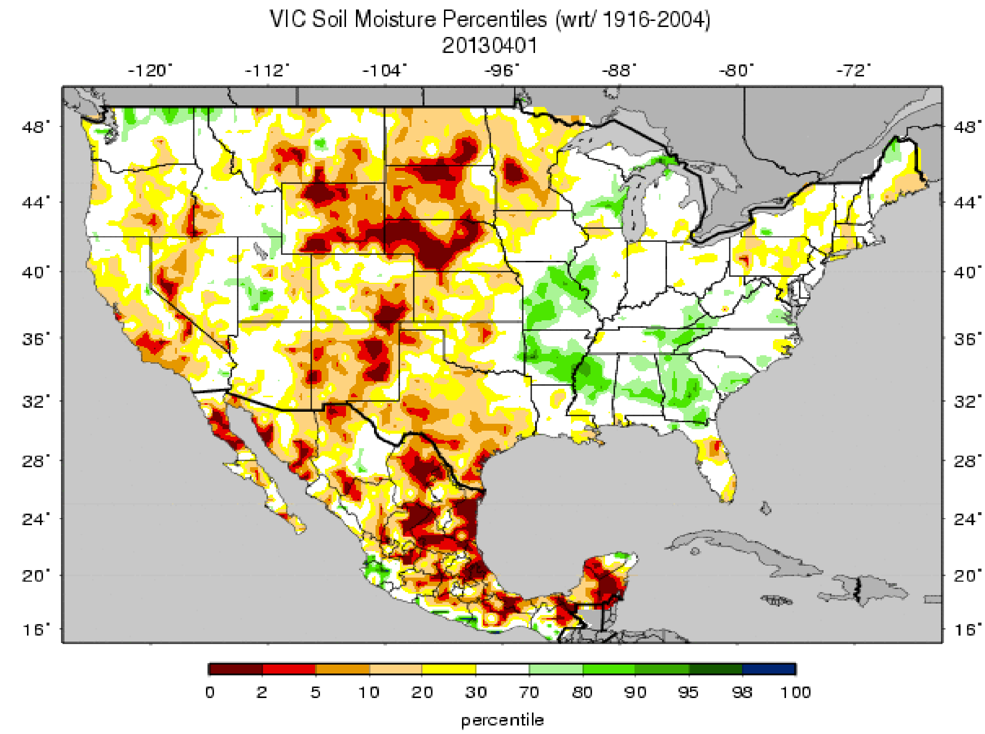


Figure 9. VIC modeled soil moisture percentiles as of April 1, 2013. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

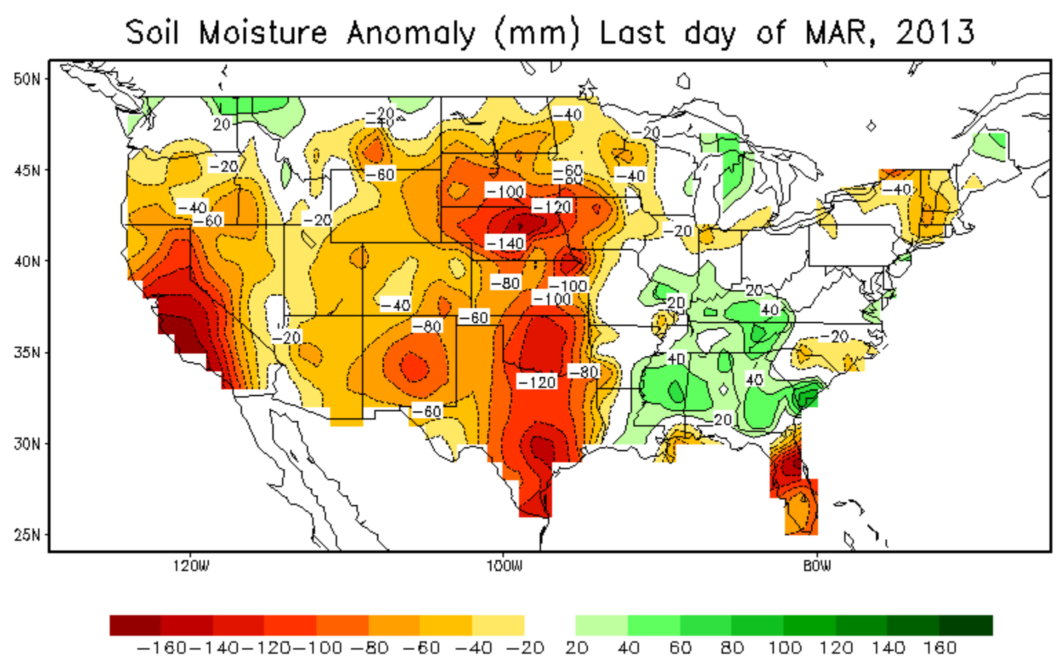


Figure 10. Calculated Soil Moisture Anomaly in on March 31, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25 percent of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

According to the National Weather Service (NWS) National Operational Hydrologic Remote Sensing Center (NOHRSC), the upper Basin is less than 50 percent snow covered with a majority of the snow located north and east of the Missouri River (Figure 11). SWE ranged from 0 – 2.0 inches with an average of about 1.0 inch of SWE. Field measurements indicate the heaviest areas of snow in and along the northern watershed boundary of the Basin range from 2.0 – 3.0 inches of SWE.

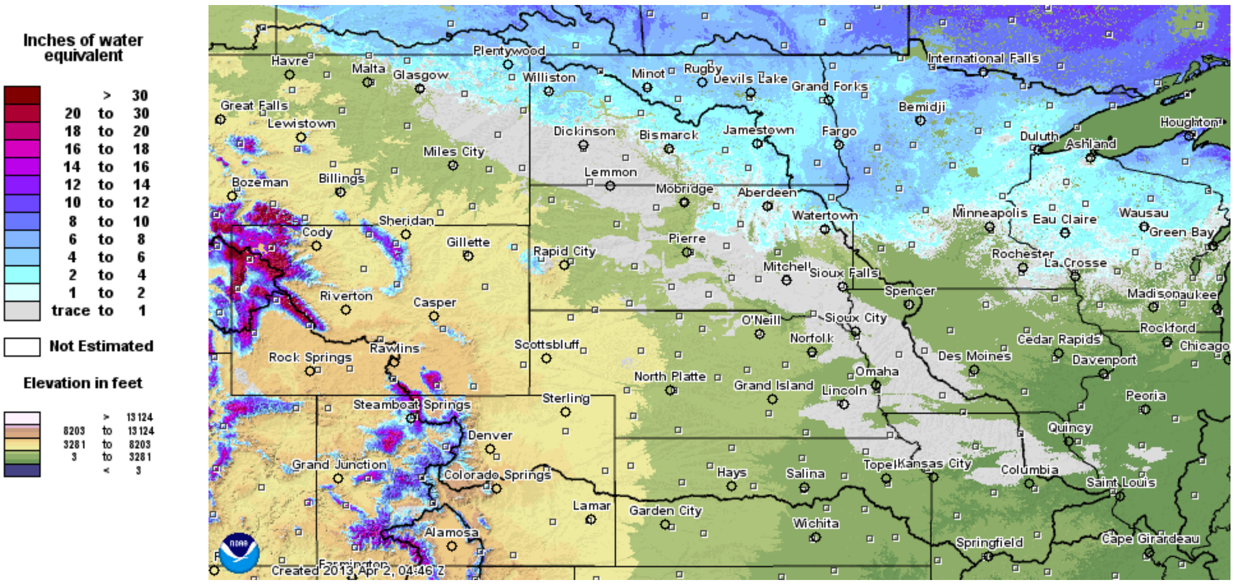


Figure 11. April 1, 2013, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Overall plains snowpack was classified as "Light" across the upper Basin according to the Corps of Engineers classification methods (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0.0 – 1.0 inch of SWE in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins. In the Garrison and Sioux City subbasins, this includes accumulations ranging from 0.0 - 2.0 inches of SWE. As of April 1, the majority of the remaining snowpack is in the Milk, upper Big Sioux, and upper James River Basins. Due to cooler-than-normal temperatures in March, little plains snowmelt and runoff occurred in these basins. Temperatures in April should initiate melting of the remaining plains snowpack and result in higher than normal runoff.

Table 1. 2013 plains snowpack classification at its maximum extent for runoff forecasting.

Reservoir Reach	Average Classification	Approximate Maximum
Above Fort Peck	Light (0 – 1 inch SWE)	2 inches
Fort Peck to Garrison	Light (0 – 2 inch SWE)	3 inches
Garrison to Oahe	Light (0 – 1 inch SWE)	2 inches
Oahe to Fort Randall	Light (0 – 1 inch SWE)	1 inch
Fort Randall to Gavins Point	Light (0 – 1 inch SWE)	1 inch
Gavins Point to Sioux City	Light (0 – 2 inch SWE)	3 inches

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. As of March 31 (see Figure 12) the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 14.2 inches, which is 90 percent of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 11.3 inches, which is 84 percent of normal based on the 1981-2010 average SWE for the Fort Peck to Garrison subbasin. Normally by April 1, 97 percent of the peak snow accumulation has occurred in the mountains.

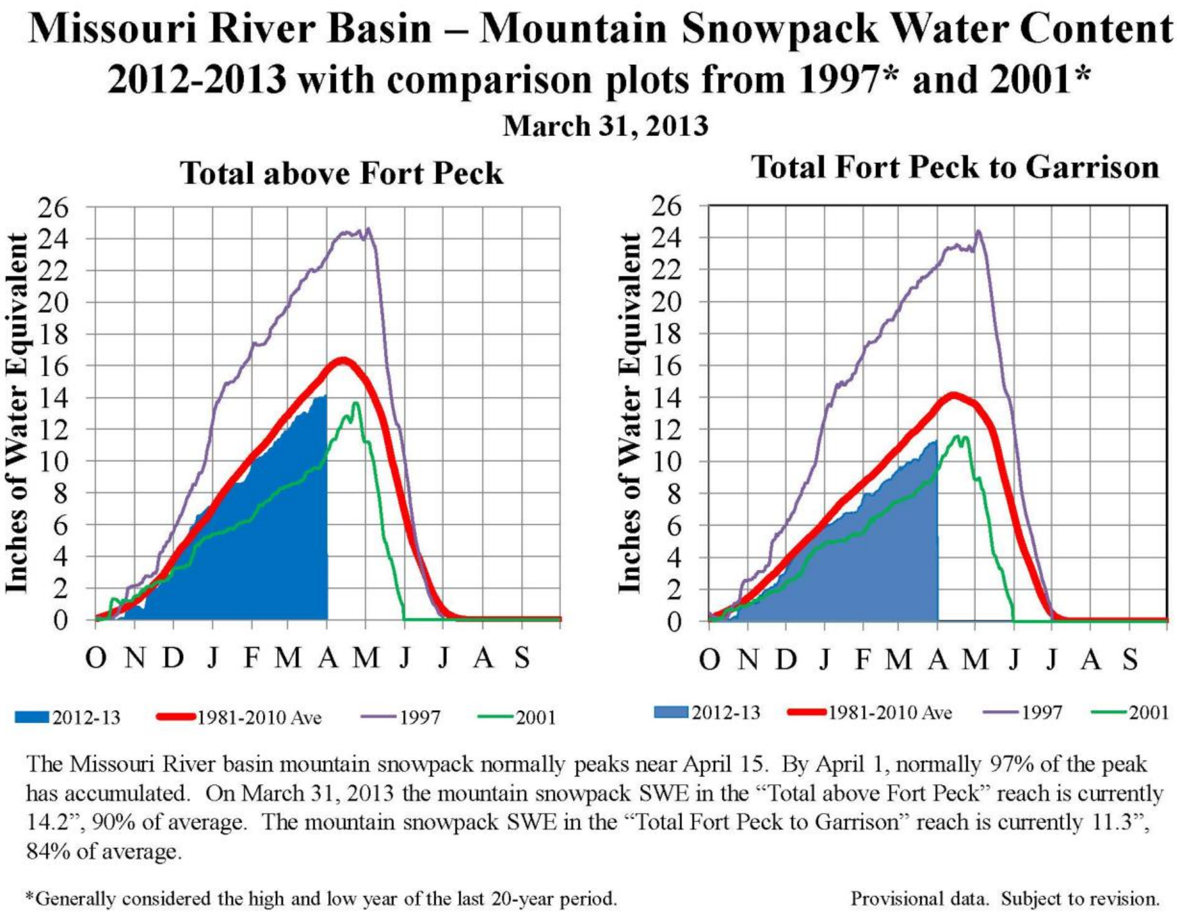


Figure 2. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific and equatorial sea surface temperatures are near average across most of the Pacific Ocean. ENSO-neutral conditions are favored in the Northern Hemisphere through summer 2013.   During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The CPC's April outlook (Figure 13) is indicating equal-chances for below-normal, above-normal, and normal temperatures for the upper Basin with the exception of North Dakota, which shows chances for below normal temperatures. The CPC's 3-month outlook for April-May-June (Figure 14) indicates probabilities ranging from increased chances for below-normal temperatures in western Montana to increased chances for above-normal temperatures in the lower Basin. The 3-month temperature outlook for June-July-August (Figure 15) indicates an increased probability for above-normal temperatures throughout most of the upper Missouri River Basin. The September-October-November temperature outlook (Figure 16) indicates an increased probability for above-normal temperatures.   With regard to precipitation, in April (Figure 13) there are equal chances for above-normal, normal and below-normal precipitation. The April-May-June precipitation outlook (Figure 14) indicates equal chances for above-normal, normal, and below-normal precipitation in much of the upper Missouri River Basin. The June-July-August precipitation outlook (Figure 15) indicates equal chances for above-normal, normal, and below-normal precipitation in the entire upper Missouri River Basin with the exception of increased chances for below-normal precipitation in western Montana. The September-October-November precipitation outlook (Figure 16) indicates equal chances for above-normal, normal, and below-normal precipitation.

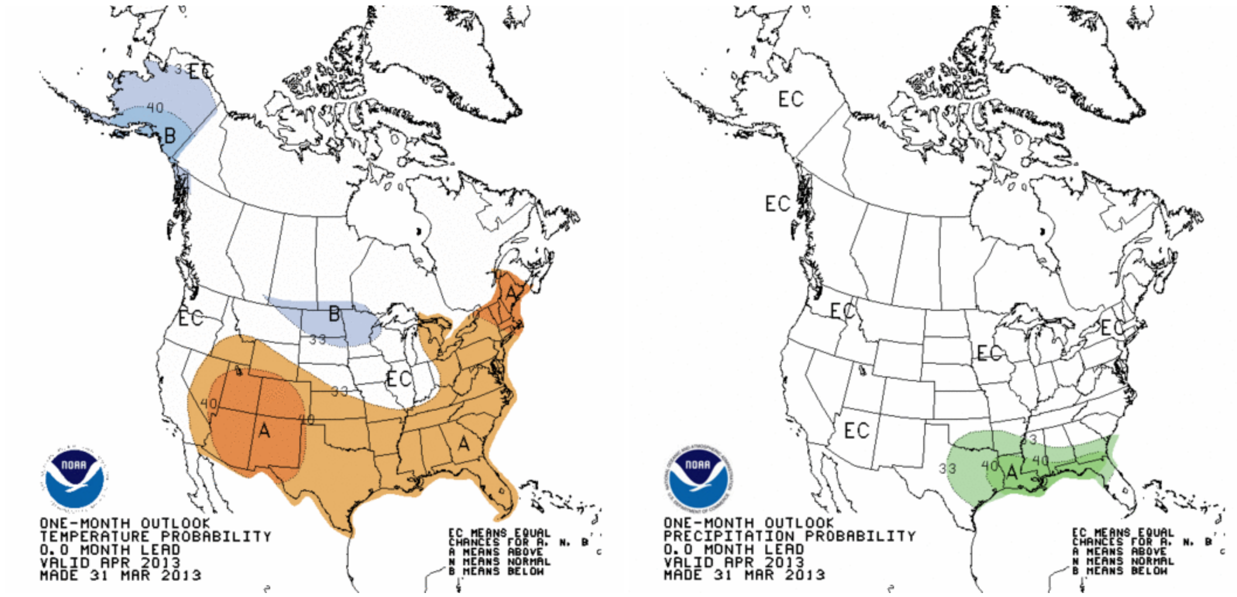


Figure 13. CPC April 2013 temperature and precipitation outlooks.

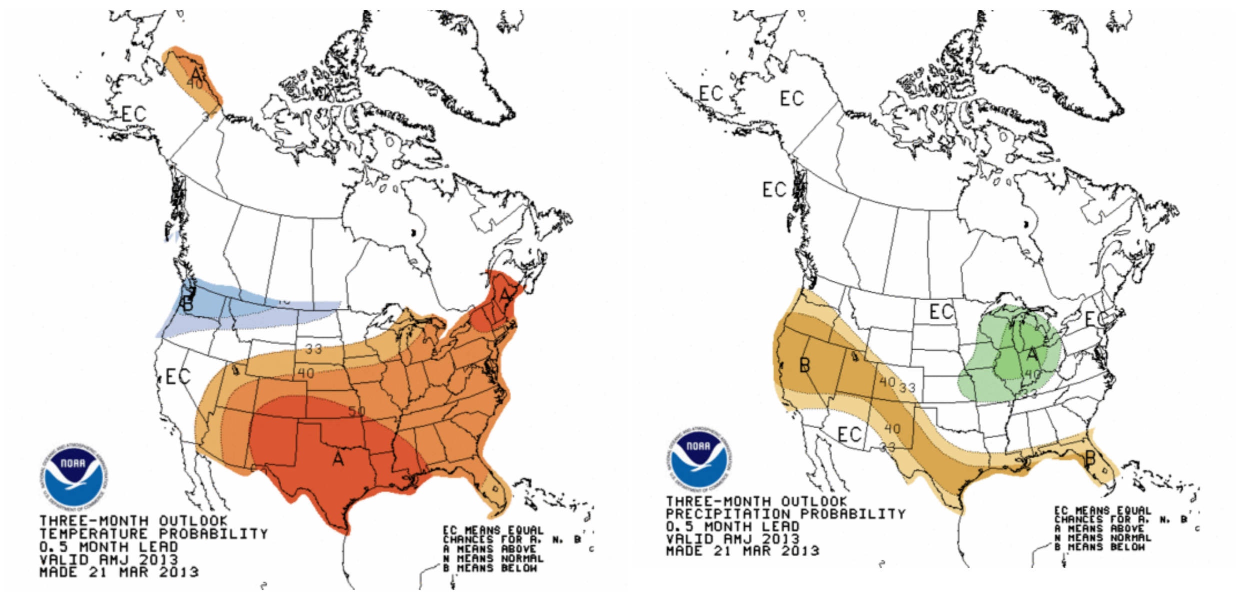


Figure 14. CPC April-May-June 2013 temperature and precipitation outlook.

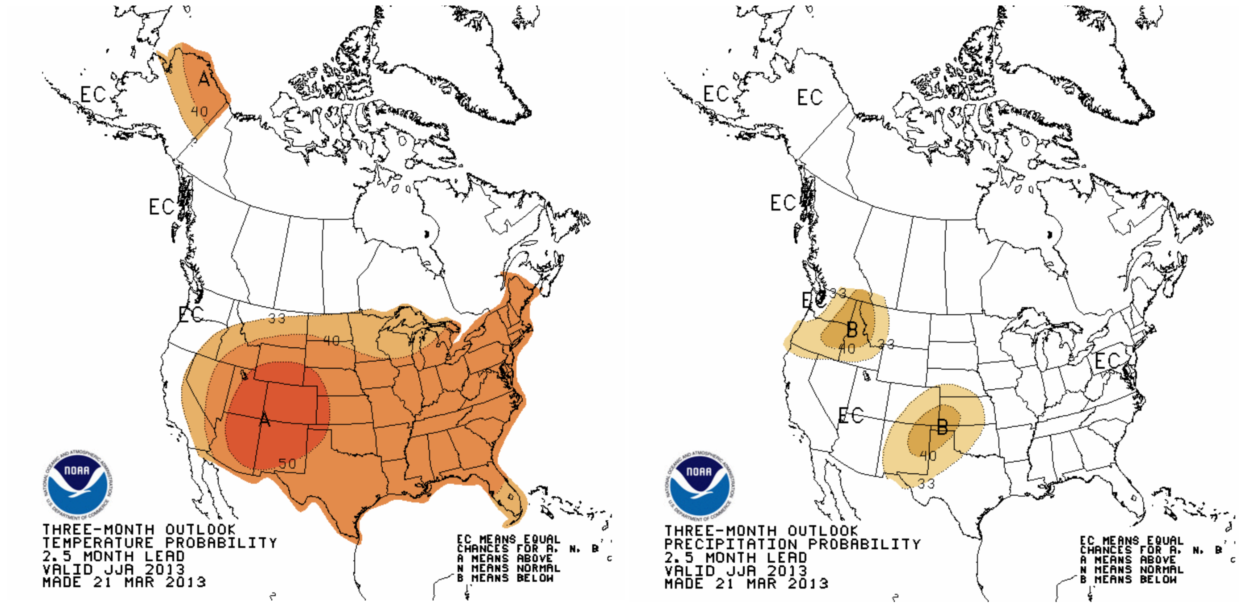


Figure 15. CPC June-July-August 2013 temperature and precipitation outlook.

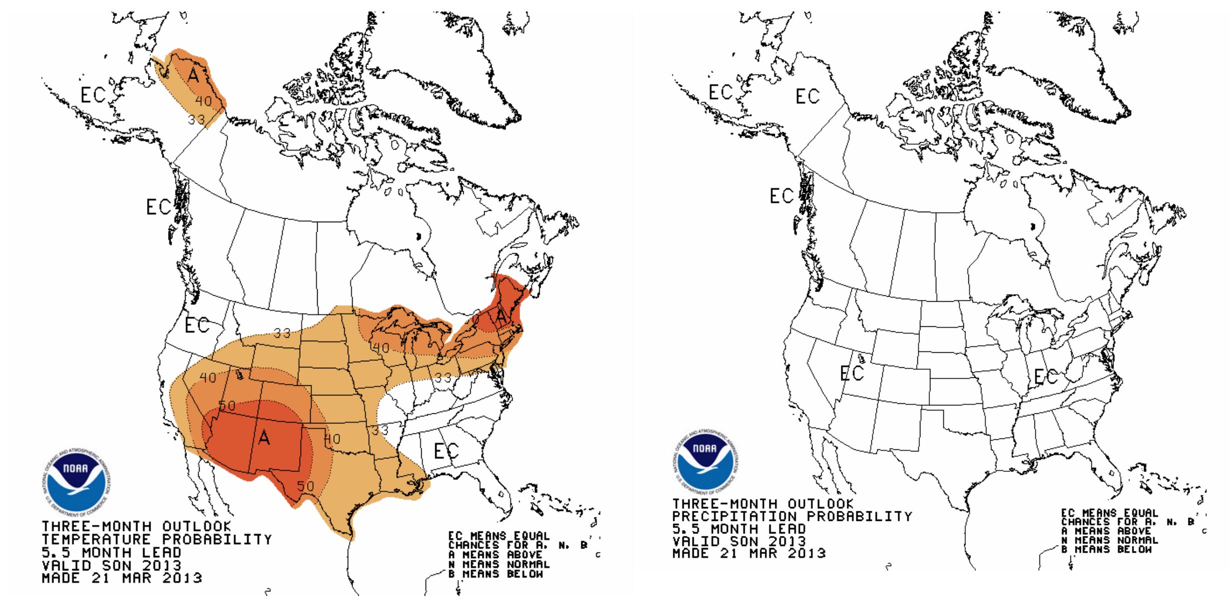


Figure 16. CPC September-October-November 2013 temperature and precipitation outlook.

March 2013 Calendar Year Runoff Forecast

The calendar year runoff forecast is 20.5 MAF (81 percent of average) above Sioux City and 18.9 MAF (82 percent of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 27.0 MAF upper basic forecast to the 14.8 MAF lower basic forecast. The upper and lower basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions.

Factors taken into consideration while preparing the 2013 forecast include continuing drought conditions in the upper Missouri River Basin, soil moisture content, antecedent precipitation, antecedent temperature conditions, plains snowpack, mountain snowpack, and the CPC's long range climate outlook.

March

Plains snow is a significant factor influencing the volume of runoff in March and April; however, precipitation and air temperature during this time period are also very important factors that need consideration. Factors taken into consideration in updating the March and April runoff forecast were: 1) the lack of plains snow cover; 2) an equal chance probability for above-normal, normal, and below-normal precipitation; and, 3) drier-than-normal soil moisture in the Dakotas and southeast Montana. During March, due to cooler-than-normal temperatures, there was little runoff from Plains snowmelt that would normally occur in a typical year. Runoff in March was only 1.6 MAF or 55% of normal.

April

The Climate Prediction Center's forecast for the first half of April indicates warmer and wetter conditions in the basin and April inflows are forecasted to be higher than normal due to the melting of the remaining plains snowpack and rainfall runoff.

May-June-July

During the May-June-July period, the mainstem system receives 50 percent of its annual runoff as a result of mountain snowmelt and spring and summer precipitation. This is the most active period for precipitation in the Basin, and so runoff can vary significantly as a result of the above-normal or below-normal rainfall.

The significance of accurately forecasting the May-June-July runoff for the Fort Peck and Garrison reaches is based on the fact that, historically, an average of 9.2 MAF of runoff occurs during these 3 months into these 2 projects, which is 37 percent of the total annual runoff into the System.

May-June-July runoff in the Fort Peck and Garrison subbasins was determined based on linear regression relationships between mountain snowpack as a percent of normal and runoff. Based on these relationships, May-June-July runoff is forecast to be 82 percent of normal above Fort Peck and 74 percent of normal in the Fort Peck to Garrison reach.

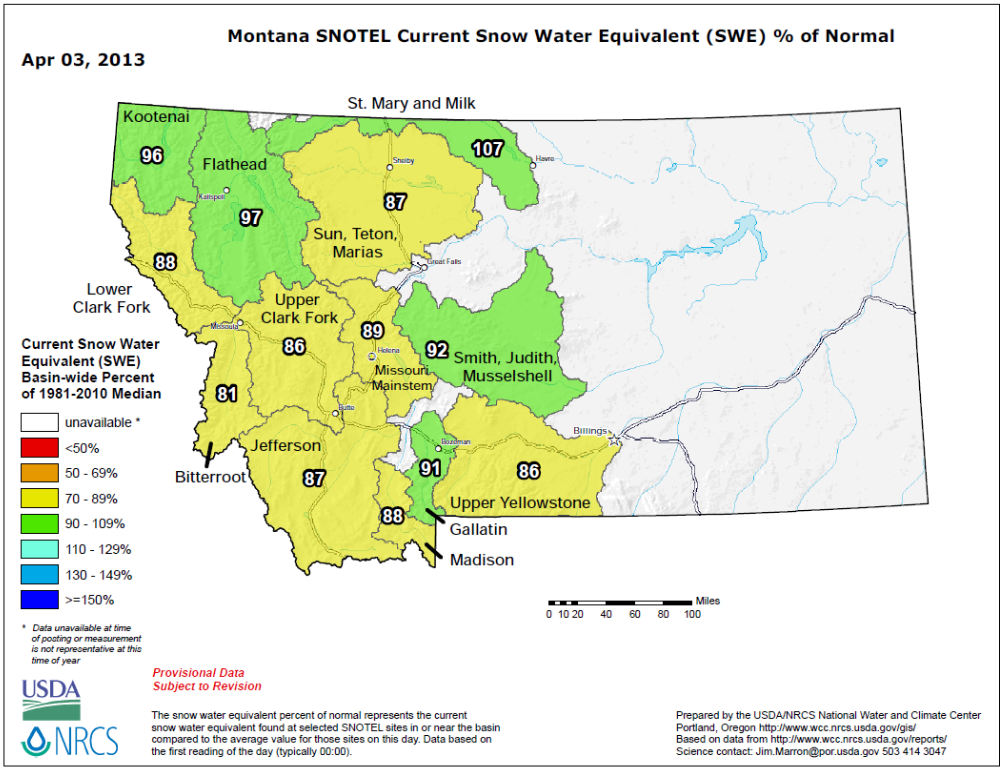
Runoff in the Oahe, Fort Randall and Gavins Point reaches is forecast to be below normal based on the fact that there is no strong climate signal that will influence the weather during the time.

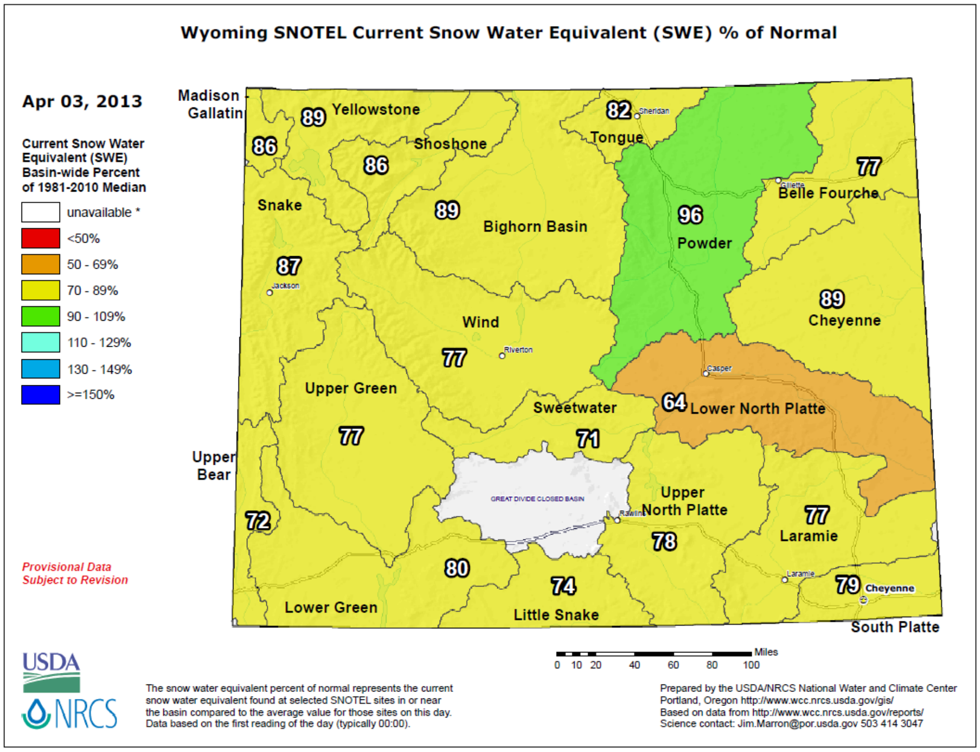
The already dry soil moisture and drought conditions in the plains are expected to persist at least into summer.

August-December

Runoff during the August-December period is expected to persist at comparable percent of normal runoff levels in all reaches. The runoff summation above Sioux City, IA ranges from 81-83 percent of normal during the August-December period. The long-lead temperature outlooks indicate increased probabilities for above-normal temperatures in the Basin, which may provide a barrier for drought recovery and the return to more runoff conditions closer to normal. The long-lead precipitation outlooks indicate precipitation chances will be equal, though there is very limited skill in long-lead precipitation forecasts.

Additional Figures





USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: April 02, 2013 08:33:06 PM
 - Based on April 01, 2013 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	102	105	116	108	96	88	97
	APR-SEP	120	107	136	127	113	104	112
St. Mary R at Int'l Boundary (2)	APR-JUL	465	107	560	505	425	370	435
	APR-SEP	535	106	635	575	495	435	505
Lima Reservoir Inflow (2)	APR-JUL	65	79	82	72	58	48	82
	APR-SEP	69	78	89	77	61	49	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	61	60	128	88	34	5.0	101
	APR-SEP	76	63	147	105	47	5.2	120
Jefferson R nr Three Forks (2)	APR-JUL	450	61	790	590	310	108	740
	APR-SEP	485	61	865	640	330	105	800
Hebgen Reservoir Inflow (2)	APR-JUL	325	88	375	345	305	275	370
	APR-SEP	415	88	475	440	390	355	470
Ennis Reservoir Inflow (2)	APR-JUL	530	85	650	580	480	410	625
	APR-SEP	665	86	800	720	610	530	775
Missouri R at Toston (2)	APR-JUL	1400	78	1970	1630	1170	830	1790
	APR-SEP	1620	78	2310	1900	1340	935	2070
Smith R bl Eagle Ck (2)	APR-JUL	99	93	151	120	78	47	106
	APR-SEP	113	97	176	139	87	50	116
Gibson Reservoir Inflow (2)	APR-JUL	350	89	430	385	315	270	395
	APR-SEP	385	88	475	420	350	295	440
Marias R nr Shelby (2)	APR-JUL	330	96	495	395	265	166	345
	APR-SEP	335	93	515	410	260	155	360
Milk R at Western Crossing	APR-JUL	31	100	54	40	22	8.1	31
	APR-SEP	33	100	58	43	23	8.0	33
Milk R at Eastern Crossing	APR-JUL	52	116	109	75	29	1.50	45
	APR-SEP	64	116	128	90	38	10.0	55

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	48	81	55	51	45	41	59
	APR-SEP	62	84	73	66	58	51	74
Wind R ab Bull Lake Ck (2)	APR-JUL	315	79	410	355	275	220	400
	APR-SEP	390	80	505	435	345	275	490
Bull Lake Ck nr Lenore	APR-JUL	112	81	148	127	97	76	139
	APR-SEP	138	82	184	157	119	92	169
Boysen Reservoir Inflow (2)	APR-JUL	390	64	725	525	255	54	610
	APR-SEP	435	65	805	585	285	64	665
Greybull R nr Meeteetse	APR-JUL	115	88	159	133	97	71	131
	APR-SEP	155	88	210	177	133	101	177
Shell Ck nr Shell	APR-JUL	47	85	61	53	41	33	55
	APR-SEP	59	89	75	66	52	43	66
Bighorn R at Kane (2)	APR-JUL	560	67	1080	770	350	110	840
	APR-SEP	600	66	1170	830	370	100	905
NF Shoshone R at Wapiti	APR-JUL	410	89	485	440	380	335	460
	APR-SEP	460	89	550	495	425	370	515
SF Shoshone R nr Valley	APR-JUL	185	86	220	200	170	148	215
	APR-SEP	215	88	260	235	197	171	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	580	86	715	635	525	445	675
	APR-SEP	650	87	810	715	585	490	745
Bighorn R nr St. Xavier (2)	APR-JUL	1000	72	1610	1250	755	390	1380
	APR-SEP	1060	73	1760	1340	780	360	1460
Little Bighorn R nr Hardin	APR-JUL	61	62	103	78	44	19.3	98
	APR-SEP	71	64	117	90	52	25	111
Tongue R nr Dayton (2)	APR-JUL	71	83	98	82	60	44	86
	APR-SEP	82	84	112	94	70	52	98
Tongue River Reservoir Inflow (2)	APR-JUL	131	68	230	171	91	32	193
	APR-SEP	151	70	255	193	109	46	215

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
NF Powder R nr Hazelton	APR-JUL	9.6	105	12.0	10.6	8.6	7.2	9.1
	APR-SEP	10.4	105	13.0	11.5	9.3	7.8	9.9
Powder R at Moorhead	APR-JUL	146	82	260	193	99	31	177
	APR-SEP	166	85	285	215	118	47	196
Powder R nr Locate	APR-JUL	164	82	300	220	108	26	199
	APR-SEP	185	84	335	245	125	37	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	APR-JUL	5.0	96	8.0	6.2	3.8	1.99	5.2
Pactola Reservoir Inflow	APR-JUL	21	95	38	28	14.2	4.1	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate	APR-JUL	100	44	193	138	62	25	225
	APR-SEP	115	46	220	158	72	30	250
Encampment R nr Encampment	APR-JUL	72	56	107	86	58	37	129
	APR-SEP	77	56	115	92	62	39	138
Rock Ck nr Arlington	APR-JUL	33	67	46	38	28	19.7	49
	APR-SEP	35	67	49	41	29	21	52
Seminoe Reservoir Inflow (2)	APR-JUL	315	44	675	460	168	115	715
	APR-SEP	350	45	750	510	189	125	770
Sweetwater R nr Alcova	APR-JUL	20	34	48	31	8.6	5.5	59
	APR-SEP	24	38	55	36	11.6	7.5	64
North Platte R bl Glendo Res (2)	APR-JUL	280	34	545	385	173	110	820
	APR-SEP	285	34	565	395	173	110	850
North Platte R bl Guernsey Res (2)	APR-JUL	265	32	595	400	132	110	820
	APR-SEP	285	34	625	425	147	110	850
Laramie R nr Woods	APR-JUL	75	65	114	91	59	36	115
	APR-SEP	83	66	127	101	65	39	126
Little Laramie R nr Filmore	APR-JUL	28	55	44	35	21	11.6	51
	APR-SEP	30	55	49	38	22	11.4	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of averagef average

Upper Missouri River Basin
Calendar Year Runoff Forecast
May 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of May 1, 2013 is 20.0 MAF (79 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 18.5 MAF (81 percent of normal). Above Sioux City, this is a decrease of 0.5 MAF from the April runoff forecast. Although precipitation in April was well above normal in much of the upper Missouri River Basin, observed April runoff was 2.3 MAF (78 percent of normal) in the upper Missouri River Basin (Basin) above Sioux City, IA and 2.1 MAF (83 percent of normal) above Gavins Point Dam. The discrepancy between above normal precipitation and below normal runoff is most likely due to the large soil moisture deficits in the upper Basin, a result of the 2012 drought.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 8 months, the range of expected inflow is quite large and ranges from the 27.1 MAF upper basic forecast to the 13.9 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's (NDMC) U.S. Drought Monitor for April 23, 2013 and March 26, 2013 are shown in Figure 1. Drought conditions as of April 23, 2013 impact much of the upper Basin with the exception of the northern half of Montana and the western half of North Dakota. Elsewhere, drought conditions range from Moderate (D1) to Extreme (D3) with small areas where conditions are Exceptional (D4). Drought conditions in the state of Missouri are almost absent with the exception of some lingering areas in northwest Missouri. Compared to March 26, 2013 current drought conditions improved significantly due to April precipitation in the Basin. In the High Plains region, which includes Wyoming, Colorado, North Dakota, South Dakota, Nebraska and Kansas, the area covered by Exceptional (D4) decreased from 22 to 7 percent. The area covered by Extreme (D3) (including D4) decreased from 55 to 38 percent. Also the area covered by Severe (D2) (including D3 and D4) decreased from 81 to 70 percent. In Montana, there was a small change to overall drought as the area covered by Severe (D2) (including D3 and D4) decreased from 20 to 12 percent.

The U.S. Seasonal Drought Outlook shown in Figure 2 will continue to improve in all areas of the Basin east of the Missouri River including a portion of eastern Nebraska west of the river. Some limited improvement is expected in central and western Nebraska, South Dakota, southeast Montana and eastern Wyoming. In the Rocky Mountains, including central and western Wyoming and southern Montana, drought conditions will likely persist through July 31, 2013.

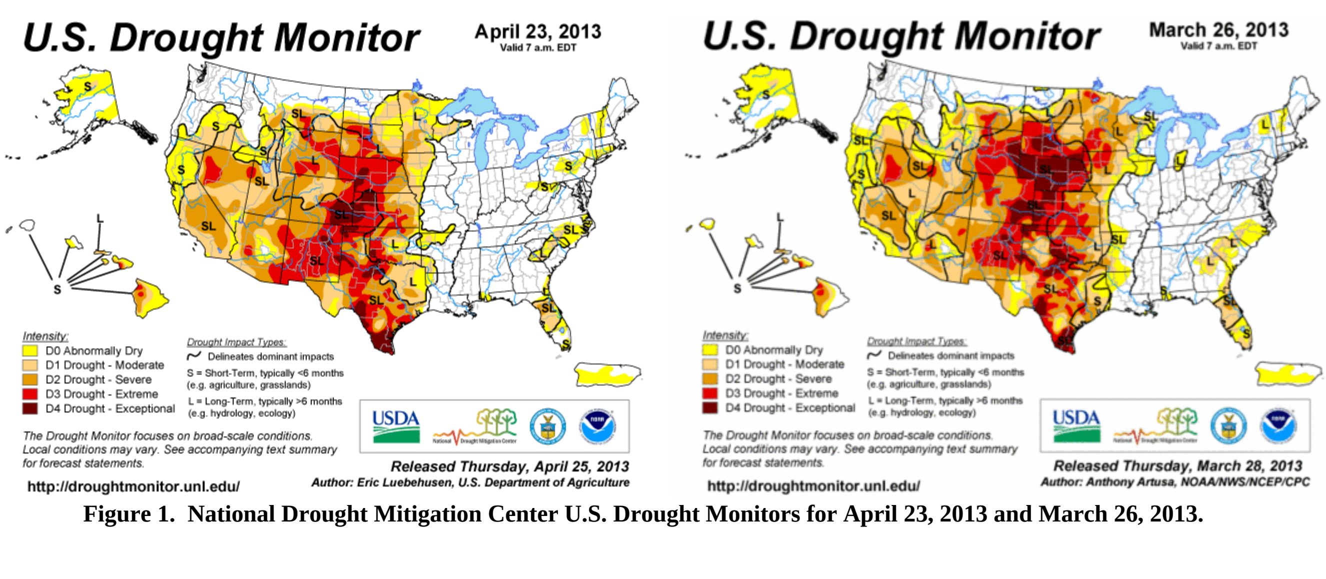


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for April 23, 2013 and March 26, 2013.

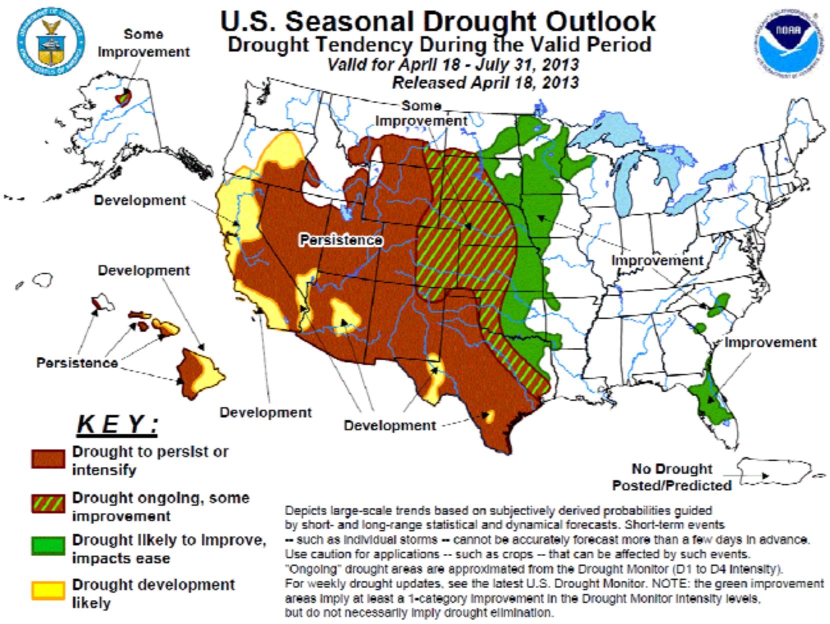


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of April is shown in Figure 3. Precipitation was heaviest in Wyoming and South Dakota in the upper Basin, and much of the lower basin as a result of four spring storms that produced moderate to heavy rainfall and heavy snow to some areas. Total precipitation during April ranged from 1-3 inches (25-76 mm) in Montana and Wyoming, with heavier precipitation ranging from 3-5 inches (76-127 mm) in the Rocky Mountains. South Dakota received the brunt of the precipitation in the upper Basin with precipitation amounts ranging from 2-5 inches (51-127 mm). Precipitation in the lower Basin was much greater ranging from 4-6 inches (102-152 mm) in many areas with as much as 10 inches (254 mm) in a small portion of north central Missouri.

The precipitation departure from normal is shown in Figure 4. Actual departures from normal were as much as 2 inches (51 mm) above normal in northeast Montana, South Dakota, and portions of south central and south eastern North Dakota. Where rainfall was heavier in the lower Basin, departures were as much as 3-5 (76-127 mm) inches above normal. The 90-day precipitation departure (Figure 5) ending on April 30, 2013 shows near normal precipitation (plus/minus 1 inch) over a majority of the upper Basin. Broad areas that received greater than normal precipitation in excess of 2 inches (51 mm) include northeast Montana and eastern South Dakota. These departures are similar to the April 2013 precipitation indicating that April precipitation has been the main contributor of precipitation in excess of normal over the past 90 days.

During April, some significant precipitation events included:

- 28.2 inches of snow at the Rapid City Airport April 8–11
- 2-3 inches (51-76 mm) of rainfall across northeast Nebraska April 8-11
- 17.3 inches of snow in Bismarck, ND recorded April14 (all-time daily record)
- 3-5 inches of rainfall (76-127 mm) April 16-18 in the lower Basin
- 10-12 inches of snow in the Black Hills and 6-8 inches of snow in Wyoming, South Dakota and Nebraska April 22-24.

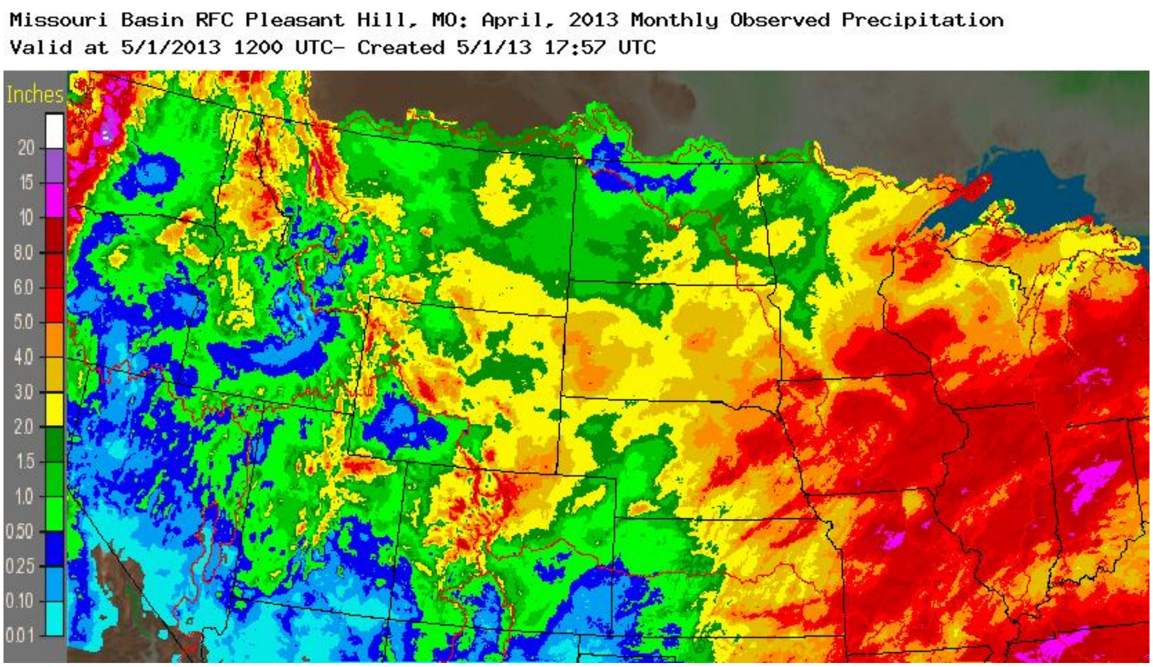


Figure 3. April 2013 precipitation (inches).

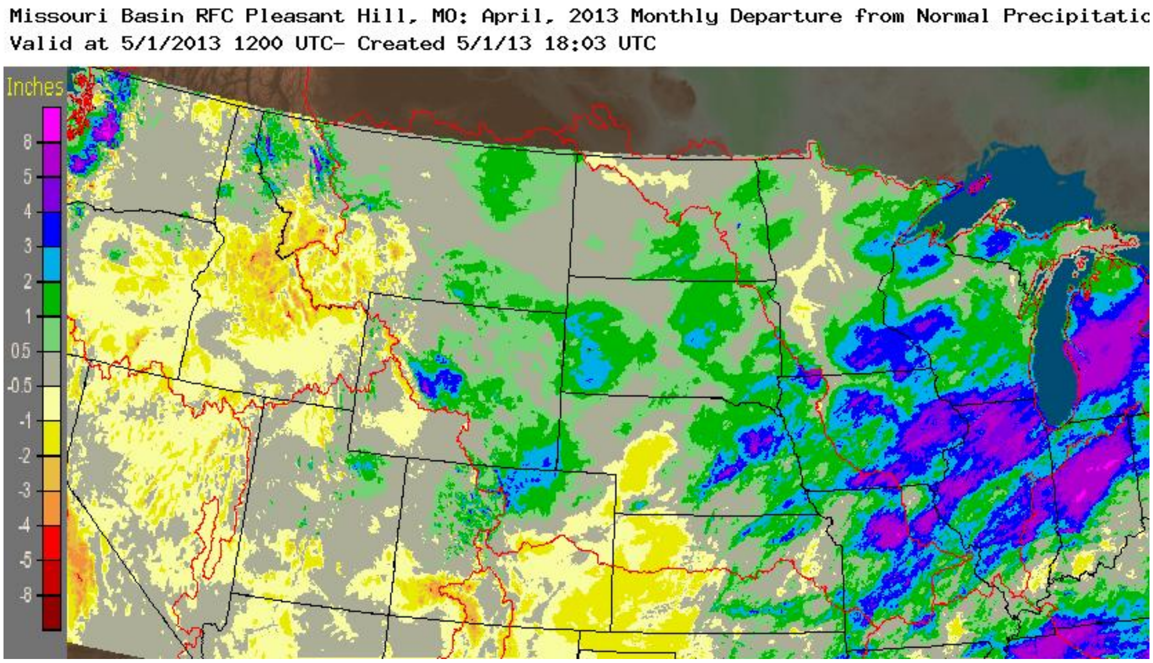


Figure 4. April 2013 precipitation departure (inches) from normal.

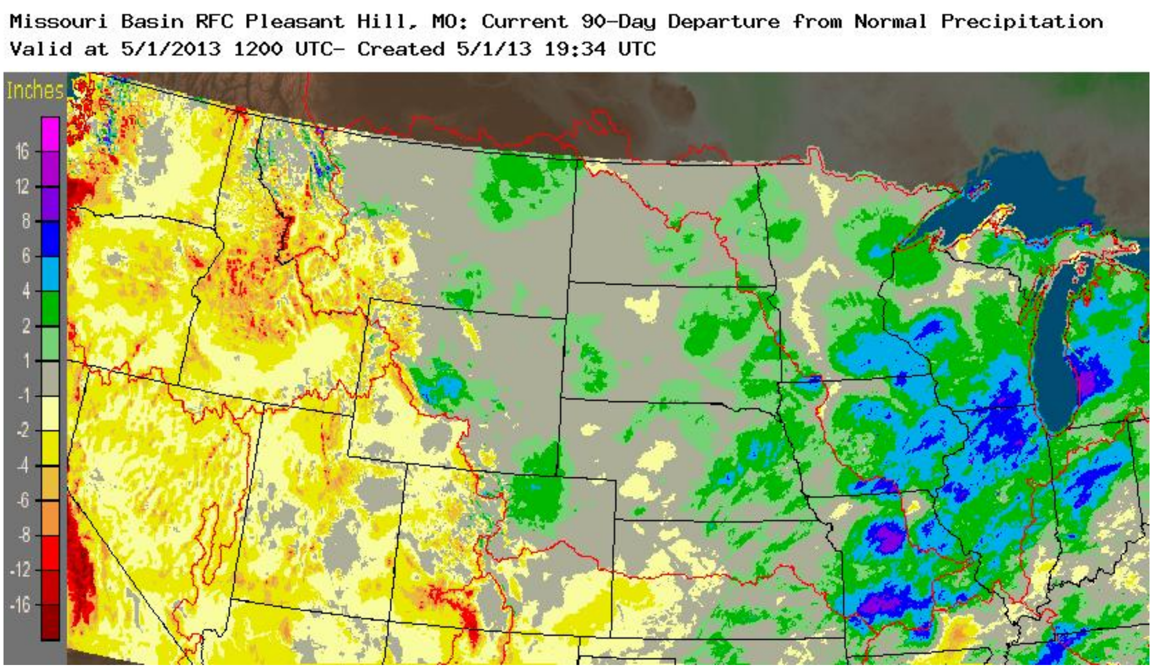


Figure 5. 90-day precipitation departure (inches) from normal, ending on April 30, 2013.

Temperature

Average temperatures throughout most of the upper Basin during the April 2013 were generally 6-8 degrees F below normal (Figure 6). April departures in the Rocky Mountains were about 2-5 degrees F below normal. In North Dakota and South Dakota, departures were greater than 8 degrees F below normal. Ninety-day (90-day) temperature departures ending at the end of April are shown in Figure 7. The 90-day temperature departure map shows below normal temperatures as well ranging from 3-7 degrees F below normal in the plains and 0-2 degrees F below normal in the Rocky Mountains.

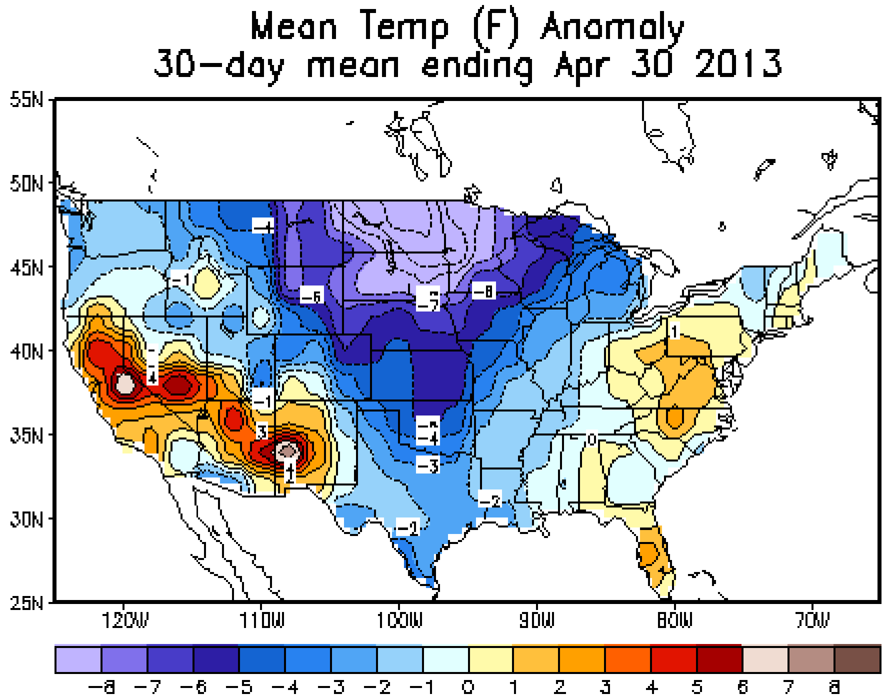


Figure 6. 30-day temperature departures (degrees F) from normal.

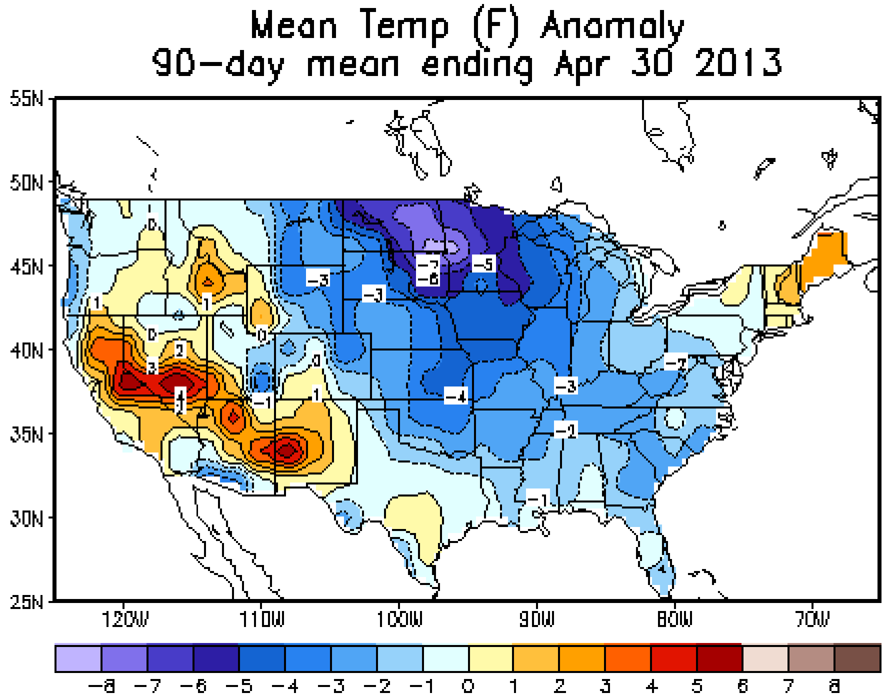


Figure 7. 90-day temperature departures (degrees F) from normal.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet, or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry, or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

In spite of above normal precipitation falling on the upper Basin in April and below normal temperatures, the observed below runoff indicates that much of the precipitation infiltrated and resulted in increased soil moisture storage rather than produce much runoff. As of May 1, soil moisture conditions in the upper Basin remain below normal, and future precipitation will continue to aid the recovery of soil moisture and drought conditions. Soil moisture conditions are discussed in more detail in the following paragraphs.

Two independent estimates of soil moisture are presented in this report. Figures 8 -10 illustrate the NOAA Climate Prediction Center's (CPC) calculated soil moisture ranking percentiles (Figure 8), calculated soil moisture anomaly (Figure 9) and the calculated soil moisture anomaly change (Figure 10). Figure 11 shows the University of Washington's Variable Infiltration Capacity (VIC) model soil moisture percentiles and Figure 12 shows the VIC models soil moisture percentile change since the end of March.

The current status of the soil is represented by the soil moisture percentile ranking in Figure 8 and Figure 11. Both soil moisture rankings depict dry soil moisture conditions throughout much of the upper Basin. The driest conditions depicted in Figure 8 range from the 1st to 5th percentile centered in south central Montana and western Nebraska. Furthermore the CPC calculated soil moisture anomaly is shown in Figure 9. In spite of the recent above normal precipitation in the upper Basin, widespread negative soil moisture anomalies still exist within the upper Basin especially in Nebraska, North Dakota, South Dakota, Wyoming and south central Montana. Soil moisture anomalies in these areas range from 40-80 mm (1.6-3.1 inches) below normal. Positive soil moisture anomalies exist in Missouri.

According to the VIC model in Figure 11, the driest conditions (less than the 5th percentile) are present in western Nebraska, southwestern Montana, north central Wyoming, northern South Dakota, and southeast North Dakota. In contrast soil moisture conditions are wetter than normal in the lower basin in eastern Nebraska, western Iowa, and Missouri. Soil moisture conditions in Missouri rank from the 80th to 95th/98th percentiles.

Over the last month soil moisture anomalies improved as a result of the melt of existing and new snow and the occurrence of heavy rainfall in the lower Basin. The change is illustrated via CPC anomaly graphic (see Figure 10). Reduction in soil moisture anomalies ranged from 10-20 mm (0.4-0.8 inch) across Wyoming, South Dakota, and Nebraska; however, the CPC model indicated very little change across North Dakota and Montana. The lack of runoff in the upper Basin during April indicates surface soils stored much of the precipitation and snowmelt in the soil profile. Reductions in the lower Basin were much greater, ranging from 30-80 mm (1.2-3.1 inches) of soil moisture, resulting in positive soil moisture anomalies in Missouri (Figure 9).

The VIC model showed increases in soil moisture represented as soil moisture percentile change (Figure 12). Increases in soil moisture percentile ranking ranged from 25 to 45 percentile rankings in eastern Wyoming, western South Dakota, eastern Nebraska and Iowa. Although significant improvement occurred, the VIC model indicates soil moisture conditions are still below normal (Figure 11).

As an indicator of future monthly runoff, low soil moisture percentile rankings (Figures 8 and 11), which signify ongoing soil moisture deficits, suggest runoff may continue to be below average throughout the upper Basin. Rainfall and snowmelt runoff in the upper Basin was not adequate enough to restore soil moisture conditions to normal conditions. In contrast, April rainfall in the lower Basin made drastic improvements to the soil moisture conditions, especially in Missouri, where soil moisture conditions are wetter than normal. As a result, runoff potential in the lower Basin is greater than normal.

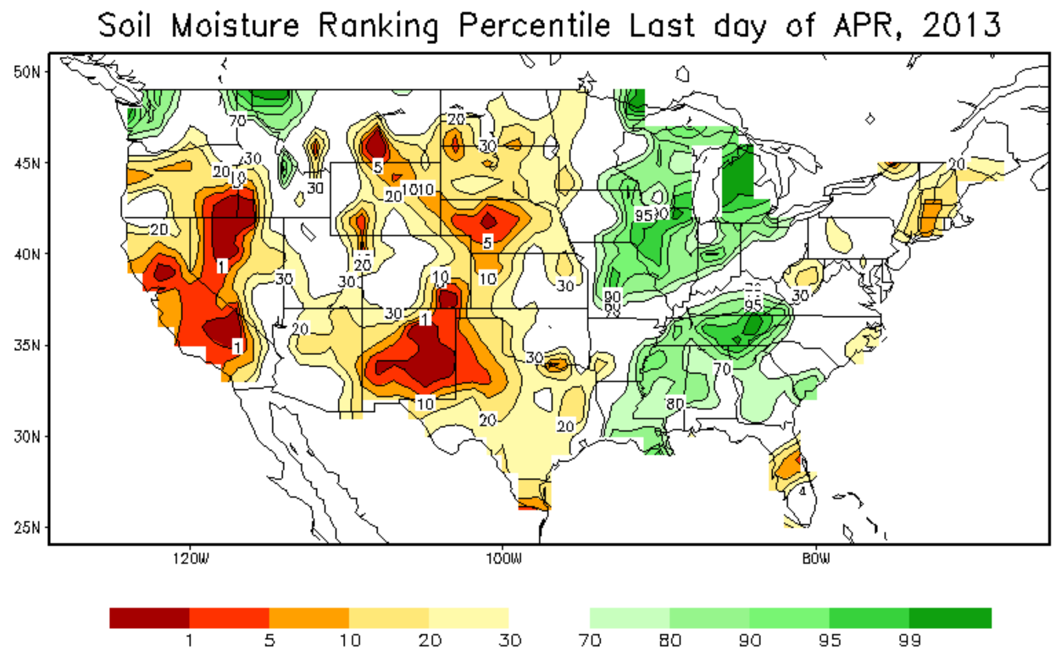


Figure 8. Calculated Soil Moisture Ranking Percentile on April 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

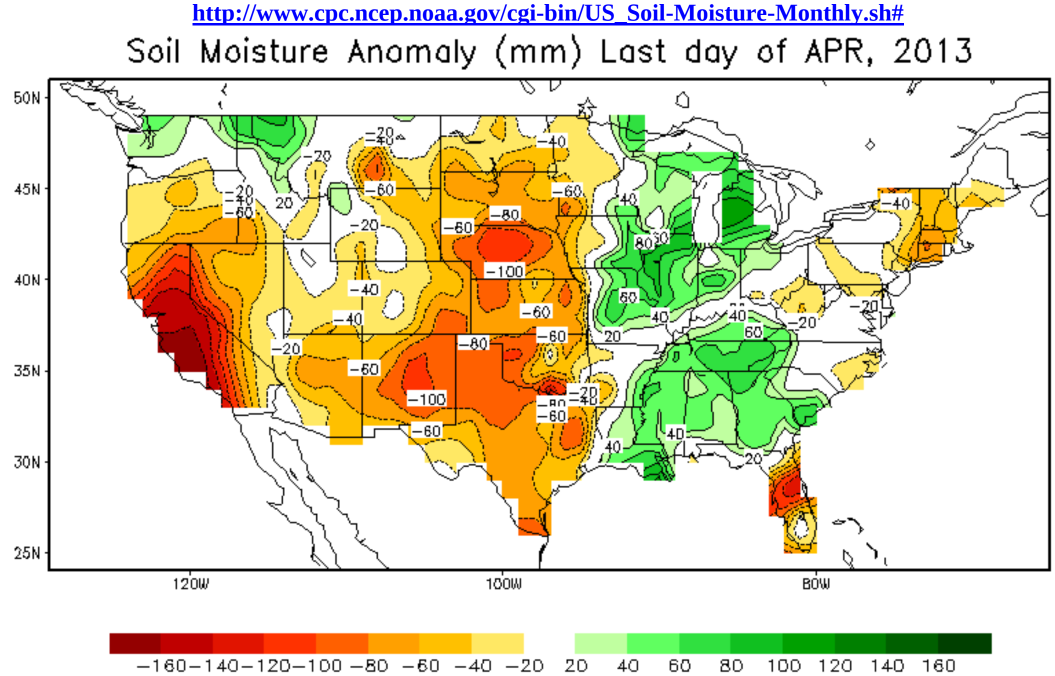


Figure 9. Calculated Soil Moisture Anomaly in on April 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

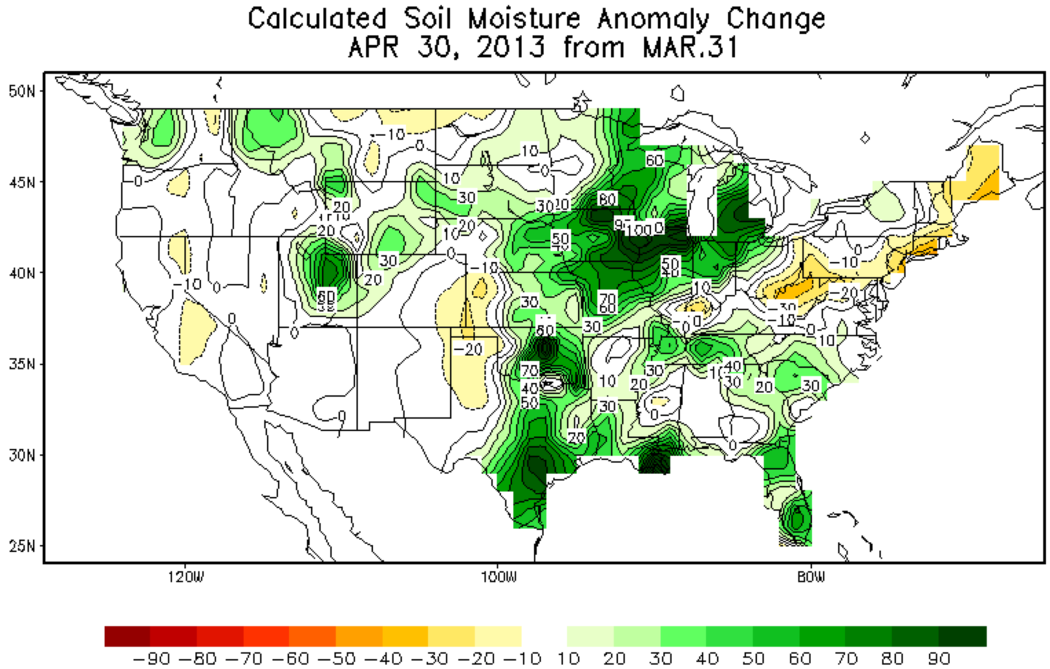


Figure 10. Calculated Soil Moisture Anomaly Change on April 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

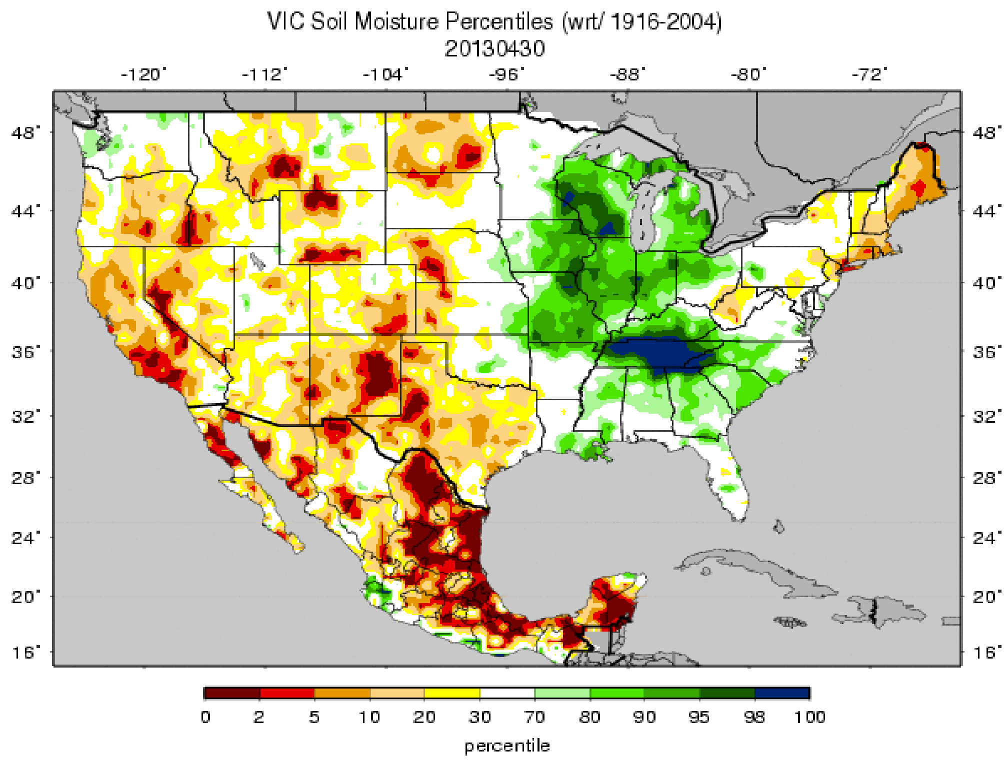


Figure 11. VIC modeled soil moisture percentiles as of April 30, 2013. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/index.shtml

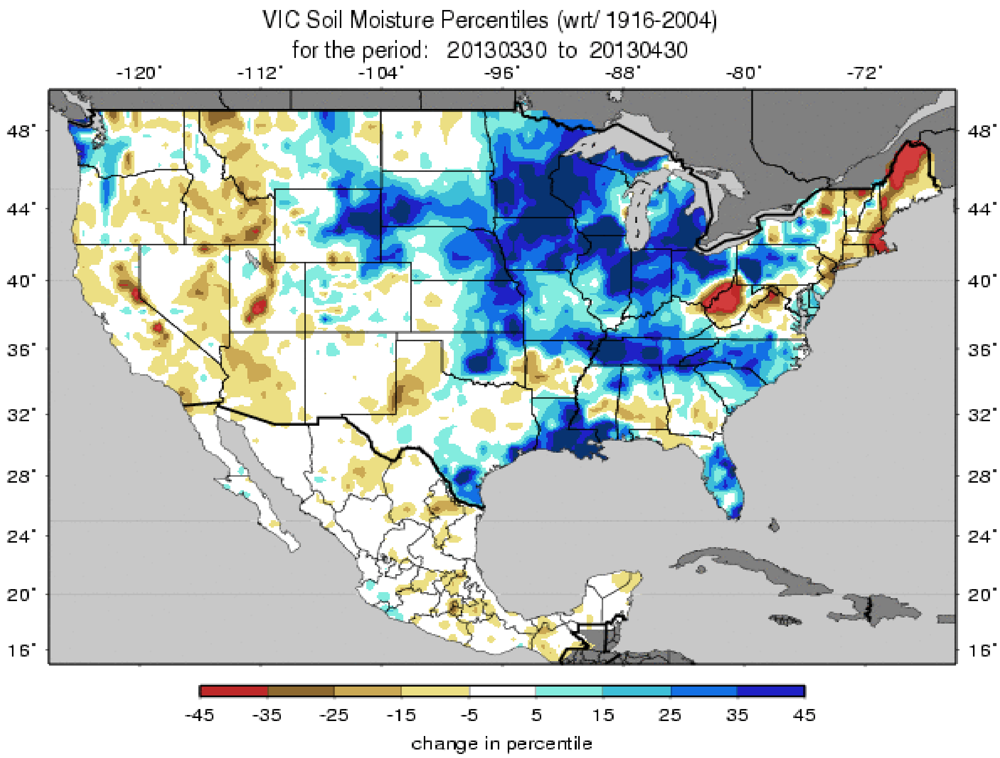


Figure 12. VIC modeled soil moisture percentile change as of April 30, 2013. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/index.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25 percent of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt.

The plains snow peaked in extent and depth in late March. SWE at that time ranged from 0-2 inches with an average of about 1 inch of SWE. Field measurements indicate the heaviest areas of snow in and along the northern watershed boundary of the Basin range from 2-3 inches of SWE. These areas included northeastern Montana, northern and eastern North Dakota, and northeast South Dakota.

According to the National Weather Service (NWS) National Operational Hydrologic Remote Sensing Center (NOHRSC), the upper Basin plains region was no longer snow covered on May 1, 2013 (Figure 11). Although temperatures have been well below normal in the Northern Plains, steady increases in temperatures allowed snowmelt to occur gradually throughout April, limiting the amount of runoff that could occur due to snowmelt. The very dry soil moisture conditions in the Northern Plains absorbed much of the snowmelt. Additional snow precipitation and melt was also absorbed by very dry plains soils.

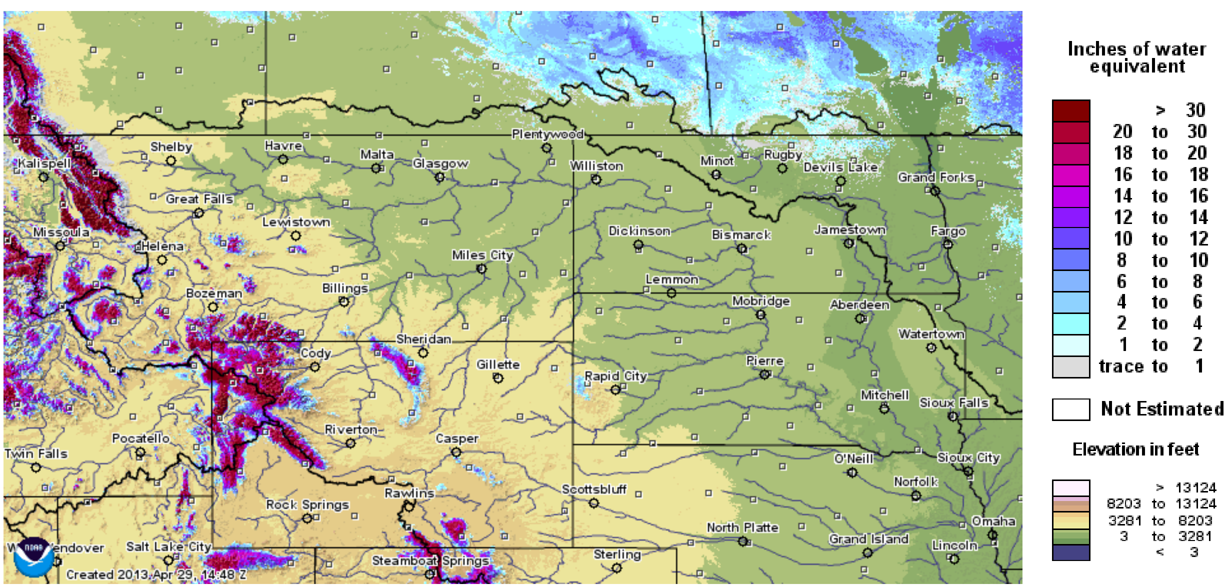


Figure 13. May 1, 2013, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. The Missouri River basin mountain snowpack normally peaks near April 15. Due to above normal precipitation and colder than normal temperatures in April, mountain snowpack continued to increase after April 15.

On April 30, 2013 (Figure 14) the mountain snowpack SWE in the reach above Fort Peck was 14.1 inches, 93 percent of average for April 30. It appears the mountain snowpack SWE above Fort Peck peaked on April 23 at 15.4 inches, 95 percent of the normal April 15 peak as a result of the colder-than-normal temperatures during April. On April 30, 2013 the mountain snowpack SWE in the Fort Peck to Garrison reach was 12.5 inches, 92 percent of average for April 30. It appears the mountain snowpack SWE between Fort Peck and Garrison peaked on April 25 at 13.5 inches, 95 percent of the normal April 15 peak.

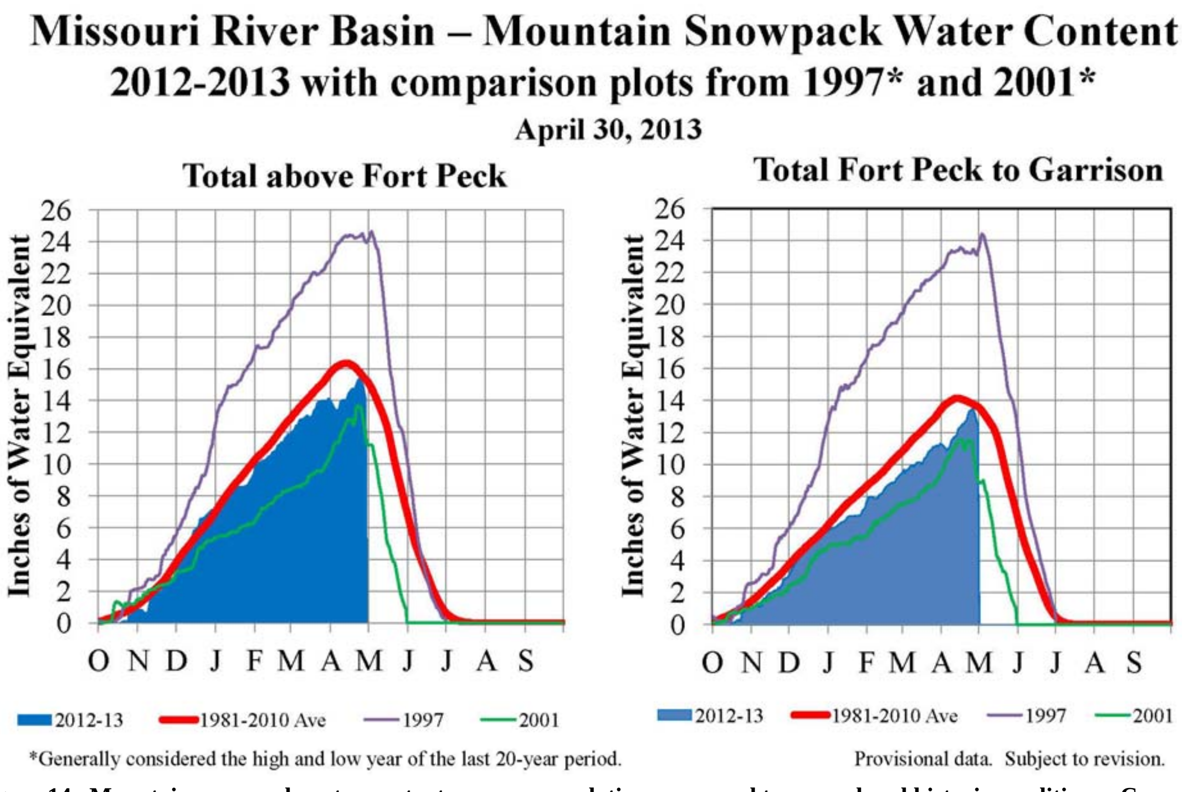


Figure 14. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific and equatorial sea surface temperatures are near average across most of the Pacific Ocean. ENSO-neutral conditions are favored in the Northern Hemisphere through summer 2013. During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's May temperature outlook (Figure 15) is indicating an increased chance for above normal temperatures in the Rocky Mountains, equal chances in much of the plains, and increased chances for below normal temperatures in northeast North Dakota and the lower Basin. The CPC's 3-month temperature outlook for May-June-July (Figure 16) indicates equal chances for above normal, normal and below normal temperatures in Montana, North Dakota and the northern half of South Dakota, while there are increased chances for above normal temperatures in the remainder of the upper Basin. Temperature chances are similar during the August-September-October outlook period (see Figure 17). The 3-month temperature outlook for November-December-January 2014 (Figure 18) indicates limited change in the temperature pattern. There are equal chances for above normal, normal and below normal temperatures in Montana and much of Wyoming; however, there is an increased probability for above normal temperatures in the remainder of the Basin.

The CPC's May precipitation outlook (Figure 15) is indicating increased chances for below normal precipitation in much of Montana and Wyoming with equal chances for above normal, normal, and below normal precipitation for the remainder of the upper Basin. There is an increased chance for above normal precipitation in a portion of the lower Basin and is centered over Iowa. The CPC's 3-month precipitation outlook for May-June-July (Figure 16) indicates an increased chance for below normal precipitation in much of Montana and Wyoming, while there are equal chances for above normal, normal and below normal precipitation in the remainder of the Basin. Precipitation chances are similar during the August-September-October outlook period (see Figure 17). The 3-month precipitation outlook for November-December-January 2014 (Figure 18) indicates equal chances for above normal, normal and below normal precipitation across the Basin.

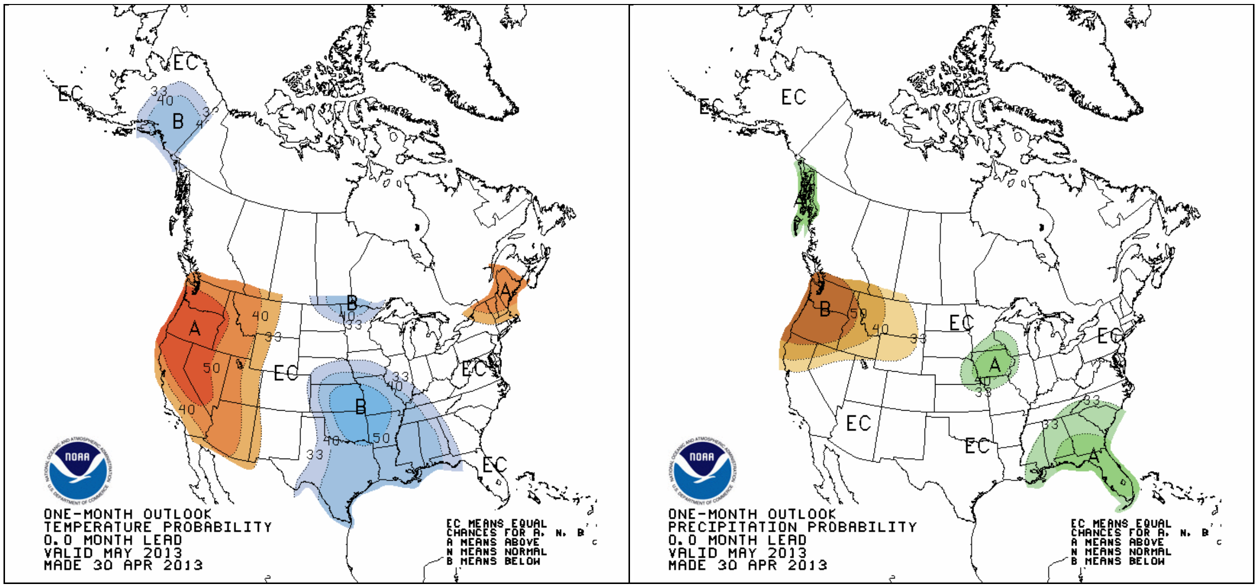


Figure 15. CPC May 2013 temperature and precipitation outlooks.

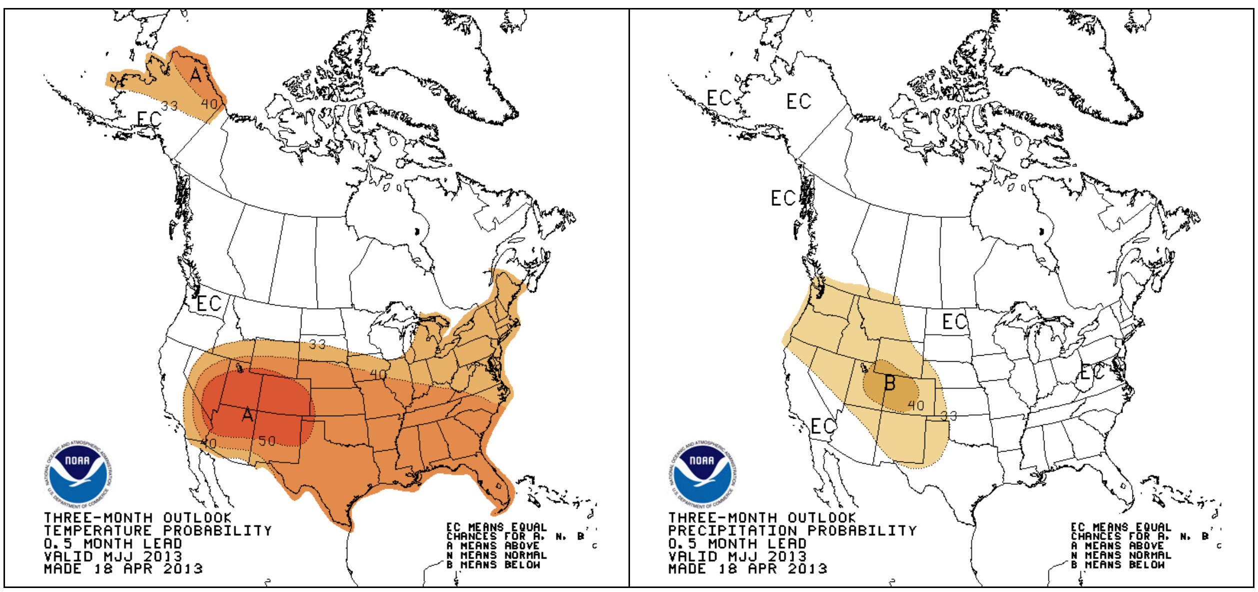


Figure 16. CPC May-June-July 2013 temperature and precipitation outlooks.

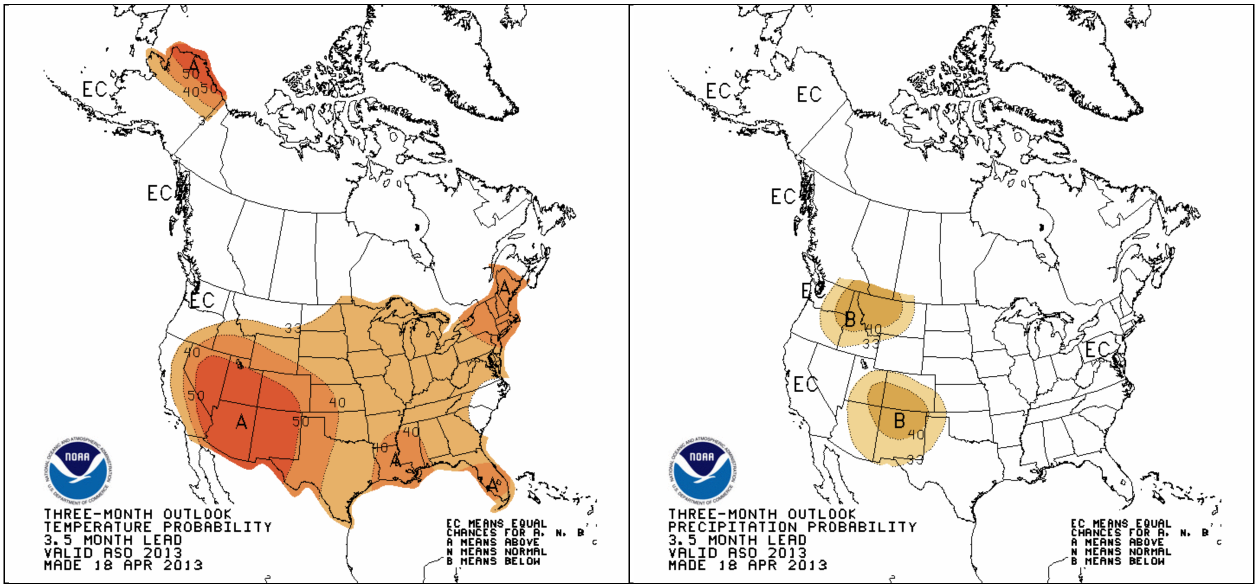


Figure 17. CPC August-September-October 2013 temperature and precipitation outlooks.

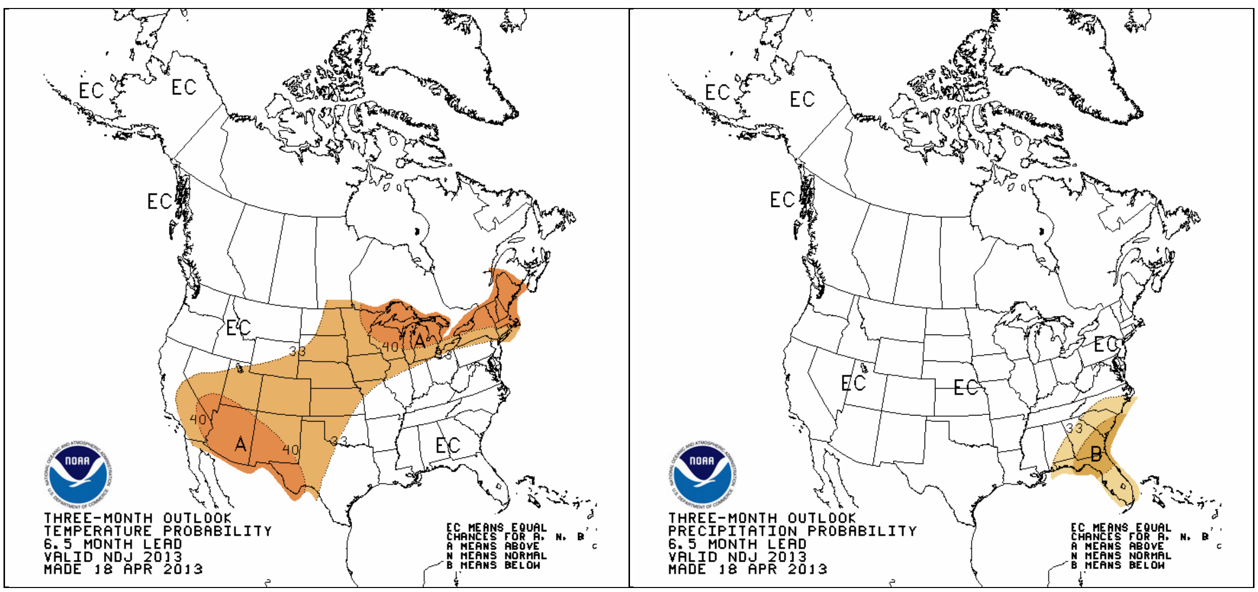


Figure 18. CPC November-December-January 2013 temperature and precipitation outlooks.

<u>May 2013 Calendar Year Runoff Forecast</u>

The annual runoff forecast as of May 1, 2013 is 20.0 MAF (79 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 18.5 MAF (81 percent of normal). Above Sioux City, this is a decrease of 0.5 MAF from the April forecast. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 8 months, the range of expected inflow is quite large and ranges from the 27.1 MAF upper basic forecast to the 13.9 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively.

April runoff was 2.3 MAF (79 percent of normal) in the upper Basin above Sioux City, IA and 2.1 MAF (83 percent of normal) above Gavins Point Dam. April runoff fell short of the April 1 runoff forecast by 1.2 MAF. The very dry soil moisture conditions described earlier in the summary absorbed much of the snowmelt from existing and new snow in April. Additionally, precipitation rates in the upper Basin were not high enough to exceed soil infiltration rates in the upper Basin.

May-June-July

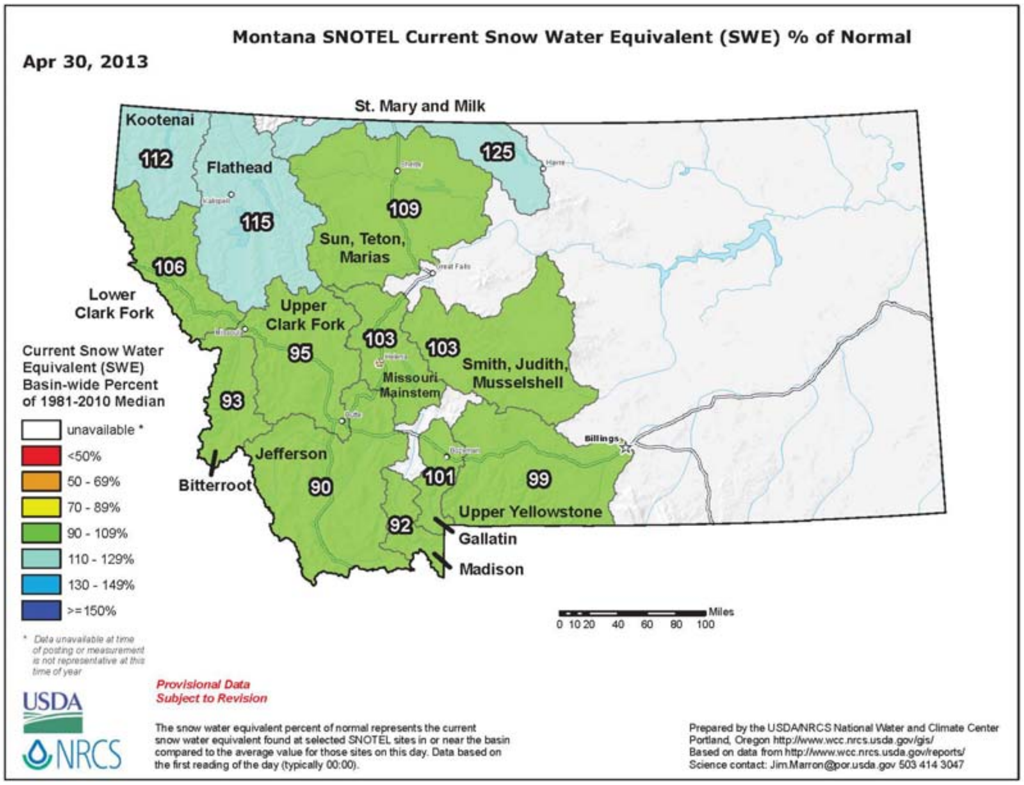
As of May 1, 2013 all plains snow had melted and much of the snowmelt infiltrated into the pre-existing dry soils. The mountain snowpack above Fort Peck peaked at 95 percent of normal on April 23, while the snowpack from Fort Peck to Garrison peaked at 95 percent of normal on April 25. May-June-July runoff in the Fort Peck and Garrison subbasins was determined based on linear regression relationships between peak mountain snowpack and runoff. The Fort Peck runoff in May-June-July is expected to be 86 percent of normal, while the runoff into Garrison is expected to be 79 percent of normal. The May-June-July climate outlook is indicating an increased probability for above normal temperatures in Wyoming with equal chances in Montana. The precipitation outlook indicates an increased probability for below normal precipitation.

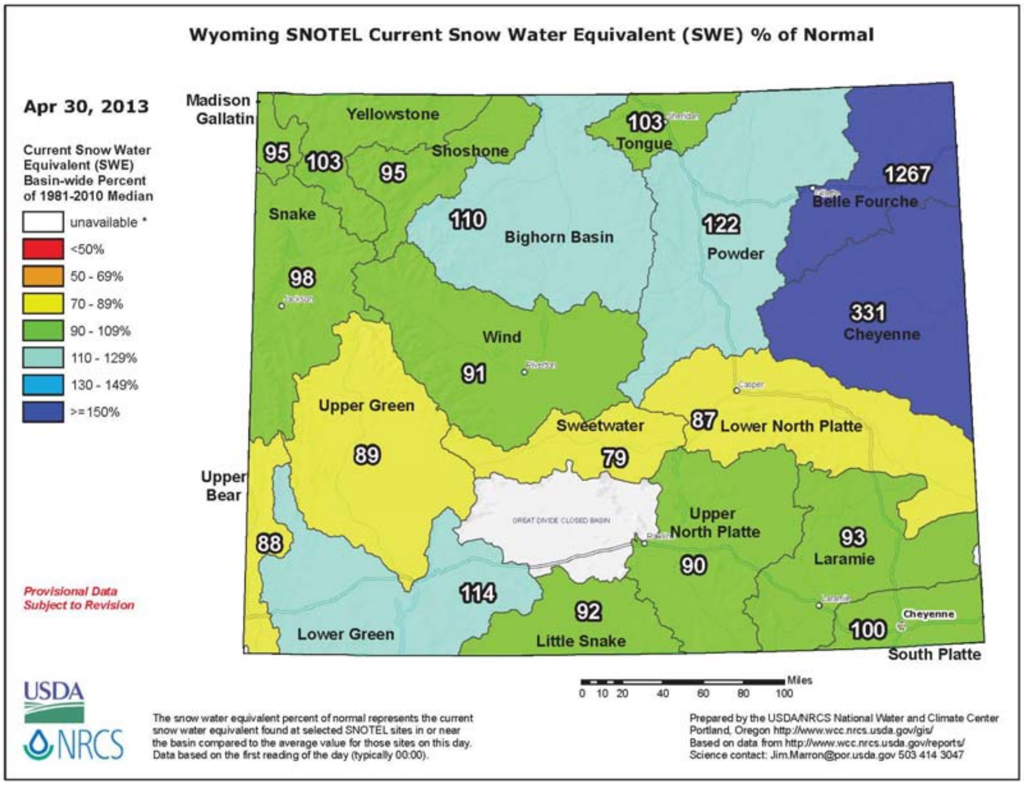
Given that soil moisture anomalies in the Oahe, Fort Randall, Gavin Point and Sioux City reaches range from 40-80 mm below normal, the runoff potential for these reaches is also below normal. The plains snowmelt helped improve soil moisture conditions; however, runoff during April was well below normal. Given the temperature and precipitation outlook that favor warm and dry conditions, the forecast for the lower four reaches is for below normal runoff.

August-December

Runoff during the August-December period is expected to continue at below normal runoff volumes, finishing the year at 79 percent of normal. The climate outlooks do not indicate an improvement to the drought conditions throughout the summer nor near the end of the calendar year. Soil moisture content as of May 1 is well below normal, so any excess rainfall will likely recover soil moisture conditions until normal levels are reached.

Additional Figures





USDA NRCS National Water & Climate Center
* - DATA CURRENT AS OF: May 03, 2013 04:12:19 PM
- Based on May 01, 2013 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	MAY-JUL	97	113	111	103	91	83	86
	MAY-SEP	113	112	129	120	106	97	101
St. Mary R at Int'l Boundary (2)	MAY-JUL	445	111	530	480	410	360	400
	MAY-SEP	515	110	610	555	475	420	470
Lima Reservoir Inflow (2)	MAY-JUL	40	70	59	48	32	21	57
	MAY-SEP	45	70	67	54	36	23	64
Clark Canyon Reservoir Inflow (2)	MAY-JUL	34	53	93	58	10.3	-25	64
	MAY-SEP	51	61	114	77	25	-12.4	83
Jefferson R nr Three Forks (2)	MAY-JUL	355	62	645	475	235	64	575
	MAY-SEP	385	61	715	520	250	55	635
Hebgen Reservoir Inflow (2)	MAY-JUL	280	92	330	300	260	230	305
	MAY-SEP	375	93	435	400	350	315	405
Ennis Reservoir Inflow (2)	MAY-JUL	465	88	575	510	420	355	530
	MAY-SEP	605	89	735	660	550	475	680
Missouri R at Toston (2)	MAY-JUL	1220	82	1680	1410	1030	755	1480
	MAY-SEP	1450	82	2020	1680	1220	875	1760
Smith R bl Eagle Ck (2)	MAY-JUL	86	97	132	105	67	40	89
	MAY-SEP	97	98	153	120	74	41	99
Gibson Reservoir Inflow (2)	MAY-JUL	350	99	415	375	325	285	355
	MAY-SEP	390	99	460	420	360	320	395
Marias R nr Shelby (2)	MAY-JUL	315	111	460	375	255	171	285
	MAY-SEP	325	108	485	390	260	164	300
Milk R at Western Crossing	MAY-JUL	29	132	56	40	17.9	1.57	22
	MAY-SEP	32	128	62	44	19.9	2.1	25
Milk R at Eastern Crossing	MAY-JUL	43	123	108	69	16.8	-5.0	35
	MAY-SEP	50	122	123	79	21	3.0	41

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	MAY-JUL	49	86	56	52	46	42	57
	MAY-SEP	64	89	75	68	60	53	72
Wind R ab Bull Lake Ck (2)	MAY-JUL	295	79	390	335	255	200	375
	MAY-SEP	370	80	480	415	325	260	465
Bull Lake Ck nr Lenore (2)	MAY-JUL	112	83	141	124	100	83	135
	MAY-SEP	138	83	175	153	123	101	166
Boysen Reservoir Inflow (2)	MAY-JUL	375	67	620	475	275	128	560
	MAY-SEP	410	67	695	525	295	124	615
Greybull R nr Meeteetse	MAY-JUL	115	93	137	124	106	93	124
	MAY-SEP	153	90	200	172	134	106	170
Shell Ck nr Shell	MAY-JUL	52	100	66	58	46	38	52
	MAY-SEP	63	100	78	69	57	48	63
Bighorn R at Kane (2)	MAY-JUL	575	75	890	705	445	260	770
	MAY-SEP	600	72	950	740	460	250	830
NF Shoshone R at Wapiti	MAY-JUL	410	95	490	440	380	330	430
	MAY-SEP	460	95	550	495	425	370	485
SF Shoshone R nr Valley	MAY-JUL	178	89	210	191	165	146	200
	MAY-SEP	205	87	240	220	190	168	235
Buffalo Bill Reservoir Inflow (2)	MAY-JUL	555	88	680	605	505	430	630
	MAY-SEP	615	88	755	670	560	475	700
Bighorn R nr St. Xavier (2)	MAY-JUL	990	79	1380	1150	830	595	1260
	MAY-SEP	1020	76	1460	1200	840	580	1340
Little Bighorn R nr Hardin	MAY-JUL	62	73	92	74	50	32	85
	MAY-SEP	72	74	104	85	59	40	97
Tongue R nr Dayton (2)	MAY-JUL	74	93	101	85	63	47	80
	MAY-SEP	86	93	115	98	74	57	92

Tongue River Reservoir Inflow (2)	MAY-JUL	145	83	235	181	109	55	175
	MAY-SEP	166	84	260	205	127	70	198
NF Powder R nr Hazelton	MAY-JUL	10.5	127	13.2	11.6	9.4	7.8	8.3
	MAY-SEP	11.3	126	14.2	12.5	10.1	8.4	9.0
Powder R at Moorhead	MAY-JUL	156	103	240	191	121	70	151
	MAY-SEP	178	105	270	215	142	88	170
Powder R nr Locate	MAY-JUL	171	104	280	215	127	62	164
	MAY-SEP	195	105	315	245	147	76	185

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAY-JUL	5.5	141	9.0	6.9	4.1	1.98	3.9
Pactola Reservoir Inflow (2)	MAY-JUL	23	131	42	31	15.4	4.2	17.5

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate	MAY-JUL	155	83	235	188	122	74	187
	MAY-SEP	174	83	270	210	136	80	210
Encampment R nr Encampment	MAY-JUL	91	77	124	104	78	58	118
	MAY-SEP	98	77	133	112	84	63	127
Rock Ck nr Arlington	MAY-JUL	37	77	48	42	32	26	48
	MAY-SEP	39	78	51	44	34	27	50
Seminoe Reservoir Inflow (2)	MAY-JUL	420	68	715	540	300	127	615
	MAY-SEP	460	69	785	590	330	136	670
Sweetwater R nr Alcova	MAY-JUL	14.0	30	37	23	4.7	1.00	46
	MAY-SEP	16.6	33	42	27	6.4	2.7	50
North Platte R-Alcova to Orin Gain	MAY-JUL	26	27	128	67	10.0	-6.0	96
	MAY-SEP	28	27	132	70	11.0	-6.0	104
North Platte R bl Glendo Res (2)	MAY-JUL	460	69	705	560	360	215	670
	MAY-SEP	485	69	735	585	385	235	700
North Platte R bl Guernsey Res (2)	MAY-JUL	480	72	775	600	360	185	670
	MAY-SEP	515	74	820	640	390	210	700
Laramie R nr Woods	MAY-JUL	95	88	129	109	81	61	108
	MAY-SEP	105	88	143	120	90	67	119
Little Laramie R nr Filmore	MAY-JUL	36	75	50	42	30	22	48
	MAY-SEP	39	75	55	45	33	23	52

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
Calendar Year Runoff Forecast
June 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of June 1, 2013 is 21.2 MAF (84 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 19.4 MAF (84 percent of normal). Above Sioux City, this is an increase of 1.2 MAF from the May runoff forecast. Precipitation in May was well above normal in much of the upper Missouri River Basin (Basin) and observed May runoff was 3.5 MAF (106 percent of normal) in the upper Basin above Sioux City, IA. Above Gavins Point Dam, runoff was 3.1 MAF (104 percent of normal).

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next seven months, the range of expected inflow is quite large and ranges from the 26.0 MAF upper basic forecast to the 17.4 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's (NDMC) U.S. Drought Monitor for April 23, 2013 and May 28, 2013 are shown in Figure 1. Drought conditions as of April 23, 2013 impact much of the upper Basin with the exception of the northern half of Montana and most of North Dakota. Elsewhere, drought conditions range from Moderate (D1) to Extreme (D3) with only isolated areas where conditions are Exceptional (D4). Drought conditions in the state of Missouri have been nearly mitigated as a result of spring precipitation. Compared to April 23, 2013 current drought conditions improved significantly due to May precipitation in the Basin. In the High Plains region, which includes Wyoming, Colorado, North Dakota, South Dakota, Nebraska and Kansas, the area covered by Extreme (D3) Drought including D4 drought decreased from 38 to 21 percent. The area covered by Severe (D2) including D3 and D4 drought decreased from 70 to 56 percent. In Montana, drought conditions remained about the same as of May 28, 2013.

According to the U.S. Seasonal Drought Outlook shown in Figure 2, drought conditions will continue to improve in all areas of the Basin east of the Missouri River including a portion of eastern Nebraska west of the river. Some limited improvement is expected in central and western Nebraska, South Dakota, southeast Montana and eastern Wyoming. In the Rocky Mountains, including central and western Wyoming and southern Montana, drought conditions will likely persist with some additional development in Montana and northwest Wyoming through July 31, 2013.

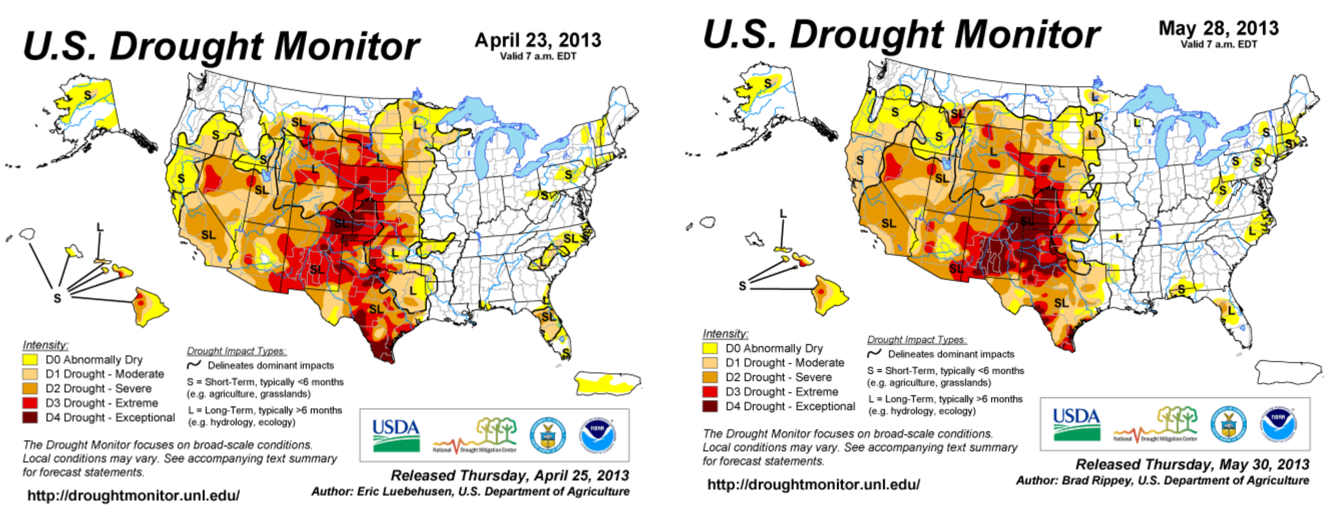


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for April 23, 2013 and May 28, 2013.

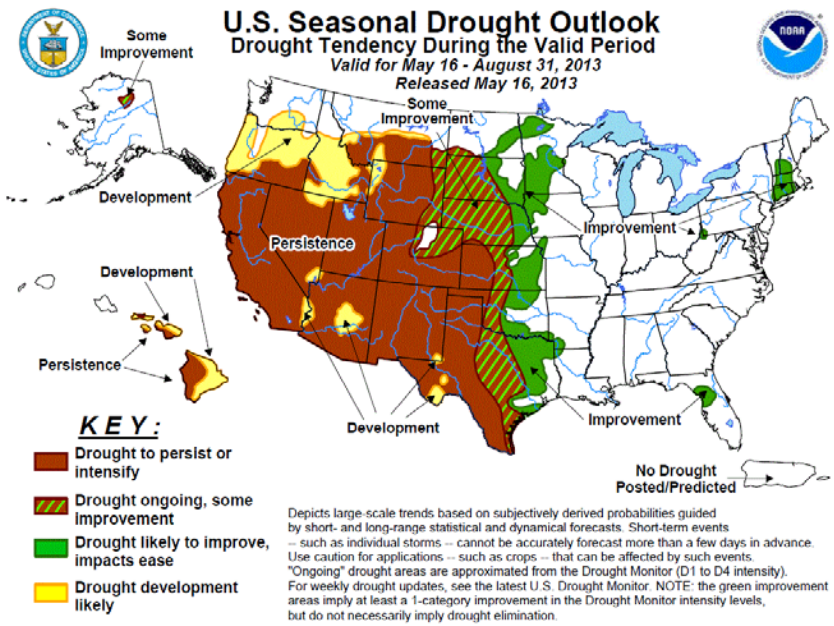


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of May is shown in Figure 3. Abundant precipitation occurred in the Basin centered in eastern Montana in the upper Basin and centered over Missouri in the lower Basin. Precipitation totals ranging from 5-8 inches occurred over much of central and eastern Montana, central and western North Dakota, portions of South Dakota, eastern Nebraska and western Iowa. Locally heavy amounts in excess of 10 inches may have occurred in a few locations in the upper Basin including southwest North Dakota, southeast Montana and the northern Black Hills in South Dakota. Rainfall amounts ranging from 5-8 inches occurred over much of the lower basin with the exception of the South Platte and North Platte basins. Rainfall amounts in excess of 10 inches occurred over slightly larger areas in the lower Basin.

Rainfall departures expressed in inches were greatest in the upper Basin, especially in Montana, western North Dakota, and northwest South Dakota where they generally ranged from 3-5 inches above normal (Figure 4). In Montana almost one-half of the state received greater than 3 inches of precipitation above normal. NWS Precipitation Analysis estimates also indicate departures in excess of 8 inches above normal in a few areas in Montana and North Dakota. In the lower Basin the magnitude of departures was similar to departures in the upper basin. Some monthly precipitation totals and departures are provided below in Table 1.

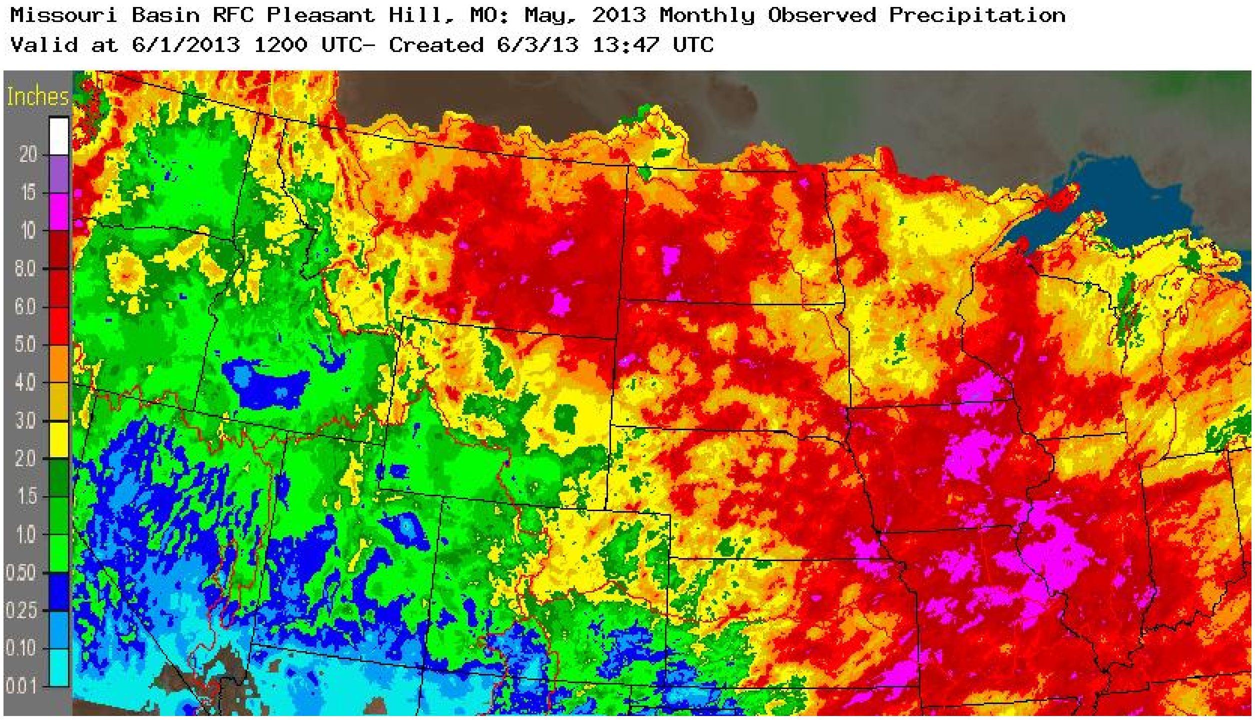


Figure 3. May 2013 precipitation (inches).

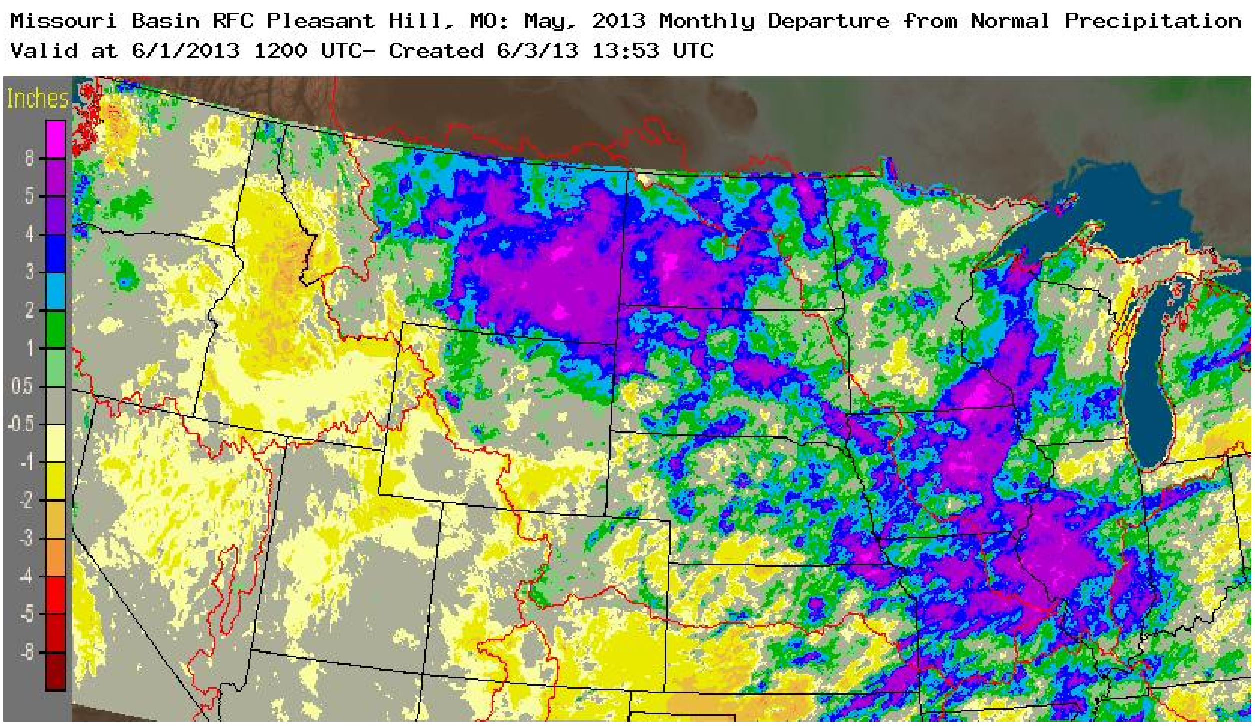


Figure 4. May 2013 precipitation departure (inches) from normal.

Table 1. Total May 2013 Rainfall and Departures from Normal.

Location	Total May Rainfall (inches)	Departure (inches)
Lewistown, MT	6.37	3.42
Glasgow, MT	4.46	2.54
Miles City, MT	6.69	4.51
Bismarck, ND	7.37	4.97
Hettinger, ND	8.02	5.66
Sioux Falls, SD	6.95	3.55
Sioux City, IA	5.28	1.54
Omaha, NE	5.74	0.98
Lincoln, NE	8.44	4.15
St. Joseph, MO	7.54	2.12
Chillicothe, MO	9.18	4.06
Columbia, MO	9.79	4.81
St. Charles, MO	8.34	3.59

Over a 90-day period ending June 2, 2013, rainfall accumulations have been above normal in the upper basin especially in eastern Montana, the Dakotas, eastern Nebraska and western Iowa (Figure 5). Departures in these areas have generally ranged from 2-6 inches above normal, while some areas have received 6-8 inches of precipitation greater than normal, such as eastern Montana. The lower basin has also received abundant precipitation with departures in Missouri ranging from 6-12 inches greater than normal for the 90-day period (March-April-May).

Finally, precipitation during the last seven days ending June 3, 2013 has been particularly wet in Montana where rainfall accumulations have ranged from 5-8 inches (Figure 6). Though some of this precipitation has fallen in May, it will provide an increase to runoff during the first two weeks of June.

Temperature

Average temperatures throughout most of the upper Basin during the past 30 days ending May 31, 2013 were generally 1-3 degrees F above normal west of the Missouri River and normal to 2 degrees F below normal east of the Missouri River (Figure 7). May temperatures indicate a slight warming trend compared to the past 90 days shown in Figure 8. The 90-day temperature departure map indicates temperatures ranged from 2-6 degrees F below normal in the plains, but slightly below normal in the Rocky Mountains. The epicenter of cold temperatures in the U.S. was in North Dakota where temperatures ranged from 5-9 degrees F below normal over the 90-day period.

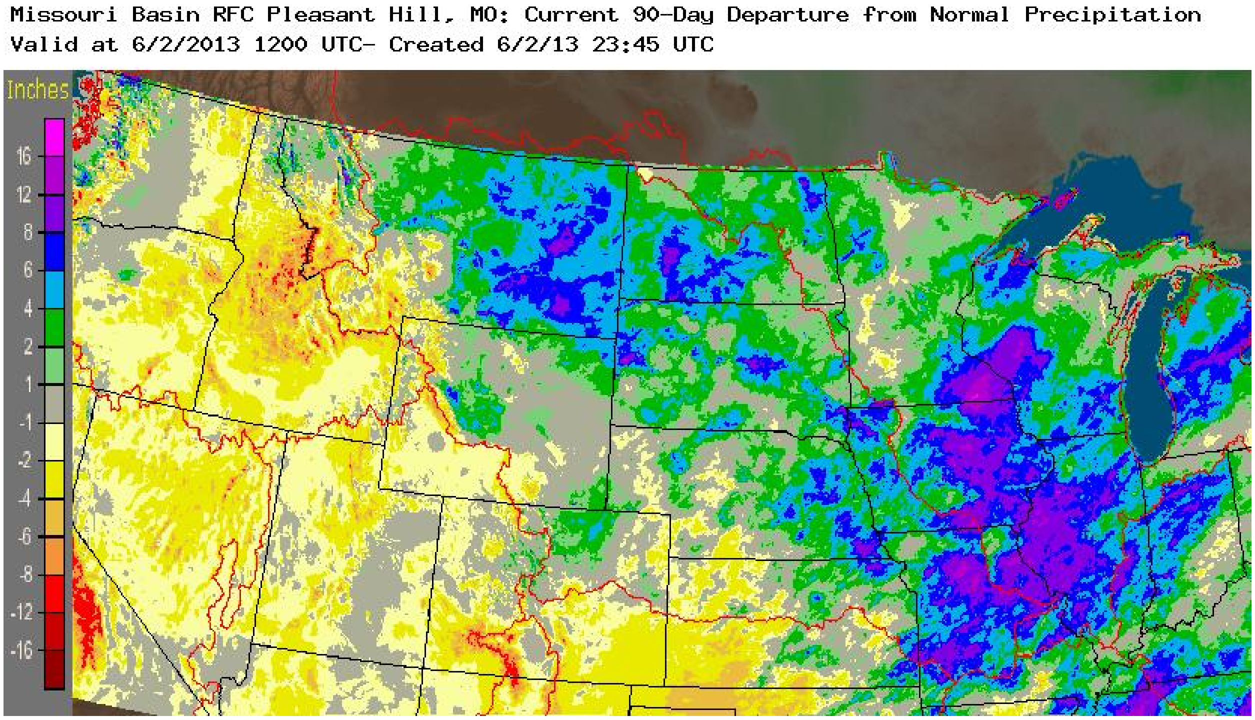


Figure 5. 90-day precipitation departure (inches) from normal, ending on June 2, 2013.

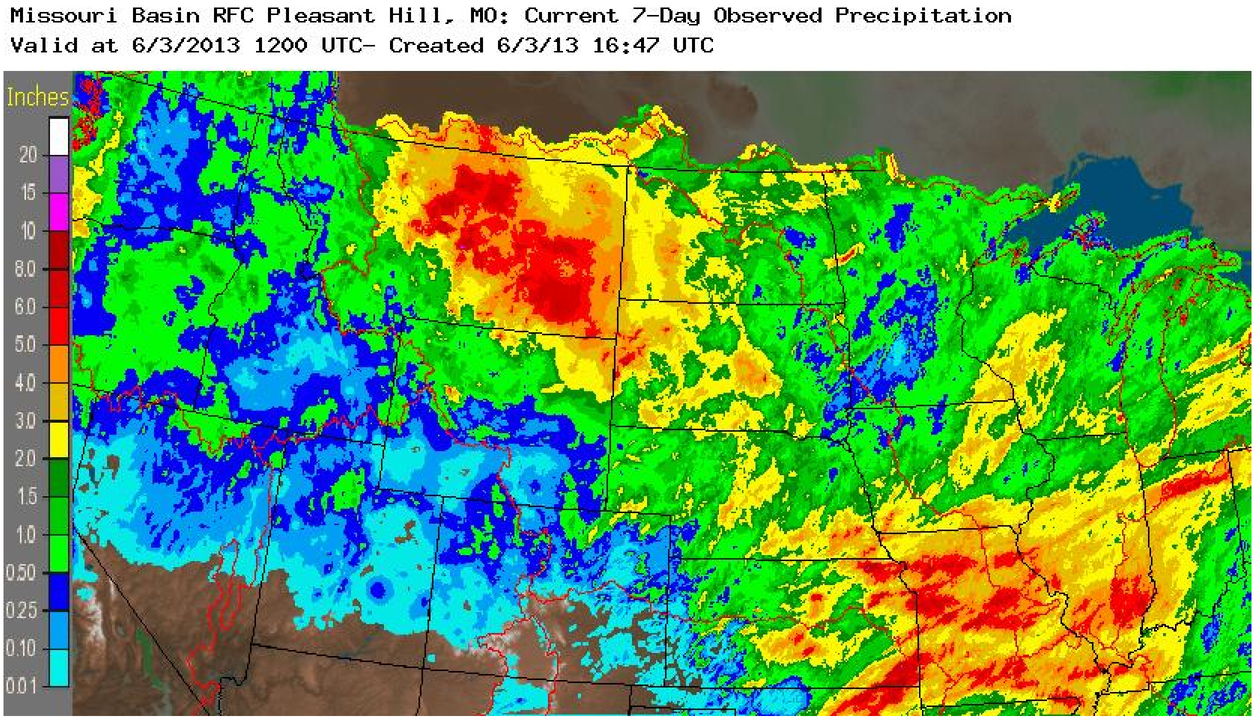


Figure 6. Seven-day precipitation (inches) ending at 7 a.m. CDT, June 3, 2013.

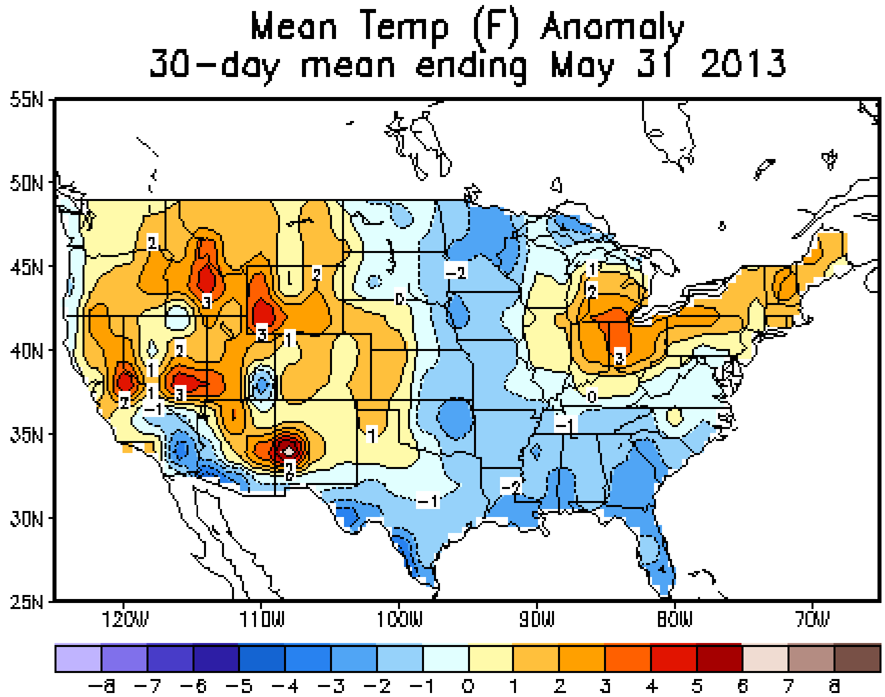


Figure 7. 30-day temperature departures (degrees F) from normal.

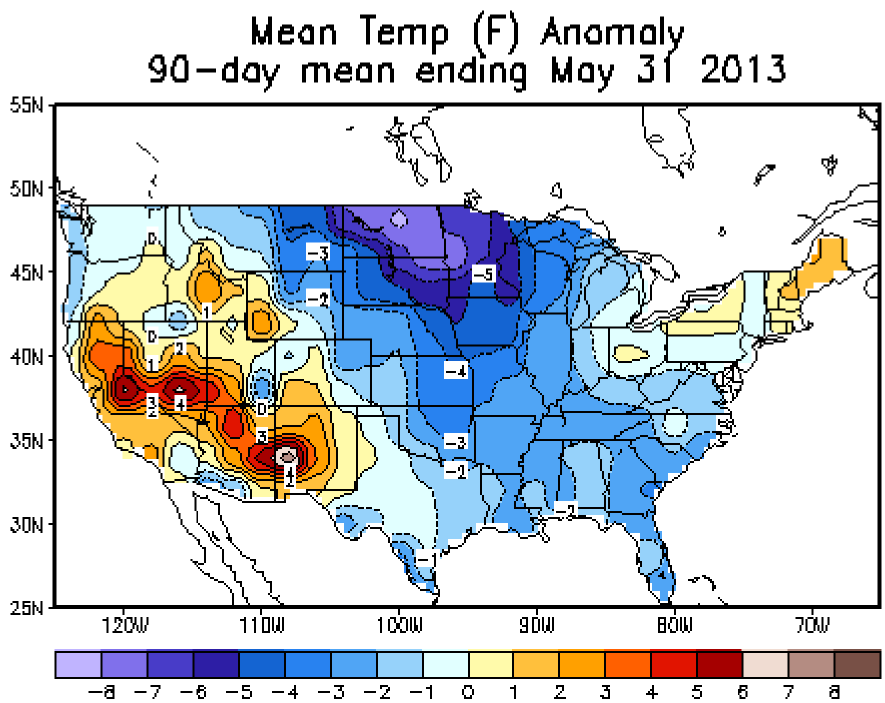


Figure 8. 90-day temperature departures (degrees F) from normal.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet, or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry, or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

In spite of well-above normal precipitation falling on the upper Basin in May, the observed runoff was about normal due to greater soil infiltration due to the dry soil conditions prior to the rainfall. In fact, soil moisture conditions improved significantly in May; however, 2- to 3-inch deficits still exist in eastern Wyoming and western South Dakota and Nebraska. Soil moisture conditions are discussed in more detail in the following paragraphs.

Two independent estimates of soil moisture are presented in this report. Figures 9-11 illustrate the NOAA Climate Prediction Center's (CPC) calculated soil moisture ranking percentiles (Figure 9), calculated soil moisture anomaly change (Figure 10) and calculated soil moisture anomaly (Figure 11). Figure 12 shows the University of Washington's Variable Infiltration Capacity (VIC) model soil moisture percentiles and Figure 13 shows the VIC models soil moisture percentile change over the past 30 days.

The current status of the soil is represented by the soil moisture percentile ranking in Figure 9 and Figure 12. Both soil moisture rankings depict dry soil moisture conditions in eastern Wyoming and western Nebraska. Wet soil moisture conditions are present in central and eastern Montana, North Dakota and northern and western South Dakota. The CPC calculated soil moisture anomaly change in Figure 10 indicates since March 31, 2013, soil moisture anomalies have improved significantly across the entire Missouri River basin. In the upper basin, soil moisture conditions with respect to normal conditions have generally increased by 40 mm (1.6 inches) of water, while in southeast Montana and southwest North Dakota, soil moisture has increased over 120 mm (4.7 inches) with respect to normal soil moisture conditions. Furthermore, soil moisture has increased over 120 mm (4.7 inches) with respect to normal conditions in eastern Nebraska and western Iowa.

The CPC calculated soil moisture anomaly is shown in Figure 11. In spite of the recent above normal precipitation in the upper Basin, widespread negative soil moisture anomalies still exist in Wyoming, South Dakota and Nebraska, ranging from 20-80 (0.8-3.1 inches) below normal. Positive soil moisture anomalies developed in May in central North Dakota and western Montana generally ranging from 20-60 mm (0.8-2.4 mm).

According to the VIC model in Figure 12, the driest conditions (less than the 5th percentile) are present in southern Wyoming. In contrast soil moisture conditions in eastern Montana and western North Dakota rank in the 95th and 98th percentiles for soil wetness. Soil moisture conditions in the 95th and 98th percentiles are also present in the lower basin in eastern Nebraska, Iowa, eastern Kansas and Missouri. According the VIC model, soil moisture ranking percentiles improved 35 to 45 percentage points over the past 30 days in much of the upper Missouri River basin (Figure 13).

As an indicator of future monthly runoff, above normal soil moisture ranking percentiles in Montana, and the Dakotas indicate that soil moisture conditions have improved significantly, and normal runoff is more likely assuming normal precipitation. Below normal soil moisture ranking percentiles in Wyoming, southwest Montana, southwest South Dakota and western Nebraska indicate soil moisture conditions are still dry, and below normal runoff is likely given normal or below normal precipitation. Normal to above normal rainfall will be needed in the dry areas in order to restore soil moisture to more normal conditions before normal runoff can occur.

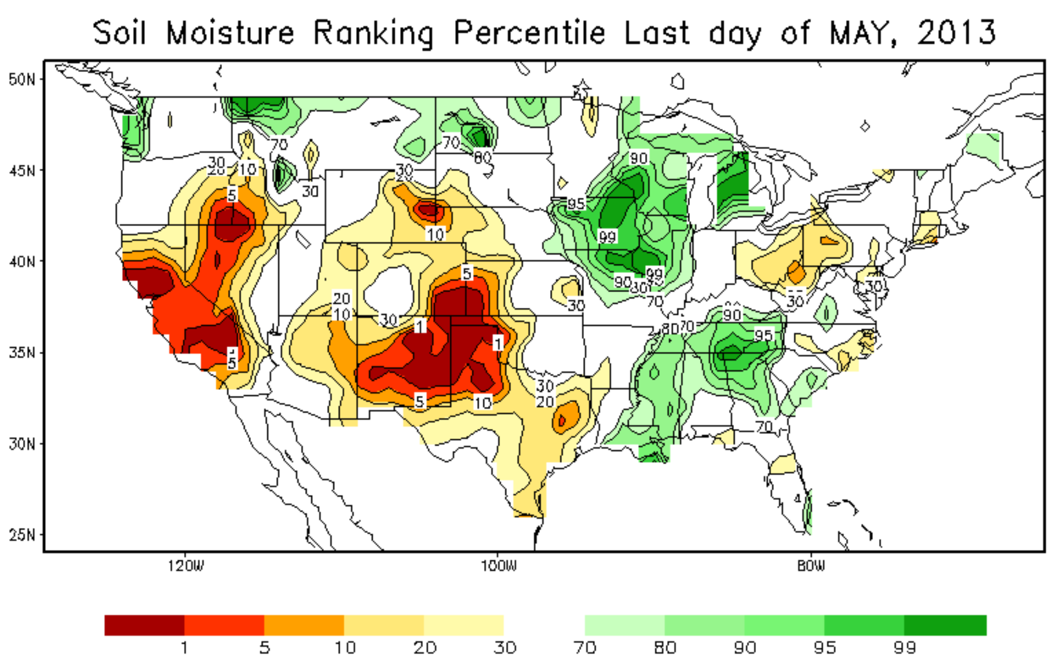


Figure 9. Calculated Soil Moisture Ranking Percentile on May 31, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

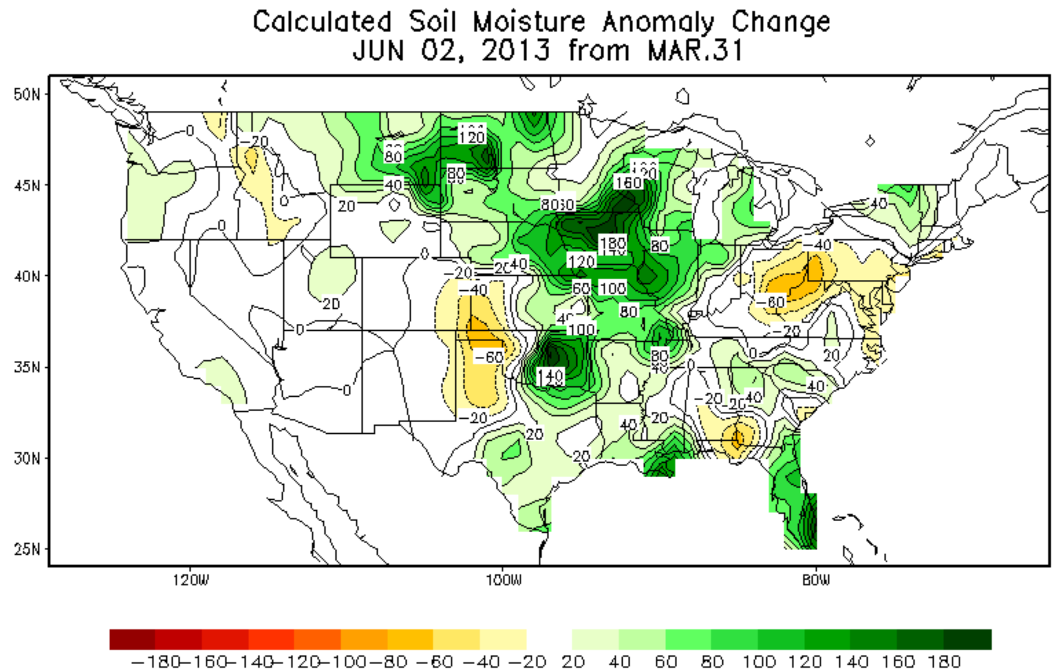


Figure 10. Calculated Soil Moisture Anomaly Change from March 31, 2013 to June 2, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

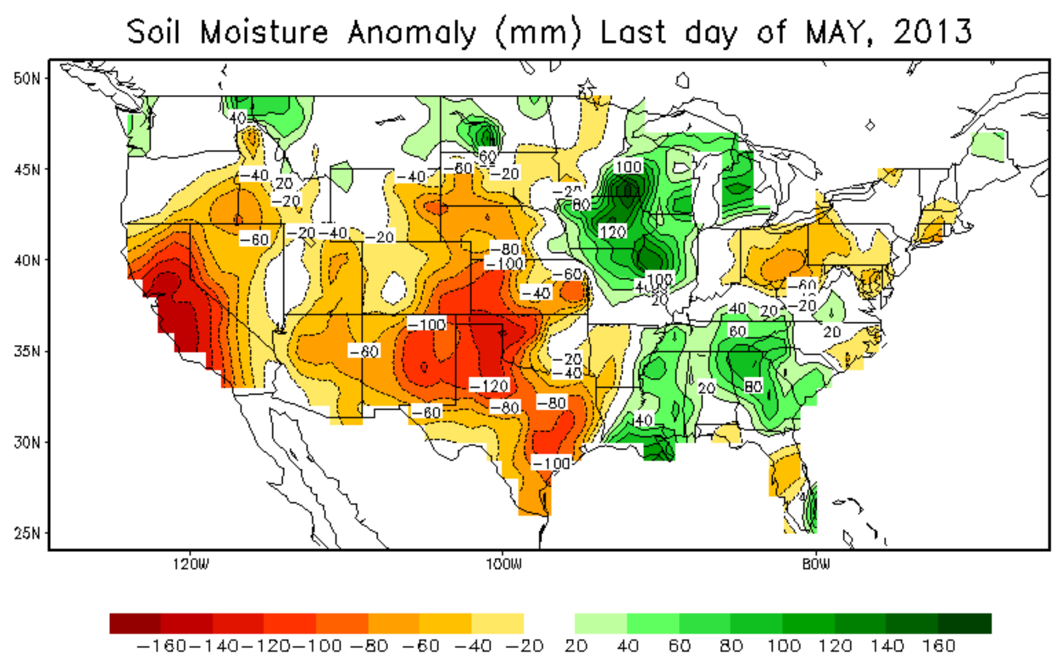


Figure 11. Calculated Soil Moisture Anomaly on May 31, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

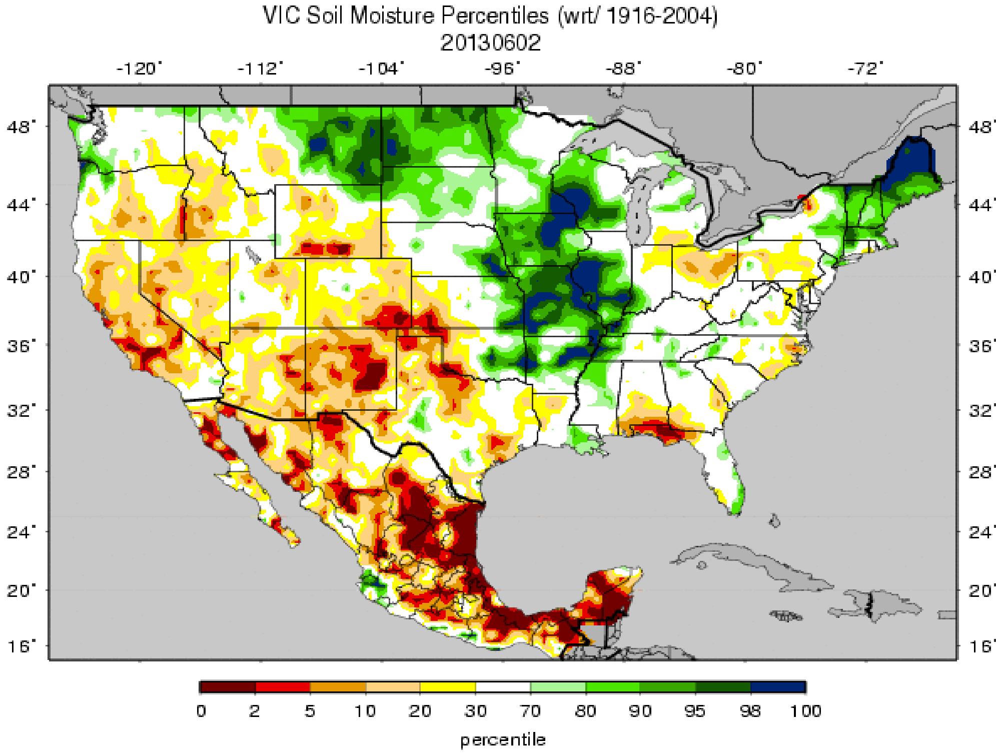


Figure 12. VIC modeled soil moisture percentiles as of June 2, 2013. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/index.shtml

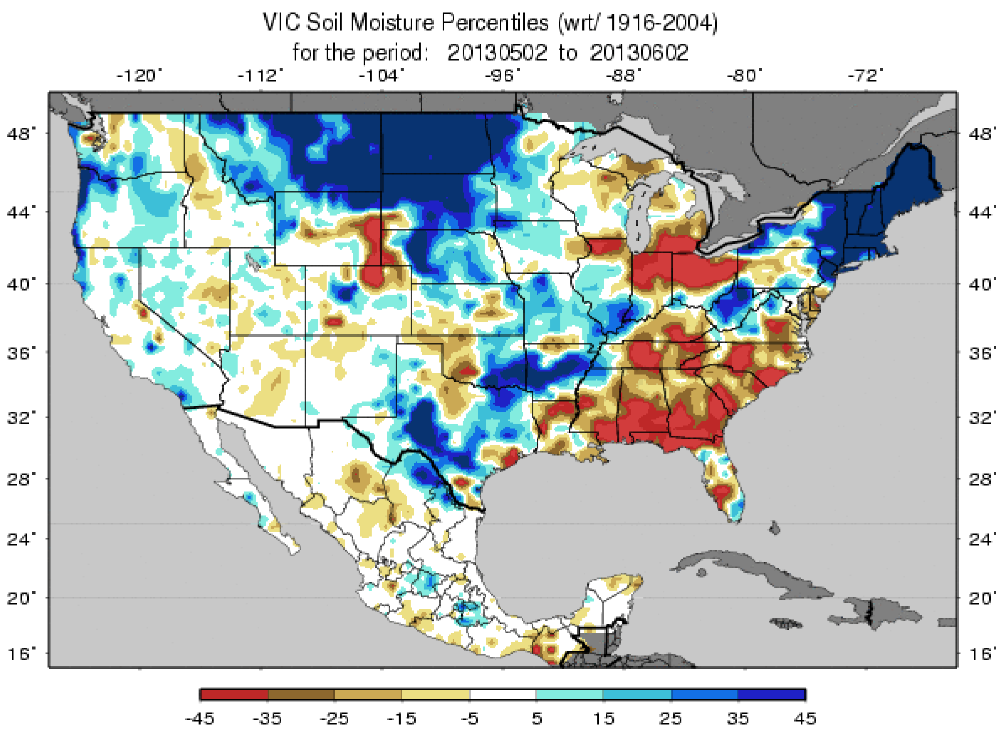


Figure 13. VIC 30-day modeled soil moisture percentile change as of June 2, 2013. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/index.shtml

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. The Missouri River basin mountain snowpack normally peaks on April 15.

The mountain snowpack SWE above Fort Peck peaked on April 23 at 15.4 inches, 95 percent of the normal April 15 peak (Figure 14). The mountain snowpack SWE between Fort Peck and Garrison peaked on April 25 at 13.5 inches, 95 percent of the normal April 15 peak. On June 1, 2013 the mountain snowpack SWE in the reach above Fort Peck was 4.3 inches, 26 percent of the normal April 15 peak. In the Fort Peck to Garrison reach the mountain snowpack SWE was 3.4 inches, 24 percent of the normal April 15 peak. Normally by June 1, about 40 percent of the snowpack still remains; therefore, the mountain snowpack remaining is less than normal.

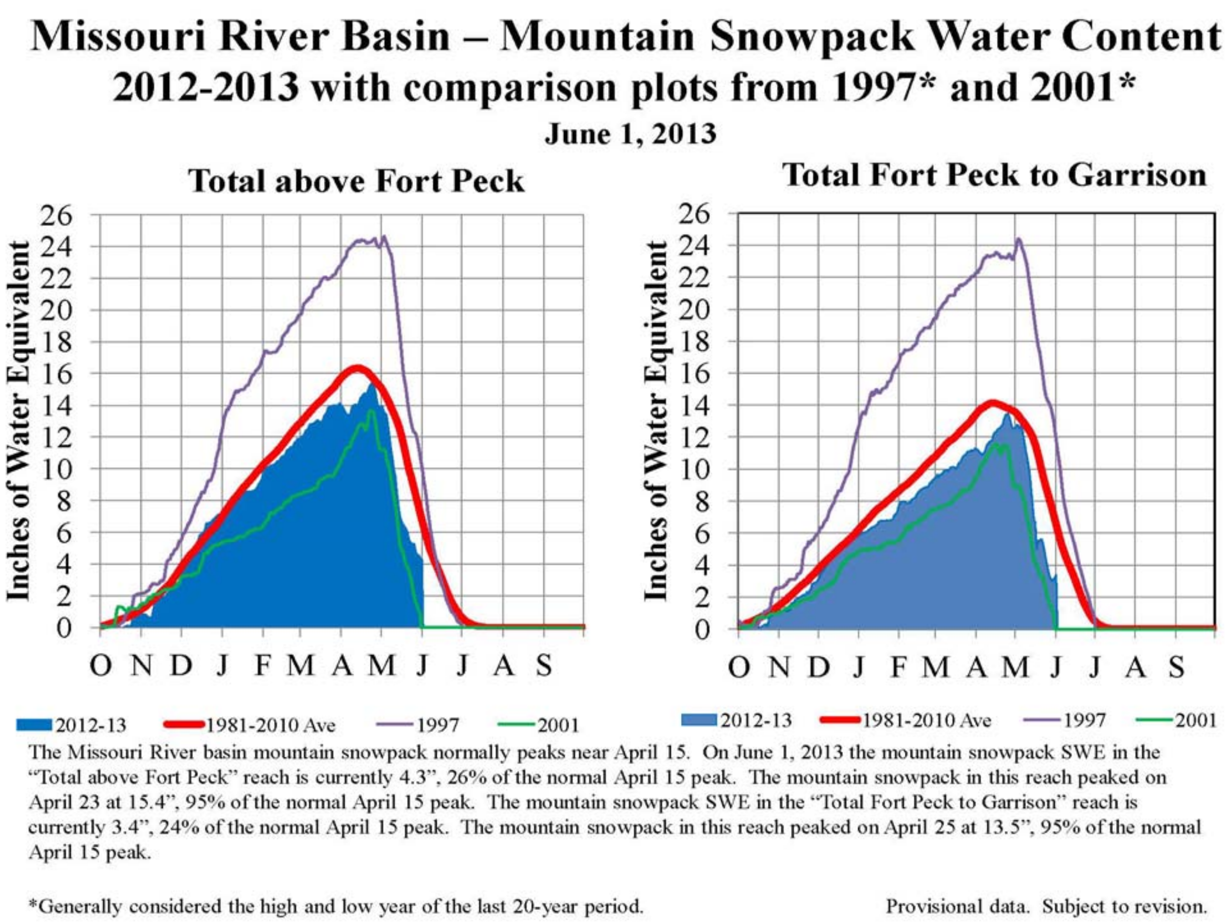


Figure 14. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific. Equatorial sea surface temperatures are near average across the western and central Pacific Ocean and below average across the eastern Pacific. ENSO-neutral conditions are favored in the Northern Hemisphere through late summer 2013. During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's June temperature outlook (Figure 15) indicates increased chances for above normal temperatures in western Montana and Wyoming with equal chances throughout the remainder of the upper basin. The CPC's 3-month temperature outlook for June-July-August (Figure 16) indicates the increased chances for above normal temperatures will expand eastward into South Dakota and Nebraska. During the September-October-November outlook period (see Figure 17) there are increased chances for above normal temperatures throughout most of the upper Missouri River basin with the exception of central and northern Montana. During the December-January-February 2014 (Figure 18) period, chances for above normal, normal and below normal temperatures are equal.

The CPC's May precipitation outlook (Figure 15) is indicating an increased chance for below normal precipitation in western Montana and Wyoming with equal chances in the Dakotas and Nebraska. In the June-July-August forecast period, precipitation chances are similar to June with increased chances for below normal precipitation in much of Nebraska and southwest South Dakota (Figure 16). These outlooks support the drought forecast which indicates drought conditions will persist west of the Missouri River and possibly expand in southern Montana and Wyoming. The precipitation outlooks for September-October-November (Figure 17) and December-January-February (Figure 18) indicate equal chances for above normal, normal and below normal precipitation.

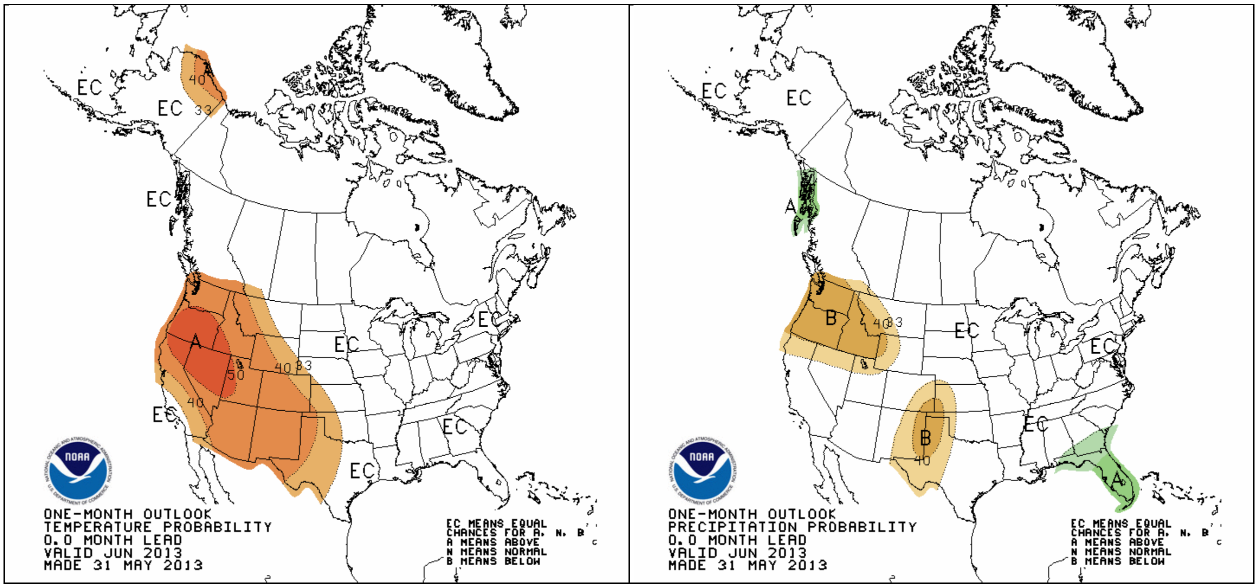


Figure 15. CPC June 2013 temperature and precipitation outlooks.

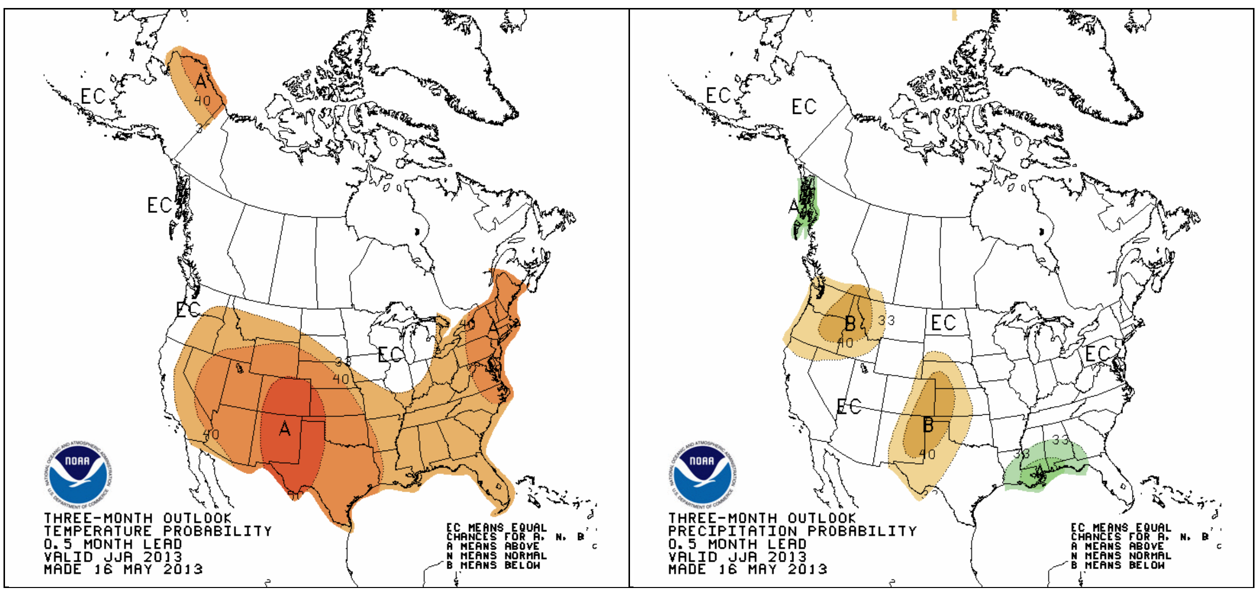


Figure 16. CPC June-July-August 2013 temperature and precipitation outlooks.

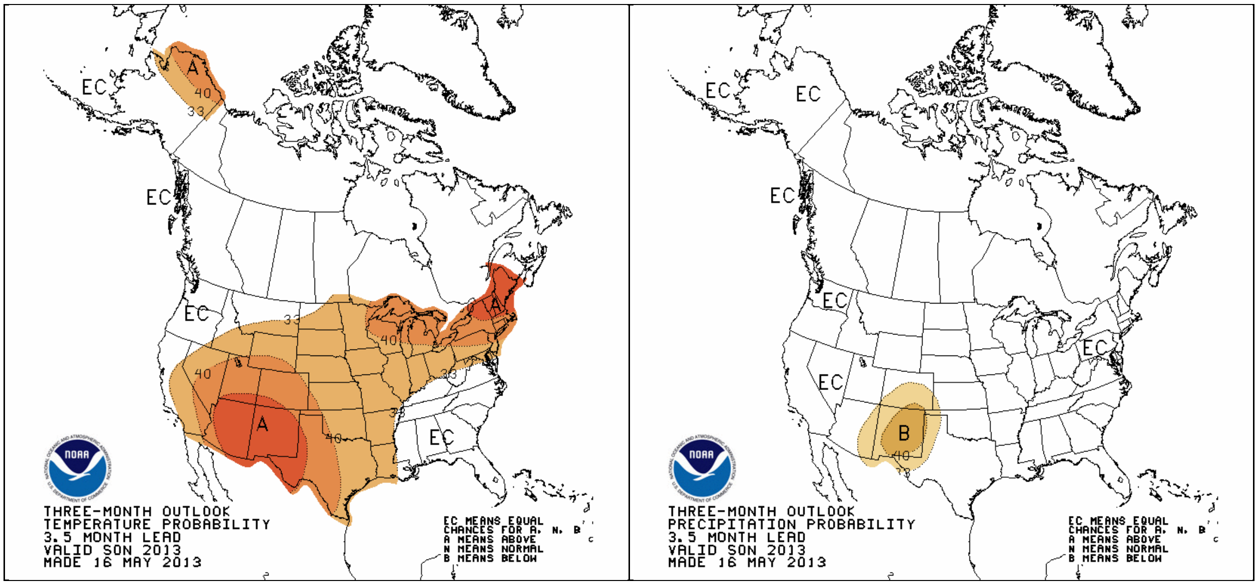


Figure 17. CPC September-October-November 2013 temperature and precipitation outlooks.

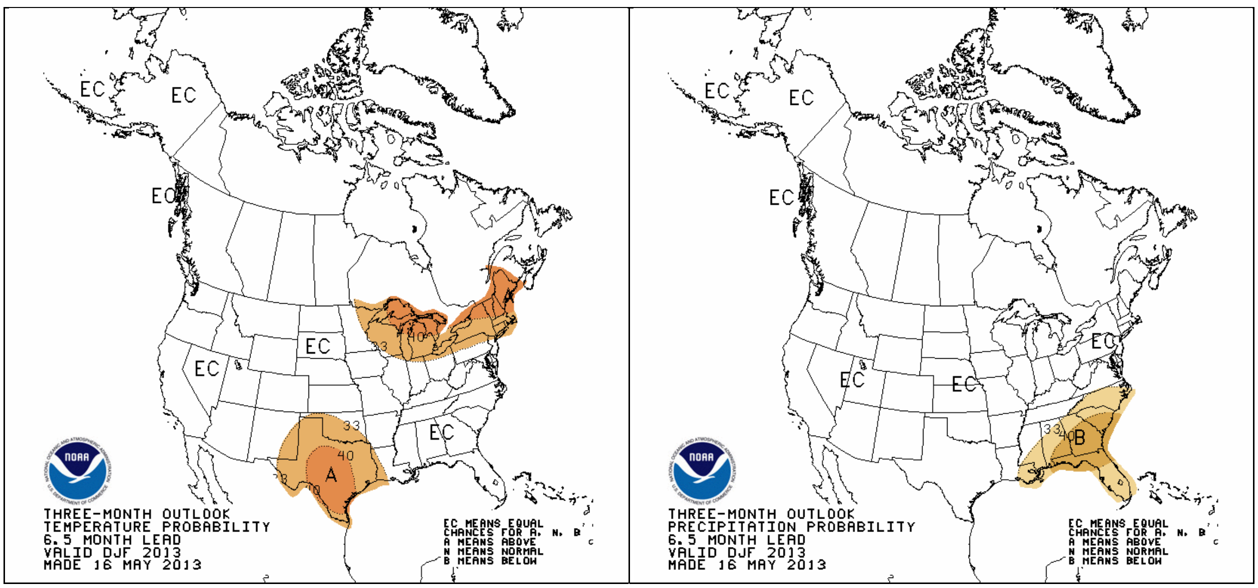


Figure 18. CPC December-January-February 2014 temperature and precipitation outlooks.

June 2013 Calendar Year Runoff Forecast

The annual runoff forecast as of June 1, 2013 is 21.2 MAF (84 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 19.4 MAF (84 percent of normal). Above Sioux City, this is an increase of 1.2 MAF from the May forecast. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next seven months, the range of expected inflow is quite large and ranges from the 26.0 MAF upper basic forecast to the 17.4 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively.

May runoff was 3.5 MAF (106 percent of normal) in the upper Basin above Sioux City, IA and 3.1 MAF (104 percent of normal) above Gavins Point Dam. May runoff exceeded the May 1 runoff forecast by 0.8 MAF due to above normal rainfall in the upper Missouri River basin

June-July

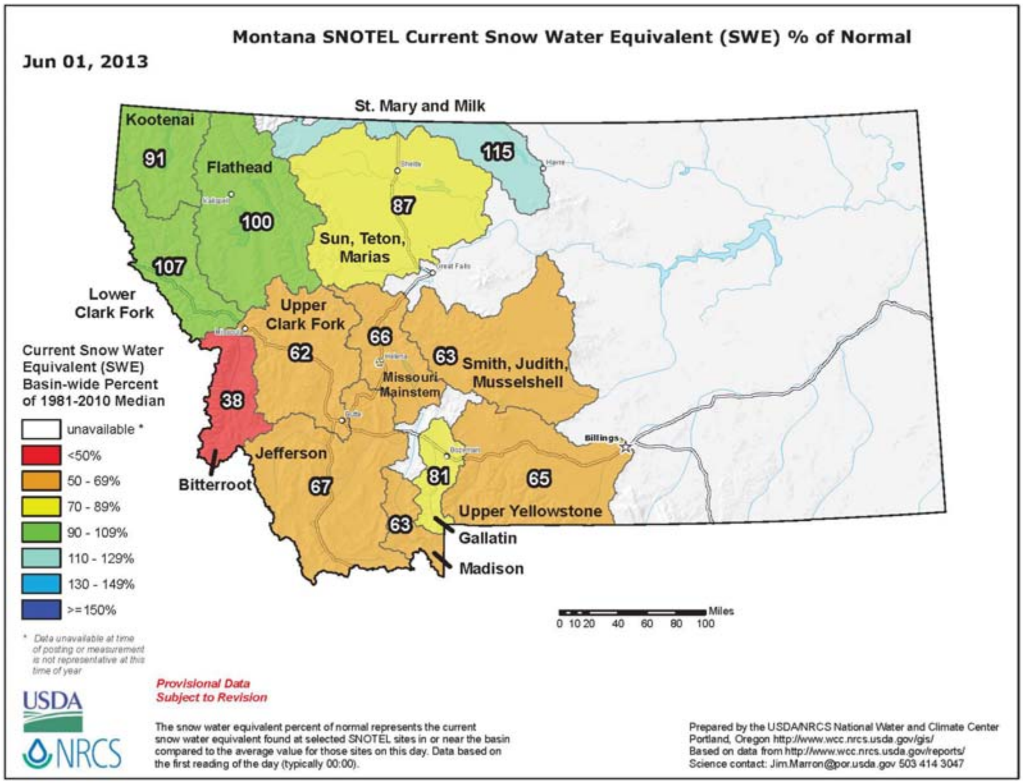
The mountain snowpack above Fort Peck peaked at 95 percent of normal on April 23, while the snowpack from Fort Peck to Garrison peaked at 95 percent of normal on April 25. As of June 1, 2013 there was 26 percent of the normal peak accumulation above Fort Peck and 24 percent of the normal peak accumulation from Fort Peck to Garrison. Normally on June 1, 40 percent of the normal peak accumulation remains. May-June-July runoff in the Fort Peck and Garrison subbasins was determined based on linear regression relationships between peak mountain snowpack, precipitation and temperature versus runoff. April-May-June temperatures and May-June-July precipitation is factored into the regression equations to account for observed meteorological conditions (April-May temperatures and May precipitation) and forecast meteorological conditions (June temperatures and June-July precipitation). Based on these factors, the Fort Peck runoff for June and July is forecast to be 79 percent of normal in June and 86 percent of normal in July. The Garrison runoff for June and July is forecast to be 85 percent of normal in June and 83 percent of normal in July. The lower-than-normal snowpack as of June 1 is the main factor affecting the lower-than-normal forecast runoff.

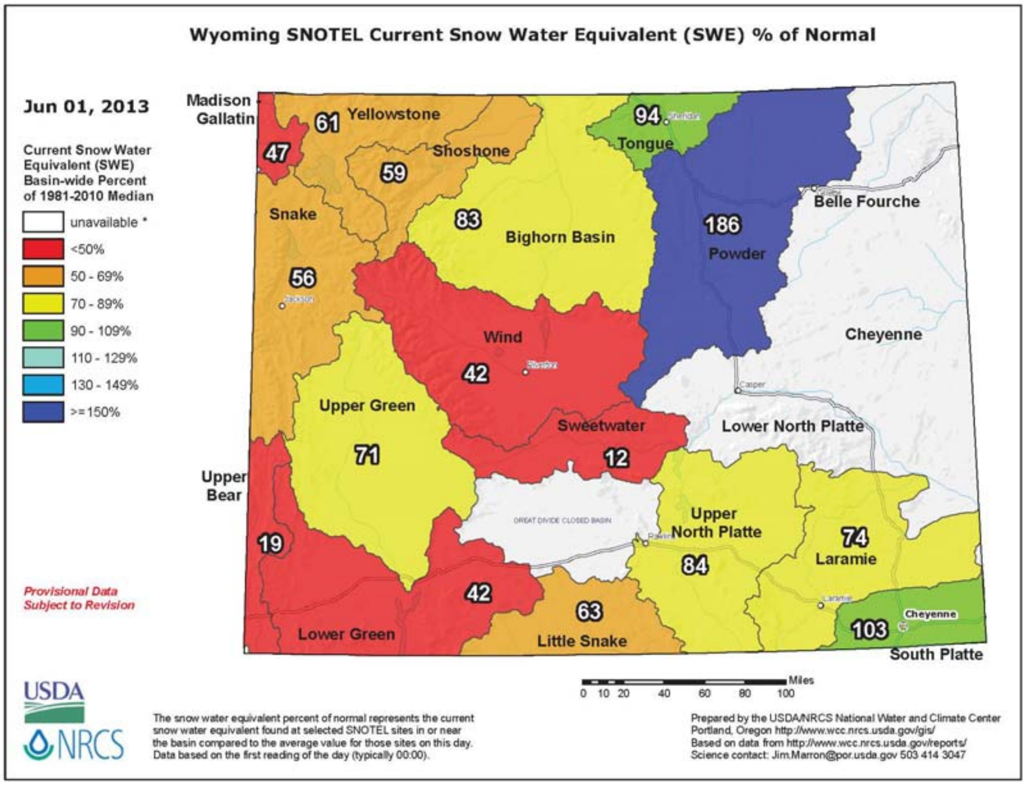
Given that soil moisture anomalies in the Oahe, Fort Randall, Gavin Point and Sioux City reaches improved in May, the June and July forecasts have been increased slightly for these reaches. Runoff above Sioux City is forecast to be 85 percent of normal in June and July.

August-December

Runoff during the August-December period is expected to continue at below normal runoff volumes, ranging from 82 to 83 percent of normal above Gavins Point and Sioux City. The drought outlook does not indicate much improvement to the drought conditions throughout the summer nor near the end of the calendar year. Improvements in soil moisture conditions have benefitted runoff in the upper basin; however, large soil moisture deficits in Wyoming will continue to limit runoff into the Mainstem system during the summer and fall.

Additional Figures





USDA NRCS National Water & Climate Center
* - DATA CURRENT AS OF: June 06, 2013 11:32:44 AM
- Based on June 01, 2013 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	JUN-JUL	62	111	75	67	57	49	56
	JUN-SEP	78	110	93	84	72	63	71
St. Mary R at Int'l Boundary (2)	JUN-JUL	295	107	365	325	265	225	275
	JUN-SEP	365	106	445	395	335	285	345
Lima Reservoir Inflow (2)	JUN-JUL	15.9	51	30	21	10.4	2.2	31
	JUN-SEP	18.8	48	36	26	11.7	1.20	39
Clark Canyon Reservoir Inflow (2)	JUN-JUL	7.6	22	52	26	-10.3	-24	35
	JUN-SEP	16.4	30	67	37	-4.0	-18.0	55
Jefferson R nr Three Forks (2)	JUN-JUL	135	38	330	215	57	-15.0	355
	JUN-SEP	150	36	385	245	55	-15.0	415
Hebgen Reservoir Inflow (2)	JUN-JUL	143	80	186	160	126	100	178
	JUN-SEP	230	82	280	250	210	178	280
Ennis Reservoir Inflow (2)	JUN-JUL	235	71	300	260	210	168	330
	JUN-SEP	360	74	445	395	325	275	485
Missouri R at Toston (2)	JUN-JUL	670	71	1040	820	520	305	940
	JUN-SEP	865	71	1370	1070	660	360	1220
Smith R bl Eagle Ck (2)	JUN-JUL	50	93	84	64	36	16.3	54
	JUN-SEP	60	92	106	78	42	14.3	65
Gibson Reservoir Inflow (2)	JUN-JUL	190	90	245	210	168	136	210
	JUN-SEP	230	92	290	255	205	172	250
Marias R nr Shelby (2)	JUN-JUL	151	106	260	195	107	41	143
	JUN-SEP	164	104	290	215	113	39	158
Milk R at Western Crossing	JUN-JUL	9.0	70	29	17.0	3.6	0.20	12.8
	JUN-SEP	10.6	71	33	19.7	3.6	0.28	14.9
Milk R at Eastern Crossing	JUN-JUL	18.8	98	68	39	7.5	-3.0	19.2
	JUN-SEP	26	104	83	49	10.0	1.00	25

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	JUN-JUL	38	81	46	41	35	30	47
	JUN-SEP	52	83	63	56	48	41	63
Wind R ab Bull Lake Ck (2)	JUN-JUL	210	72	305	250	171	114	290
	JUN-SEP	280	75	390	325	235	171	375
Bull Lake Ck nr Lenore (2)	JUN-JUL	82	76	106	92	72	58	108
	JUN-SEP	107	77	139	120	94	75	139
Boysen Reservoir Inflow (2)	JUN-JUL	255	60	440	330	181	71	425
	JUN-SEP	285	59	515	380	192	56	485
Greybull R nr Meeteetse	JUN-JUL	79	82	104	89	69	54	96
	JUN-SEP	120	85	153	133	107	87	142
Shell Ck nr Shell	JUN-JUL	34	97	44	38	30	24	35
	JUN-SEP	45	98	56	50	40	34	46
Bighorn R at Kane (2)	JUN-JUL	355	62	595	450	260	114	570
	JUN-SEP	385	61	685	505	265	83	630
NF Shoshone R at Wapiti	JUN-JUL	285	93	345	310	260	225	305
	JUN-SEP	330	92	400	360	300	260	360
SF Shoshone R nr Valley	JUN-JUL	128	82	154	138	118	102	157
	JUN-SEP	155	82	189	169	141	121	189
Buffalo Bill Reservoir Inflow (2)	JUN-JUL	370	80	475	410	330	265	465
	JUN-SEP	435	81	565	490	380	305	535
Bighorn R nr St. Xavier (2)	JUN-JUL	615	67	920	740	490	310	920
	JUN-SEP	655	65	1060	820	490	250	1010
Little Bighorn R nr Hardin	JUN-JUL	37	70	66	49	25	8.3	53
	JUN-SEP	48	73	82	62	34	14.0	66
Tongue R nr Dayton (2)	JUN-JUL	40	82	56	46	34	24	49
	JUN-SEP	52	84	71	60	44	33	62
Tongue River Reservoir Inflow (2)	JUN-JUL	74	67	119	92	56	29	110
	JUN-SEP	94	70	150	116	72	38	134

NF Powder R nr Hazelton	JUN-JUL	4.7	104	6.9	5.6	3.8	2.5	4.5
	JUN-SEP	5.4	104	7.8	6.4	4.4	3.0	5.2
Powder R at Moorhead	JUN-JUL	51	55	105	73	29	7.2	92
	JUN-SEP	60	55	126	87	33	10.0	110
Powder R nr Locate	JUN-JUL	56	55	128	85	27	10.0	101
	JUN-SEP	63	52	154	100	26	10.0	122

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	JUN-JUL	2.0	87	5.2	3.3	0.70	0.50	2.3
Pactola Reservoir Inflow (2)	JUN-JUL	6.8	65	23	13.4	2.7	1.60	10.5

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate	JUN-JUL	93	76	137	111	75	49	123
	JUN-SEP	110	75	164	132	88	56	146
Encampment R nr Encampment	JUN-JUL	46	61	71	56	36	21	75
	JUN-SEP	52	62	79	63	41	25	84
Rock Ck nr Arlington	JUN-JUL	22	69	30	25	19.5	15.2	32
	JUN-SEP	24	69	32	27	21	16.1	35
Seminoe Reservoir Inflow (2)	JUN-JUL	245	63	390	305	187	100	390
	JUN-SEP	280	63	455	350	210	104	445
Sweetwater R nr Alcova	JUN-JUL	2.8	11	14.6	7.6	1.30	1.00	26
	JUN-SEP	4.5	15	18.8	10.3	1.80	1.50	31
North Platte R bl Glendo Res (2)	JUN-JUL	193	51	305	240	148	81	375
	JUN-SEP	191	47	310	240	143	73	405
North Platte R bl Guernsey Res (2)	JUN-JUL	210	57	345	265	156	76	370
	JUN-SEP	220	55	365	280	161	73	400
Laramie R nr Woods	JUN-JUL	46	65	68	55	37	24	71
	JUN-SEP	54	66	79	64	44	29	82
Little Laramie R nr Filmore	JUN-JUL	23	66	32	27	19.3	13.9	35
	JUN-SEP	26	67	37	30	22	15.3	39

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
Calendar Year Runoff Forecast
July 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of July 1, 2013 is 22.3 MAF (88 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.1 MAF (88 percent of normal). Above Sioux City, this is an increase of 1.1 MAF from the May runoff forecast. Precipitation in June was well above normal in much of the upper Missouri River Basin (Basin) and observed May runoff was 6.3 MAF (116 percent of normal) in the upper Basin above Sioux City, IA. Above Gavins Point Dam, runoff was 5.8 MAF (113 percent of normal).

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next six months, the range of expected inflow is quite large and ranges from the 24.1 MAF upper basic forecast to the 20.6 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's (NDMC) U.S. Drought Monitor for May 28, 2013 and July 2, 2013 are shown in Figure 1. Drought conditions as of July 2, 2013 impact a large portion of the upper Basin with the exception of the northern half of Montana and North Dakota. Elsewhere, drought conditions range from Moderate (D1) to Extreme (D3) with only isolated areas where conditions are Exceptional (D4). Drought conditions in the states of Missouri and Iowa have been nearly mitigated as a result of spring precipitation. Compared to May 28, 2013, current drought conditions improved slightly due to June precipitation in the Basin. In the High Plains region, which includes Wyoming, Colorado, North Dakota, South Dakota, Nebraska and Kansas, the area covered by Extreme (D3) Drought including D4 drought remained essentially the same, from 21 to 23 percent. The area covered by Severe (D2) including D3 and D4 drought decreased from 56 to 47 percent.

According to the U.S. Seasonal Drought Outlook shown in Figure 2, drought conditions will continue to improve in all areas of the Basin east of the Missouri River including a portion of eastern Nebraska west of the river. Some limited improvement is expected in central and western Nebraska, South Dakota, southeast Montana and eastern Wyoming.

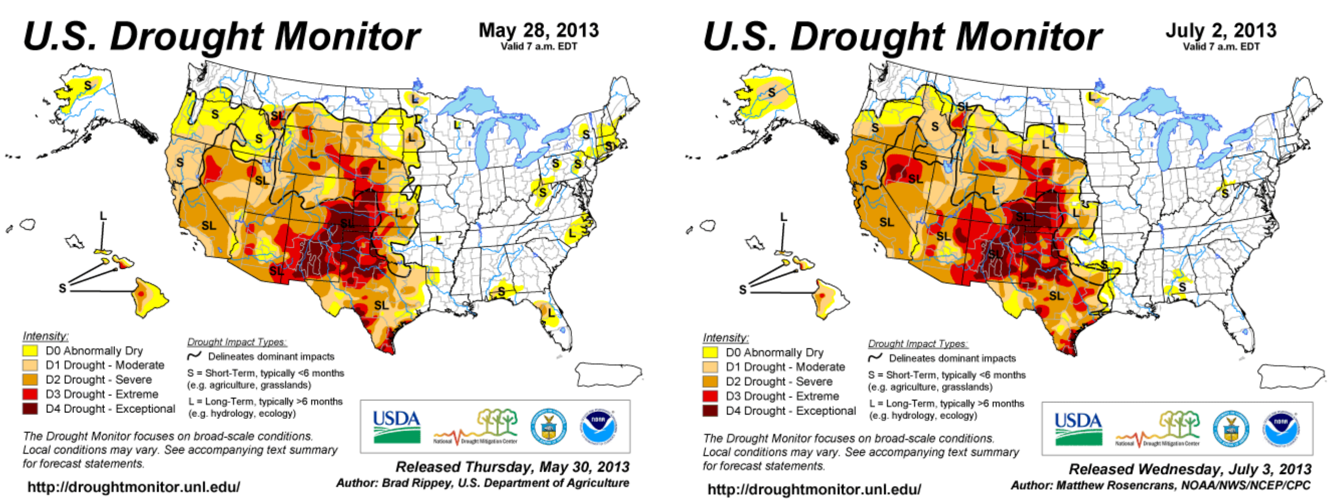


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for May 28, 2013 and July 2, 2013.

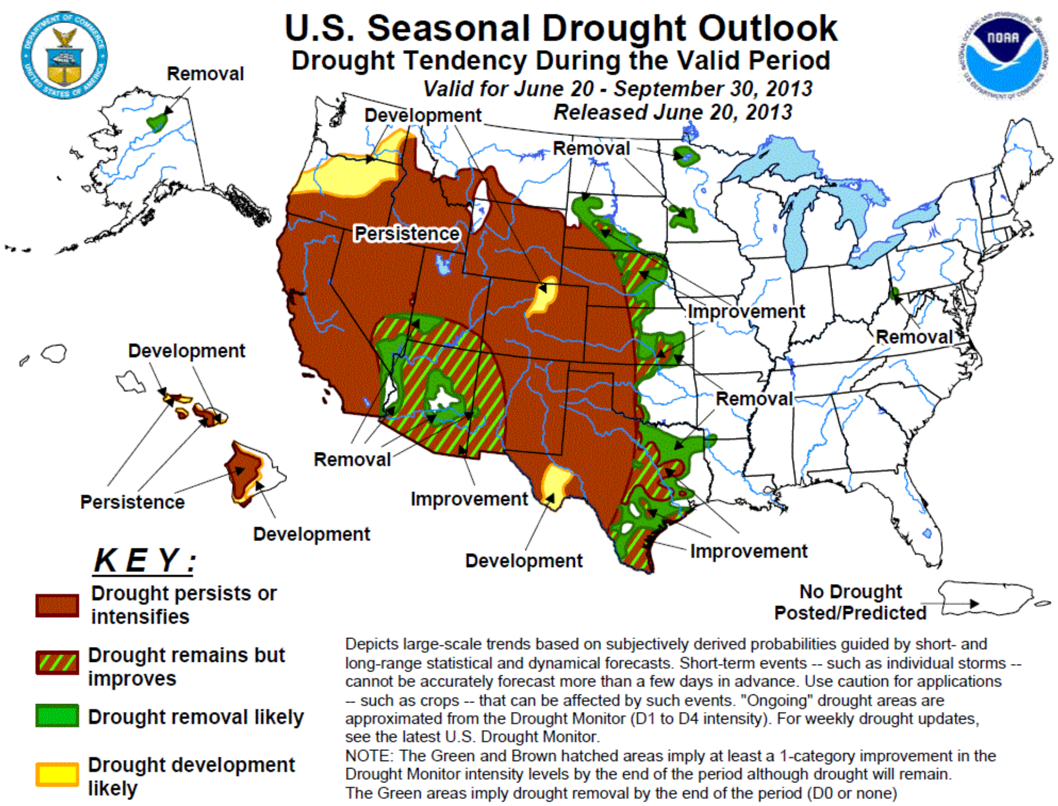


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of June is shown in Figure 3. Abundant precipitation occurred in the Basin centered in Montana in the upper. Precipitation totals ranging from 5-8 inches occurred over much of northern and eastern Montana, central and western North Dakota, portions of South Dakota, eastern Nebraska and western Iowa.

Rainfall departures for June expressed in inches were greatest in the upper Basin, especially in Montana, western North Dakota, and northwest South Dakota where they generally ranged from 2-4 inches above normal (Figure 4). In the lower Basin, conditions were somewhat dry for the month of June, typically 1 to 2 inches below normal.

Rainfall departures for April through June expressed in inches were also greatest in the upper Basin, especially in Montana, western North Dakota, and northwest South Dakota where they generally ranged from 4-8 inches above normal (Figure 5).

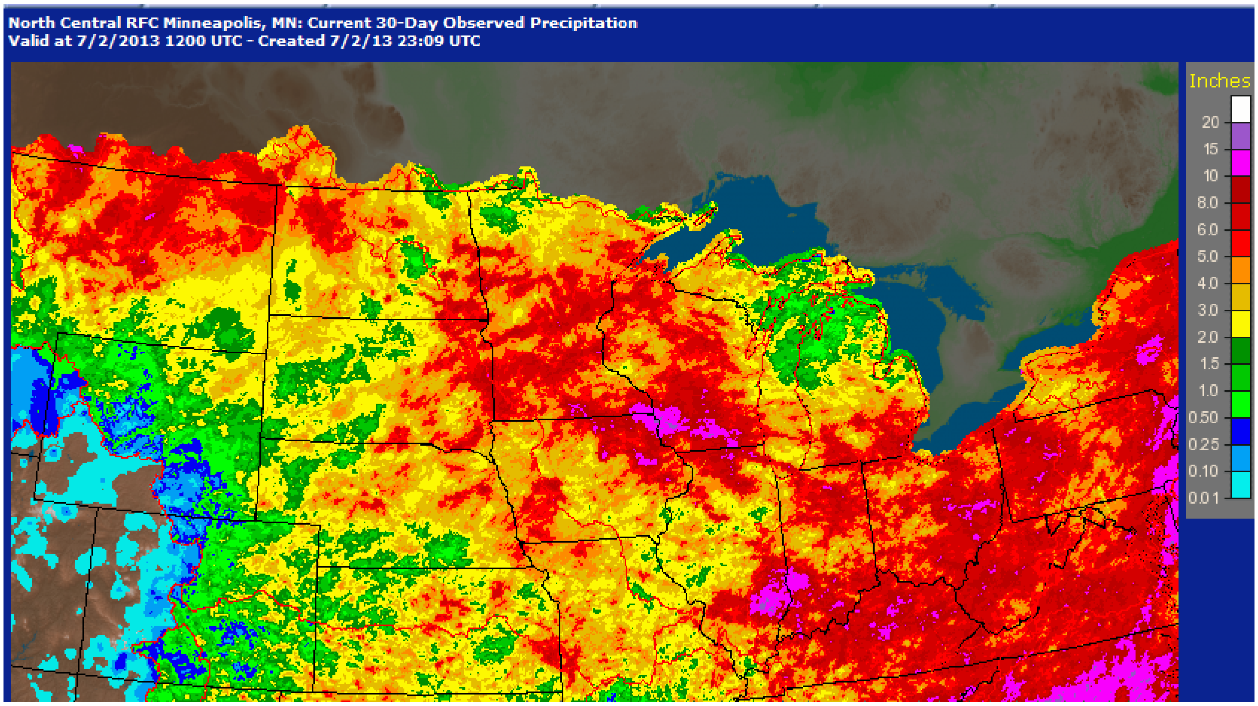


Figure 3. June 2013 precipitation (inches).

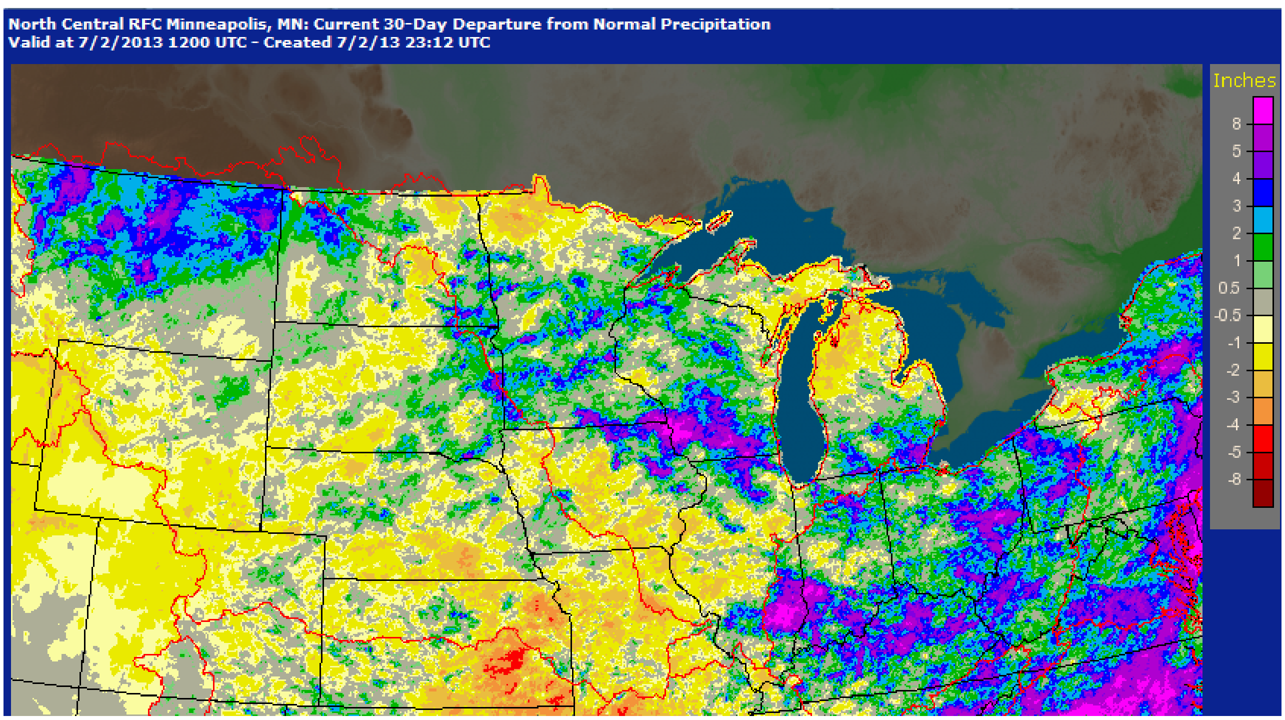


Figure 4. June 2013 precipitation departure (inches) from normal.

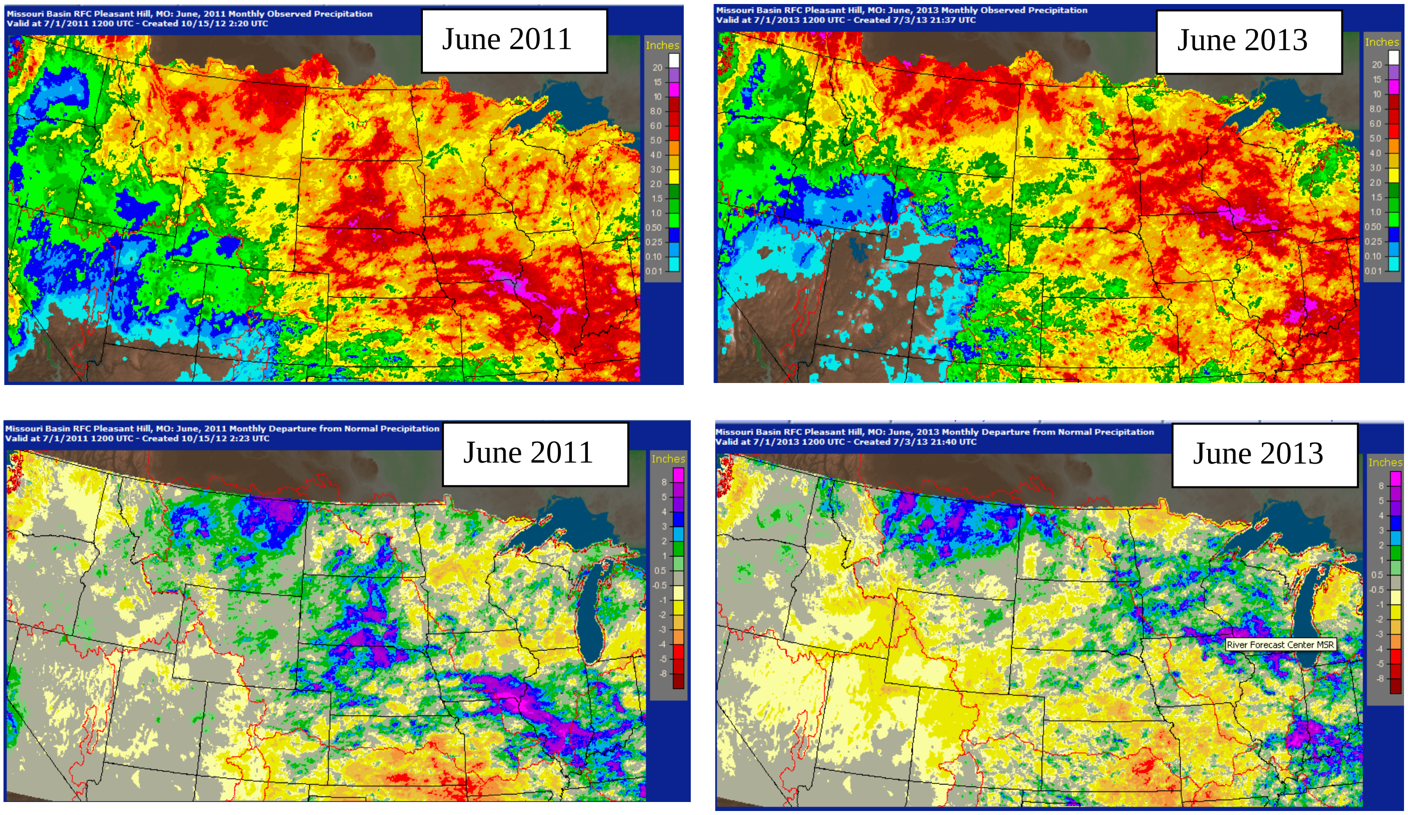


Figure 5. Comparison of June 2013 Precipitation to June 2011 Precipitation – Actual Precipitation and Departure from Normal Precipitation.

Figure 5 shows the comparison of the June 2013 monthly precipitation to the June 2011 monthly precipitation for both observed precipitation and departure from normal precipitation. Especially for Montana, the precipitation amounts are very similar. Table 1 shows the June runoff for 2011 and 2013. While the June precipitation amounts were similar, there is a big disparity in the associated June runoff. This is most likely due to the very different antecedent soil moisture conditions between the two years. There were four years of above average runoff prior to the 2011 June runoff, but two years of below average runoff prior to the 2013 June runoff. Consequently, due to saturated soil conditions in 2011, a large percentage of the precipitation became runoff, while dry soil conditions in 2013 resulted in lesser runoff as precipitation helped offset the soil moisture conditions instead being realized as reservoir inflow.

Table 1. Comparison of June 2013 Fort Peck and Garrison Runoff

	June 2011 Runoff		**June 2013 Runoff**	
	Volume	**Percent of Normal**	**Volume**	**Percent of Normal**
Fort Peck	4825 KAF	299%	1682 KAF	103%
Garrison	6485 KAF	243%	3194 KAF	118%

Temperature

Average temperatures throughout most of the upper Basin during the past 30 days ending Jul 1, 2013 were generally 1-3 degrees F below (Figure 6). June temperatures indicate a slight cooling trend compared to the past 90 days shown in Figure 7. The 90-day temperature departure map indicates temperatures ranged from 2-6 degrees F below normal in the plains, but slightly below normal in the Rocky Mountains. The epicenter of cold temperatures in the U.S. was in North Dakota where temperatures ranged from 5-9 degrees F below normal over the 90-day period.

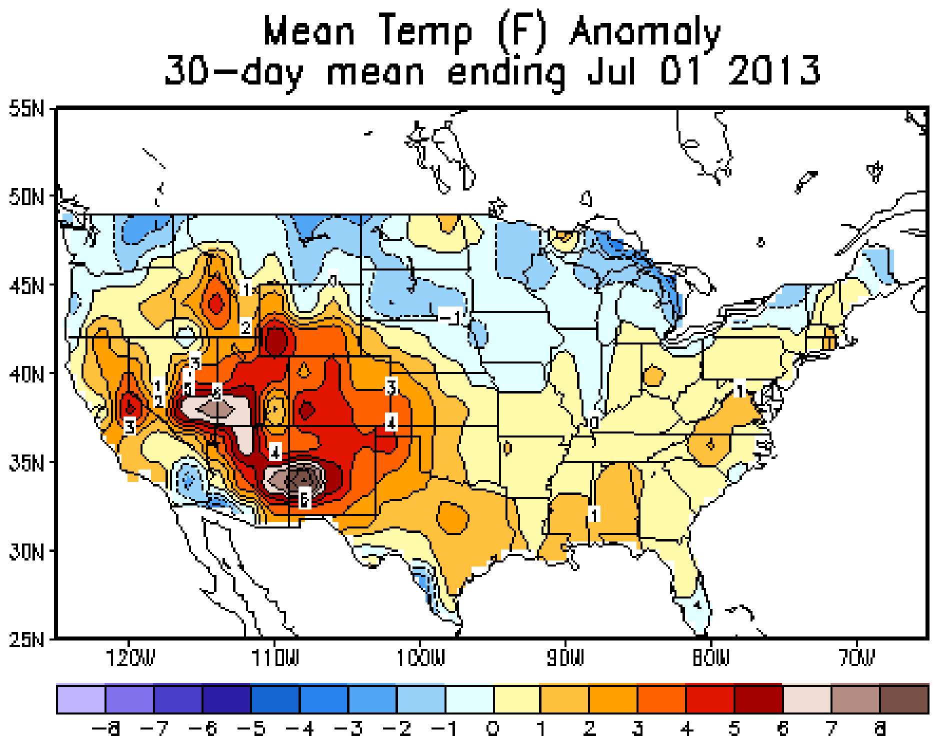


Figure 6. 30-day temperature departures (degrees F) from normal.

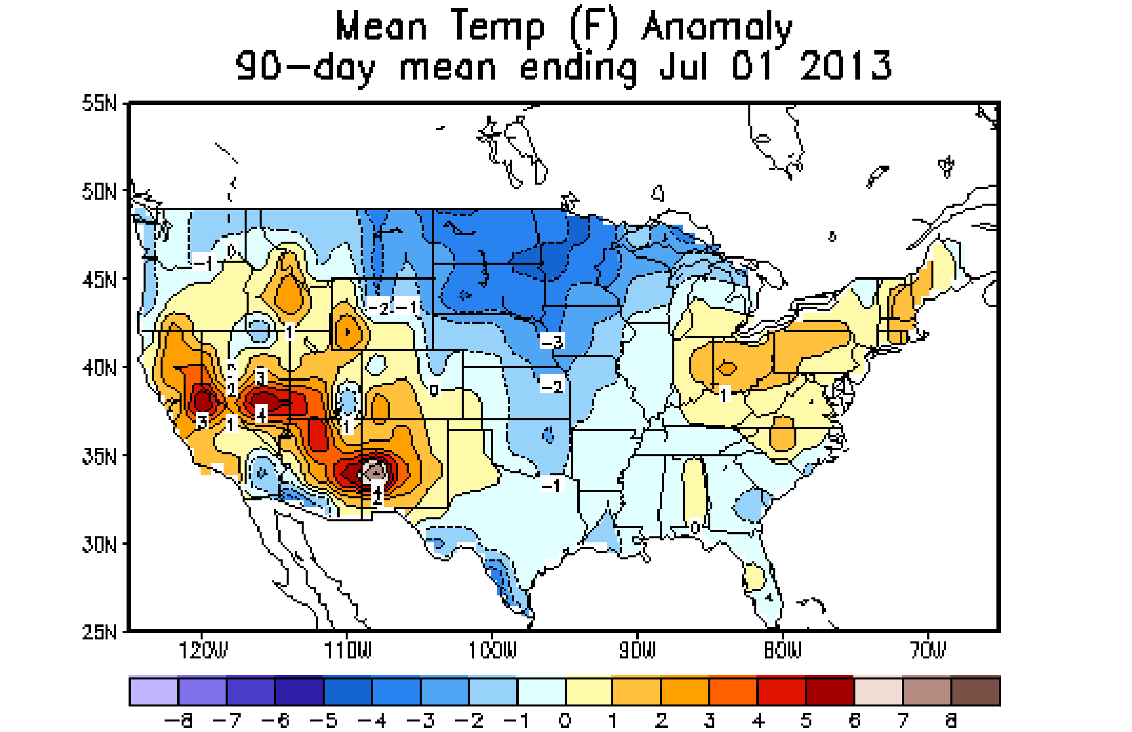


Figure 7. 90-day temperature departures (degrees F) from normal.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet, or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry, or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

In spite of well above normal precipitation falling on the upper Basin in May, the observed runoff was about normal due to greater soil infiltration due to the dry soil conditions prior to the rainfall. In fact, soil moisture conditions improved significantly in May; however, 2- to 3-inch deficits still exist in eastern Wyoming and western South Dakota and Nebraska. Soil moisture conditions are discussed in more detail in the following paragraphs.

Two independent estimates of soil moisture are presented in this report. Figures 8-9 illustrate the NOAA Climate Prediction Center's (CPC) calculated soil moisture ranking percentiles (Figure 8) and calculated soil moisture anomaly (Figure 9). Figure 10 shows the University of Washington's Variable Infiltration Capacity (VIC) model soil moisture percentiles and Figure 11 shows the VIC models soil moisture percentile change over the past 30 days.

The current status of the soil is represented by the soil moisture percentile ranking in Figure 9 and Figure 10. The soil moisture rankings depict dry soil moisture conditions in eastern Wyoming and western Nebraska. Wet soil moisture conditions are present in northern Montana, North Dakota.

The CPC calculated soil moisture anomaly is shown in Figure 11. In spite of the recent above normal precipitation in the upper Basin, widespread negative soil moisture anomalies still exist in Wyoming, South Dakota and Nebraska, ranging from 20-80 (0.8-3.1 inches) below normal. Positive soil moisture anomalies developed in May and June in central North Dakota and western Montana generally ranging from 20-60 mm (0.8-2.4 mm).

According to the VIC model in Figure 10, the driest conditions (less than the 5^{th} percentile) are present in north-central and southern Wyoming. In contrast, soil moisture conditions in northern Montana rank in the 95^{th} and 98^{th} percentiles for soil wetness.

As an indicator of future monthly runoff, above normal soil moisture ranking percentiles in Montana and the Dakotas indicate that soil moisture conditions have improved significantly, and normal runoff is more likely assuming normal precipitation. Below normal soil moisture ranking percentiles in Wyoming, southwest Montana, and central Nebraska indicate soil moisture conditions are still dry, and below normal runoff is likely given normal or below normal precipitation. Normal to above normal rainfall will be needed in the dry areas in order to restore soil moisture to more normal conditions before normal runoff can occur.

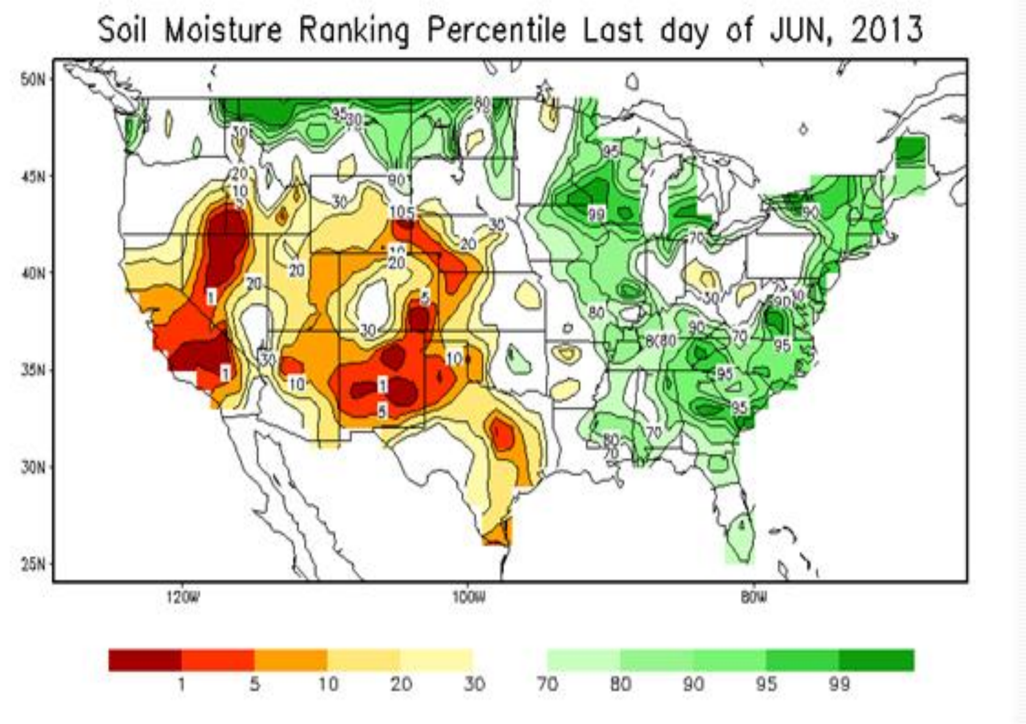


Figure 8. Calculated Soil Moisture Ranking Percentile on Jun 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

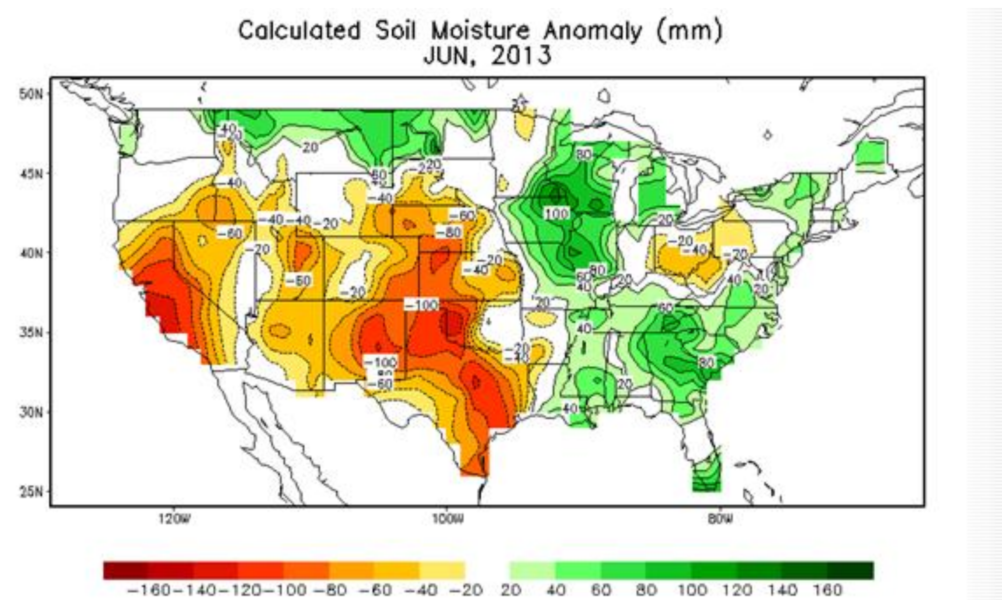


Figure 6. Calculated Soil Moisture Anomaly on May 31, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

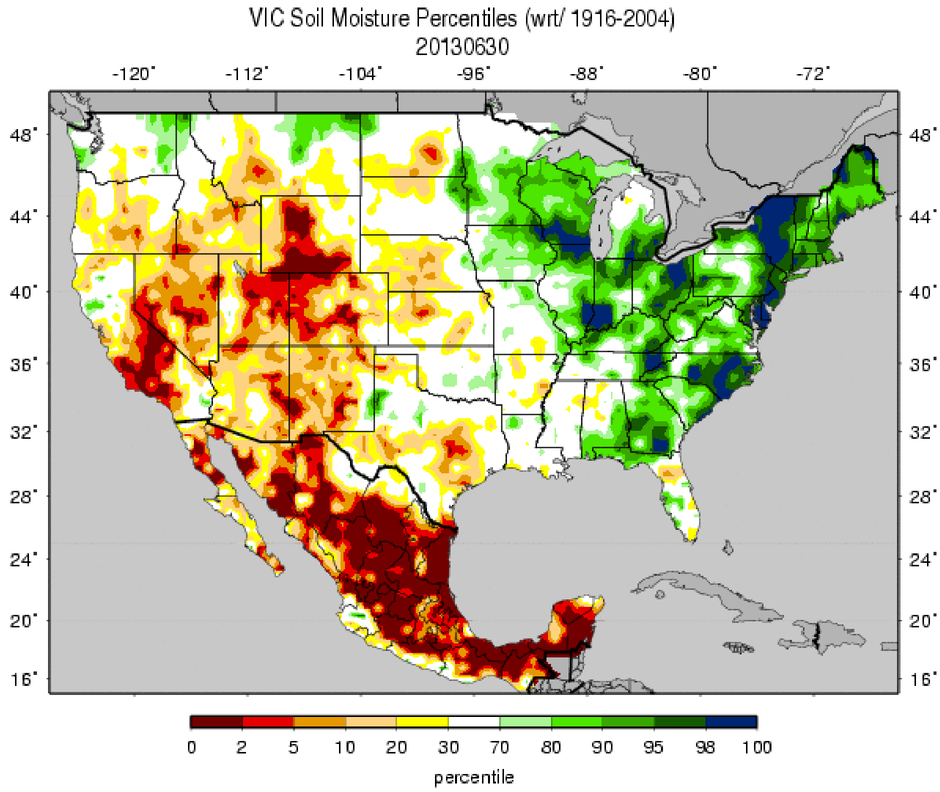


Figure 7. VIC modeled soil moisture percentiles as of June 2, 2013. Source: University of Washington. **http://www.hydro.washington.edu/forecast/monitor/index.shtml**

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. The Missouri River basin mountain snowpack normally peaks on April 15.

The mountain snowpack SWE above Fort Peck peaked on April 23 at 15.4 inches, 95 percent of the normal April 15 peak (Figure 14). The mountain snowpack SWE between Fort Peck and Garrison peaked on April 25 at 13.5 inches, 95 percent of the normal April 15 peak. On June 1, 2013 the mountain snowpack SWE in the reach above Fort Peck was 1 percent of the normal April 15 peak. In the Fort Peck to Garrison reach there is no remaining mountain snowpack. Normally by July 1, about 3 percent of the snowpack still remains.

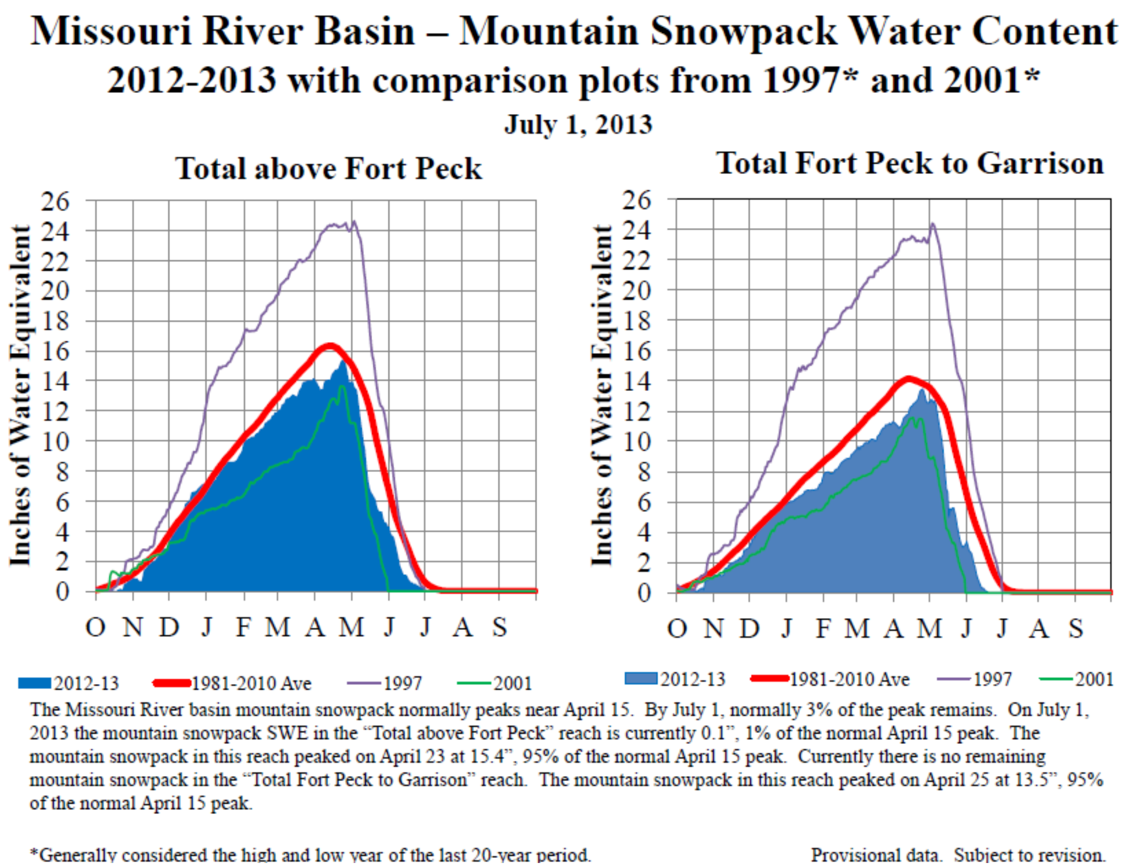


Figure 8. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific. Equatorial sea surface temperatures are near average across the western and central Pacific Ocean and below average across the eastern Pacific. ENSO-neutral conditions are favored in the Northern Hemisphere through late summer 2013. During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's July temperature outlook (Figure 12) indicates increased chances for above normal temperatures in western Montana and western Wyoming with equal chances throughout the remainder of the upper basin. The CPC's 3-month temperature outlook for July-August-September (Figure 13) indicates the increased chances for above normal temperatures will expand eastward into South Dakota, Nebraska and western Missouri. During the September-October-November outlook period (see Figure 14) there are increased chances for above normal temperatures throughout most of the upper Missouri River. During the December-January-February 2014 (Figure 15) period, chances for above normal, normal and below normal temperatures are equal.

The CPC's July precipitation outlook (Figure 12) is indicating equal chances for below normal , normal, and above normal precipitation throughout the basin. In the July-August-September forecast period, precipitation chances are similar to June with increased chances for below normal precipitation in eastern Montana (Figure 13). These outlooks support the drought forecast which indicates drought conditions will persist west of the Missouri River and possibly expand in southern Montana and Wyoming. The precipitation outlooks for September-October-November (Figure 14) and December-January-February (Figure 15) indicate equal chances for above normal, normal, and below normal precipitation.

The drought outlook does not indicate much improvement to the drought conditions throughout the summer nor near the end of the calendar year. Improvements in soil moisture conditions have benefitted runoff in the upper basin; however, large soil moisture deficits in Wyoming will continue to limit runoff into the Mainstem system during the summer and fall.

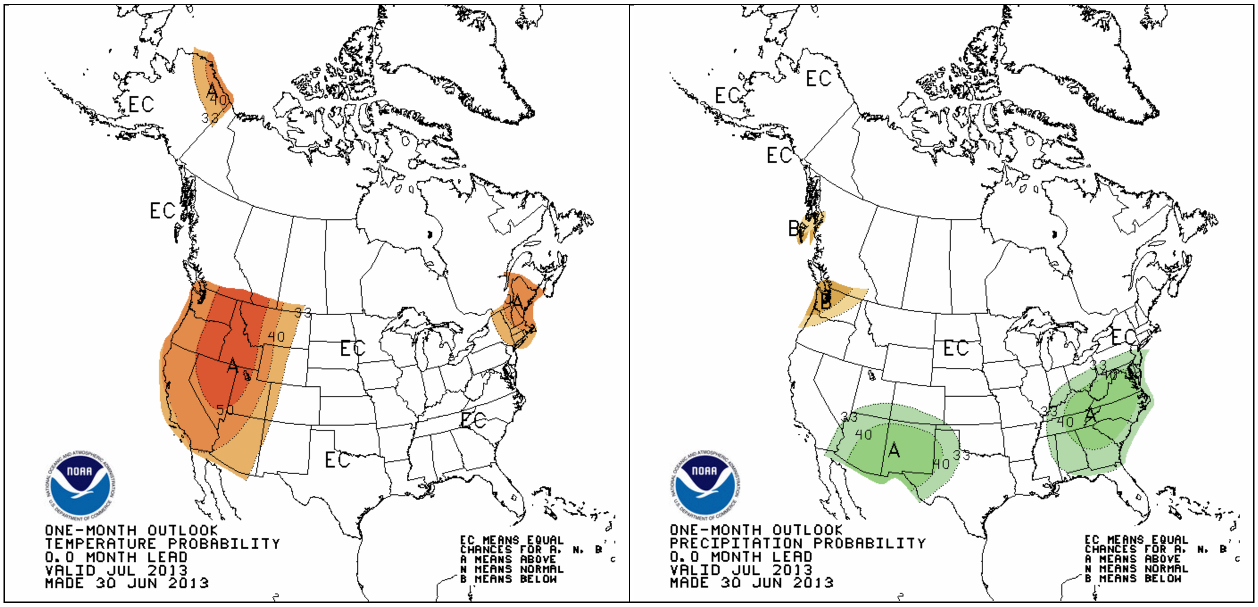


Figure 12. CPC June 2013 temperature and precipitation outlooks.

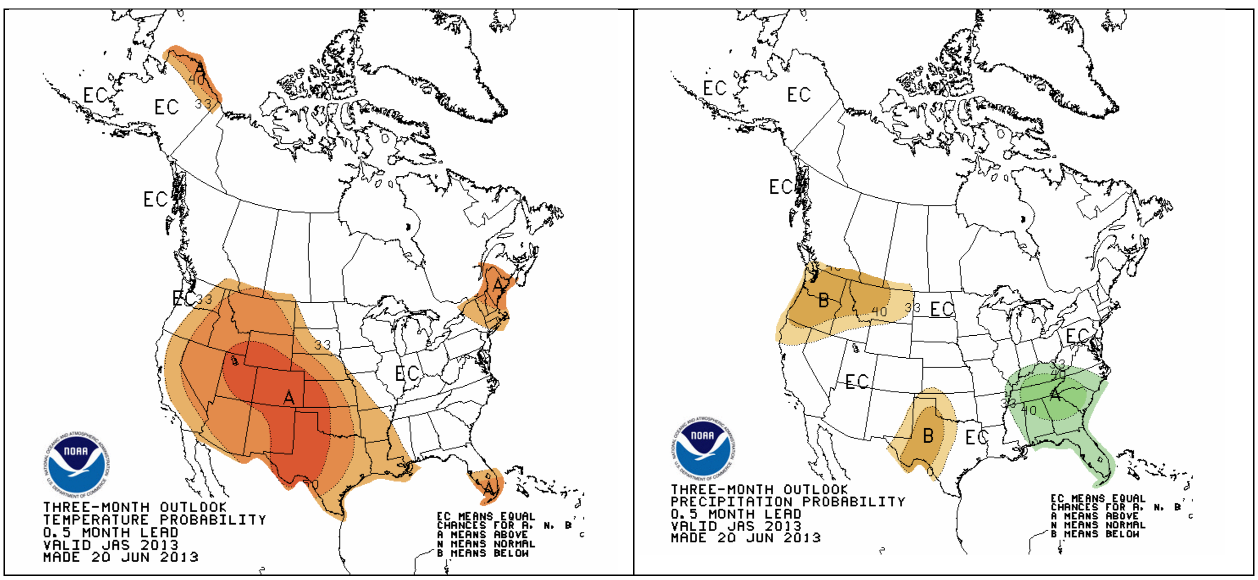


Figure 9. CPC July-August-September 2013 temperature and precipitation outlooks.

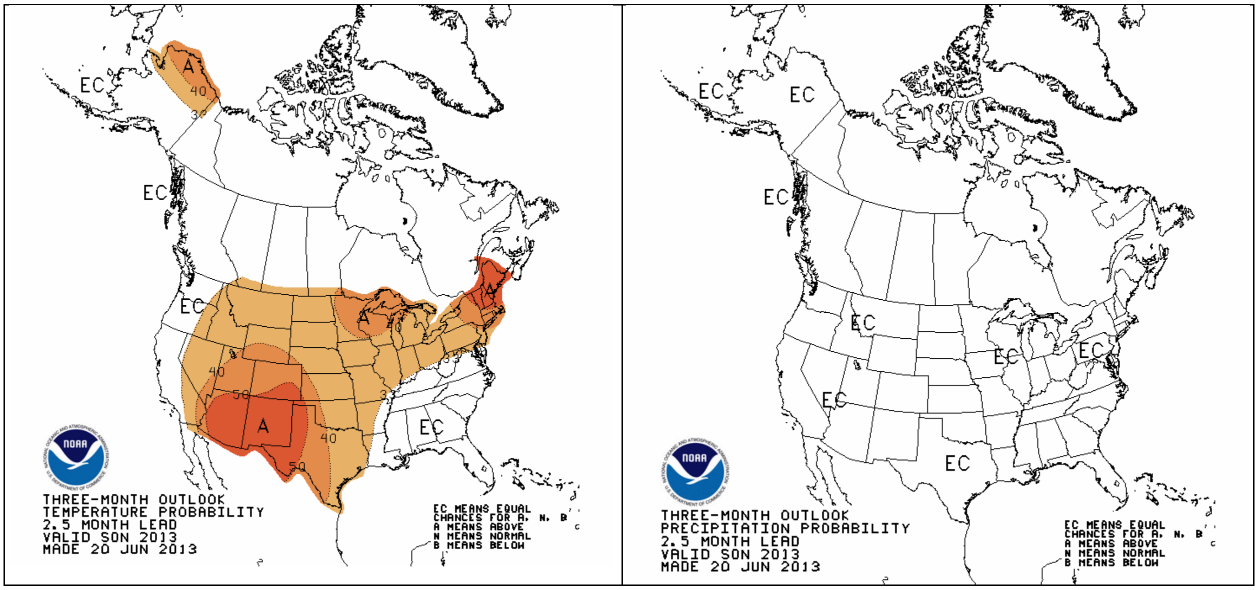


Figure 14. CPC September-October-November 2013 temperature and precipitation outlooks.

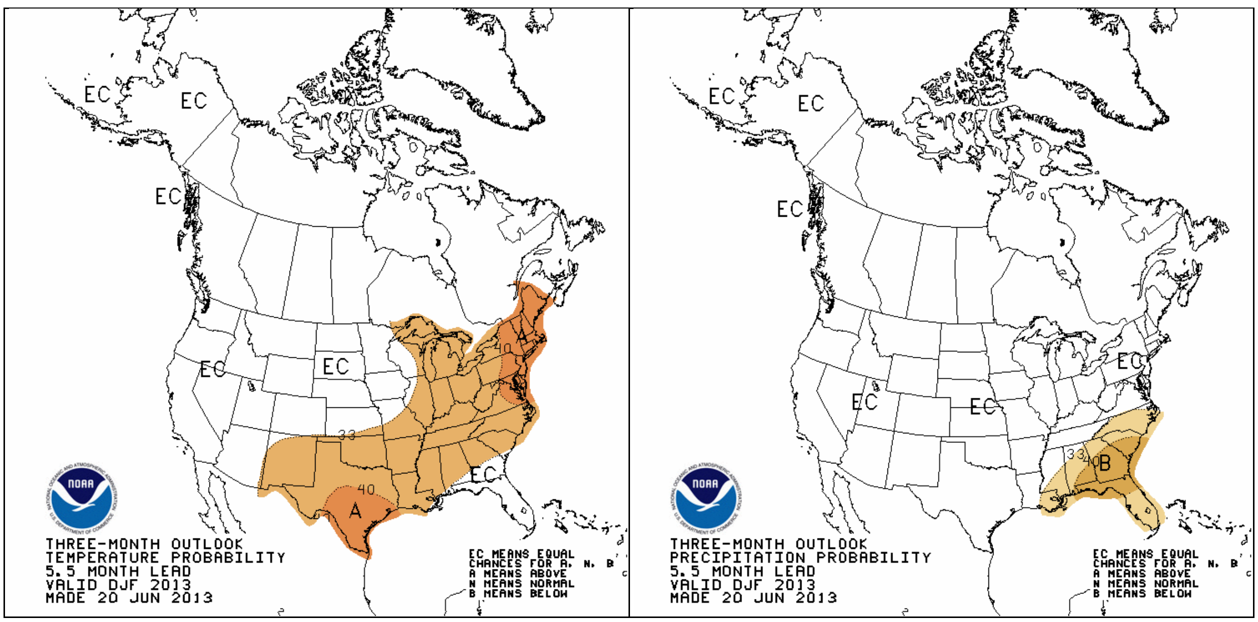


Figure 15. CPC December-January-February 2014 temperature and precipitation outlooks.

Summary

The annual runoff forecast as of July 1, 2013 is 22.3 MAF (88 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.1 MAF (88 percent of normal). Above Sioux City, this is an increase of 1.1 MAF from the May runoff forecast. Precipitation in June was well above normal in much of the upper Missouri River Basin (Basin) and observed May runoff was 6.3 MAF (116 percent of normal) in the upper Basin above Sioux City, IA. Above Gavins Point Dam, runoff was 5.8 MAF (113 percent of normal).

Upper Missouri River Basin
Calendar Year Runoff Forecast
August 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of August 1, 2013 is 22.7 MAF (90 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.6 MAF (90 percent of normal).

Above Sioux City, this is an increase of 0.4 MAF from the July runoff forecast. Precipitation in July was below normal throughout most of the upper Missouri River Basin (Basin) and observed July runoff was 2.6 MAF (80 percent of normal) above Sioux City, IA and 2.3 MAF (76 percent of normal above Gavins Point Dam. July runoff contrasted sharply with June runoff which was 116 percent of normal above Sioux City, IA and 113 percent of normal above Gavins Point. A majority of the snowmelt runoff occurred in June, leaving a very limited volume of snowmelt runoff for the month of July; however, May-June-July runoff was 12.5 MAF (104 percent of normal). The end-of-July annual accumulated runoff above Sioux City, IA is 18.3 MAF (92 percent of normal).

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next six months, the range of expected inflow is quite large and ranges from the 23.6 MAF upper basic forecast to the 21.8 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The National Drought Mitigation Center’s (NDMC) U.S. Drought Monitor for July 2 and July 30, 2013 are shown in Figure 1. Drought conditions as of July 30, 2013 impact a large portion of the upper Basin with the exception of the northern half of Montana and western North Dakota. Drought conditions range from Moderate (D1) to Extreme (D3) with only isolated areas where conditions are Exceptional (D4). The worst drought conditions exist in Wyoming and western Nebraska. Compared to July 2, July 30 Abnormally Dry (D) conditions expanded into western Iowa and eastern North Dakota during July.

According to the U.S. Seasonal Drought Outlook shown in Figure 2, drought conditions will continue to persist in the drought impact areas through the end of October 2013.

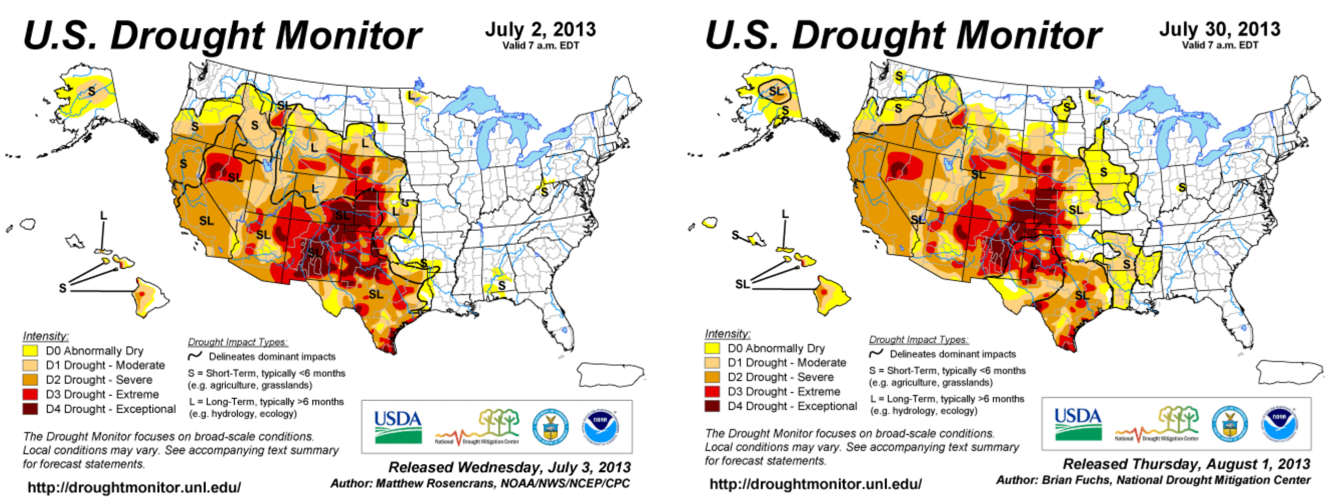


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for July 2 and July 30, 2013.

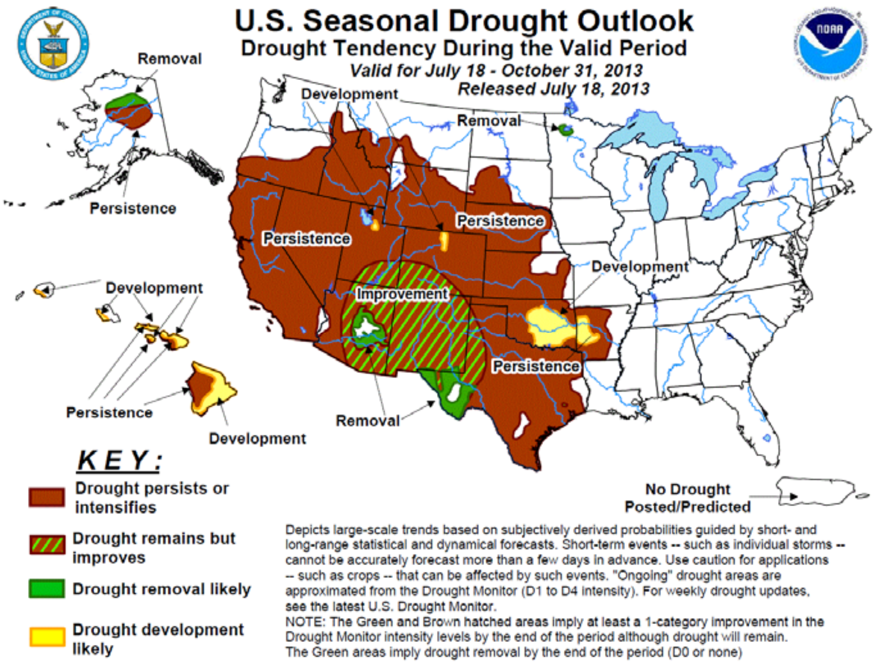


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of July is shown in Figure 3. Precipitation primarily occurred due to thunderstorms moving across the basin; therefore, precipitation amounts were locally heavy, but not widespread. Several areas that received heavy precipitation during July included north central Montana, northwest North Dakota, south central South Dakota and north central Nebraska. Rainfall amounts in these areas ranged from two to six inches (Figure 3). July rainfall amounts in most other areas of the Basin ranged from one to three inches.

Rainfall departures for July expressed in inches were greatest in north central Montana and very localized portions of south central South Dakota and north central Nebraska, where departures ranged from two to four inches (Figure 4). With the exception of these few areas, July precipitation in western North Dakota, western South Dakota, Wyoming and much of Montana was normal. Precipitation in other areas of the upper Basin was one to three inches below normal. Precipitation departures were well below normal in eastern Nebraska, western Iowa and Missouri ranging from about two to four inches below normal.

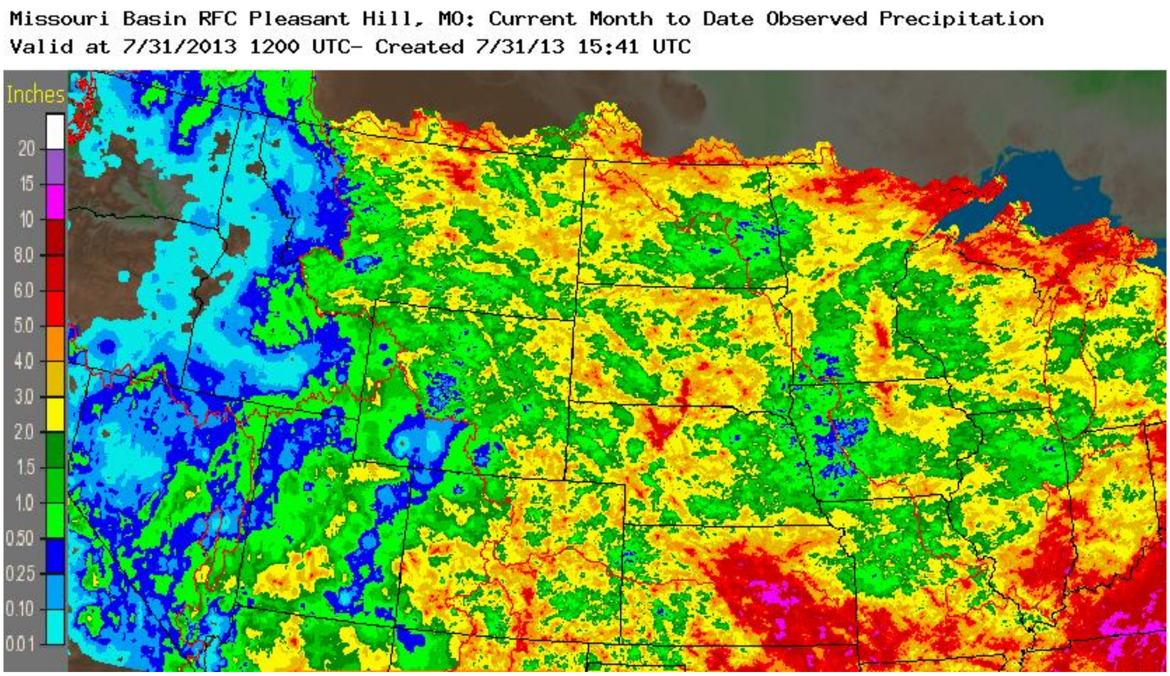


Figure 3. July 2013 precipitation (inches).

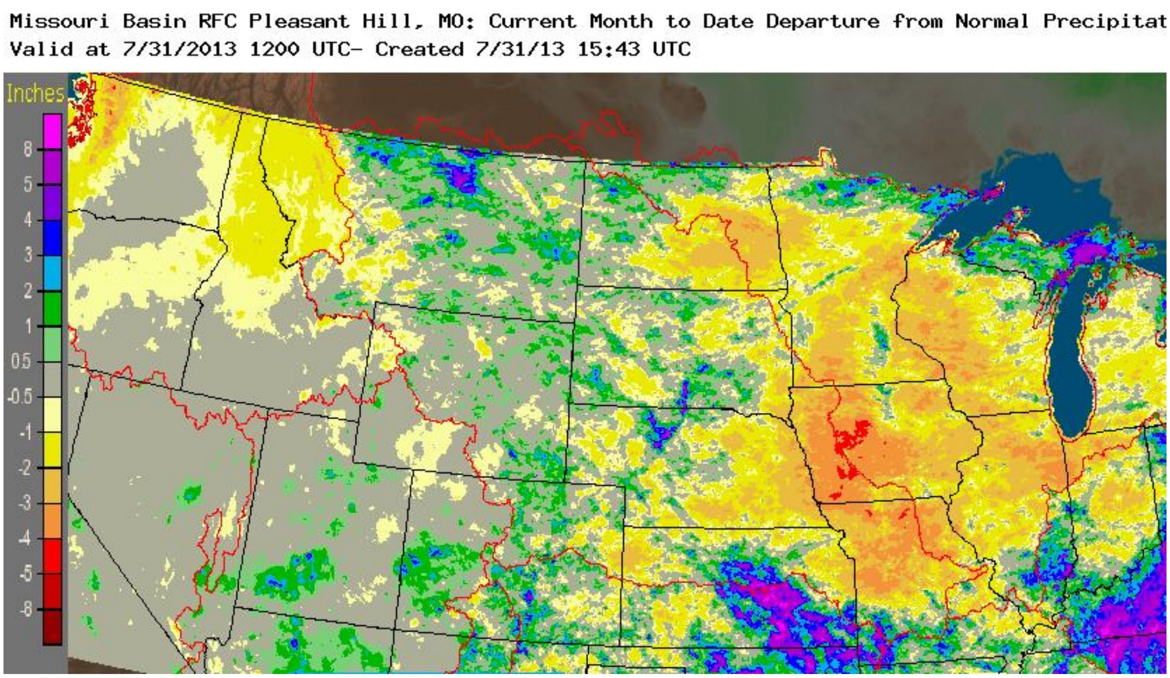


Figure 4. July 2013 precipitation departure (inches) from normal.

Temperature

Average temperatures throughout most of the upper Basin during the past month ending July 31, 2013 were generally one to two degrees F below normal (Figure 5) across the plains, while temperatures in the mountains were one to four degrees F above normal. The 90-day temperature departure map indicates temperatures ranged from normal to one degree F below normal in the plains, while temperatures in the mountains were normal to three degrees F above normal.

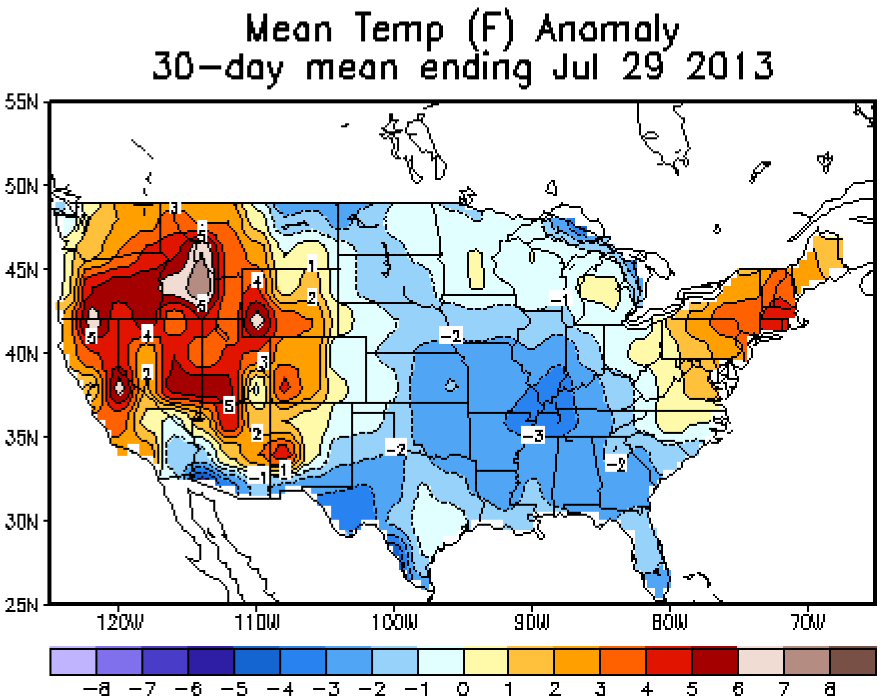


Figure 5. 30-day temperature departures (degrees F) from normal.

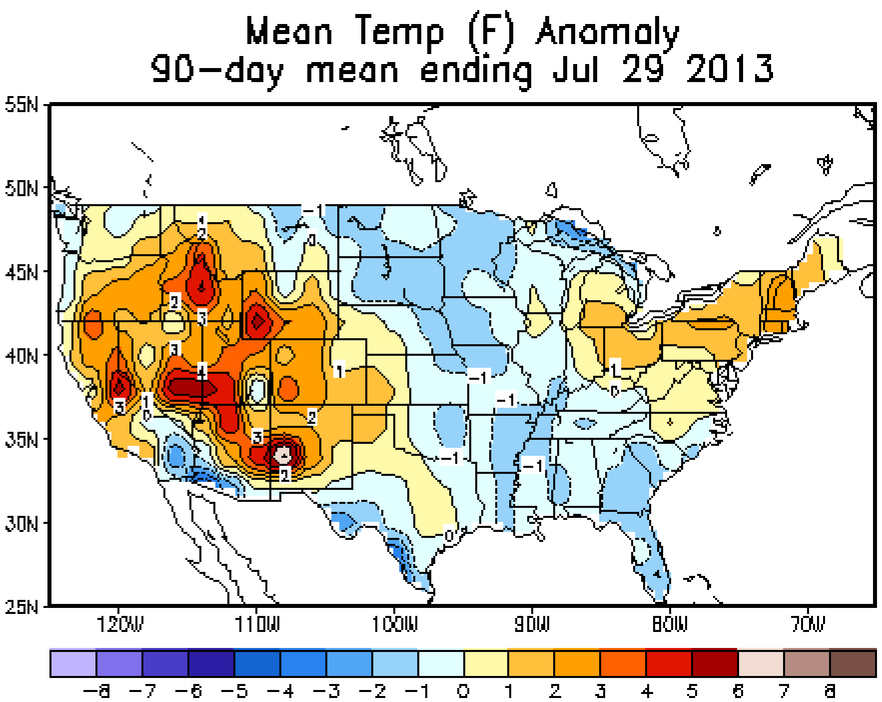


Figure 6. 90-day temperature departures (degrees F) from normal.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet, or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry, or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

Two independent estimates of soil moisture are presented in this report. Figures 7 and 8 illustrate the soil moisture ranking percentiles developed by the NOAA Climate Prediction Center's (CPC) in Figure 7 and the University of Washington's Variable Infiltration Capacity (VIC) model in Figure 8. The CPC's calculated soil moisture anomaly is shown in Figure 9.

The current status of the soil is represented by the soil moisture percentile ranking in Figure 7 and Figure 8. The soil moisture rankings depict dry soil moisture conditions in much of and Nebraska. Wet soil moisture conditions are present in northern and eastern Montana, and much of North Dakota. According to the VIC model soil moisture ranking percentile in Figure 8, the driest conditions (less than the 5^{th} percentile) are present in north-central and south central Wyoming. Furthermore, dry soil moisture conditions below the 20^{th} percentile ranking are present in western Montana. The VIC soil moisture percentiles also show wetter than average conditions in northern and eastern Montana and northwest North Dakota. It also indicates drier than average conditions in portions of the lower Basin.

As an indicator of future monthly runoff, above normal soil moisture ranking percentiles in Montana and the Dakotas indicate that soil moisture conditions have improved significantly, and normal runoff is more likely assuming normal precipitation. Below normal soil moisture ranking percentiles in Wyoming, western Montana, and Nebraska indicate soil moisture conditions are still dry, and below normal runoff will likely to occur. Normal to above normal rainfall will be needed in the dry areas in order to restore soil moisture to more normal conditions before normal runoff can occur.

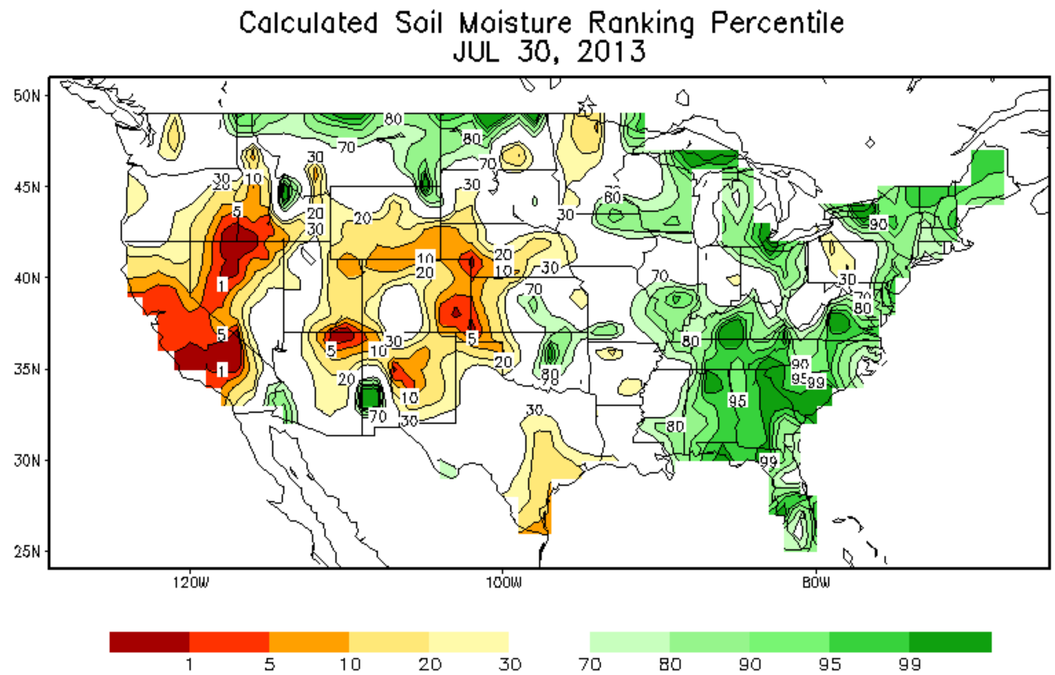


Figure 7. Calculated Soil Moisture Ranking Percentile on Jul 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

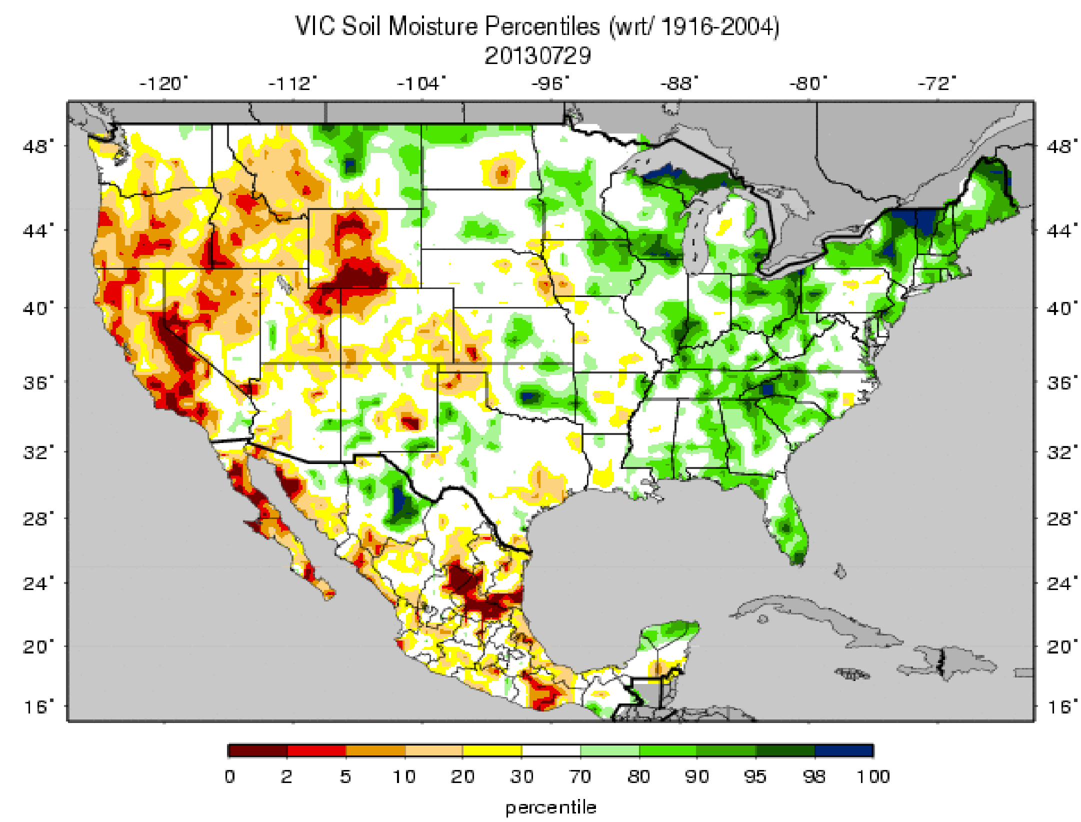


Figure 8. VIC modeled soil moisture percentiles as of July 29, 2013. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/index.shtml

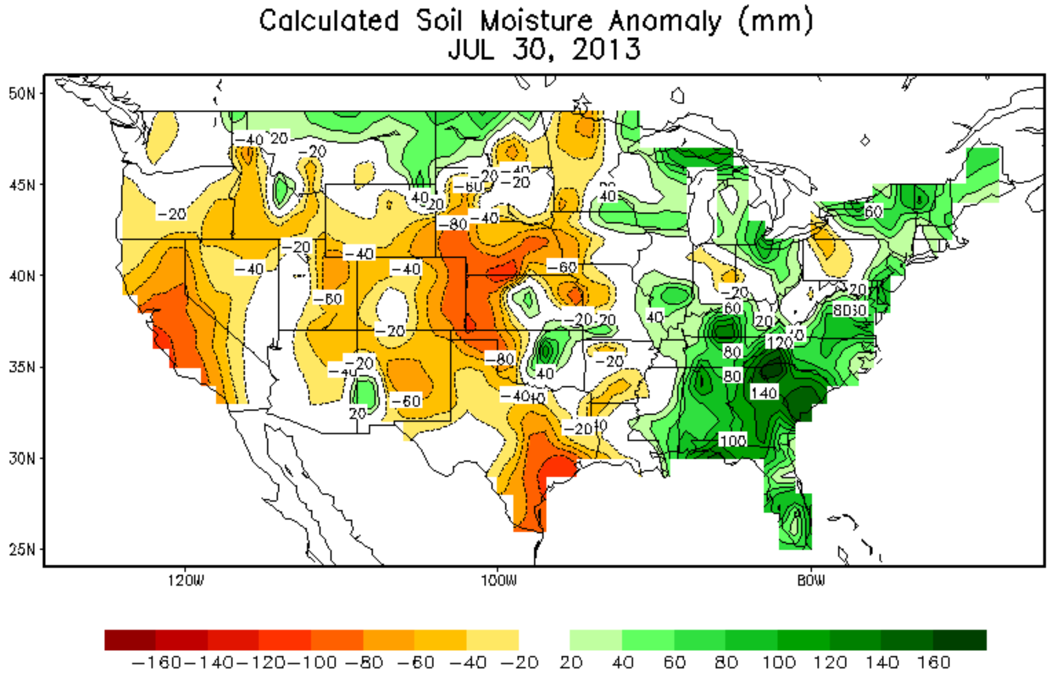


Figure 9. Calculated Soil Moisture Anomaly on Jul 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. The Missouri River basin mountain snowpack normally peaks on April 15.

The mountain snowpack SWE above Fort Peck peaked on April 23 at 15.4 inches, 95 percent of the normal April 15 peak (Figure 14). The mountain snowpack SWE between Fort Peck and Garrison peaked on April 25 at 13.5 inches, 95 percent of the normal April 15 peak. On July 15, 2013 there was effectively no measureable mountain snowpack remaining in the reach above Fort Peck and in the Garrison reach.

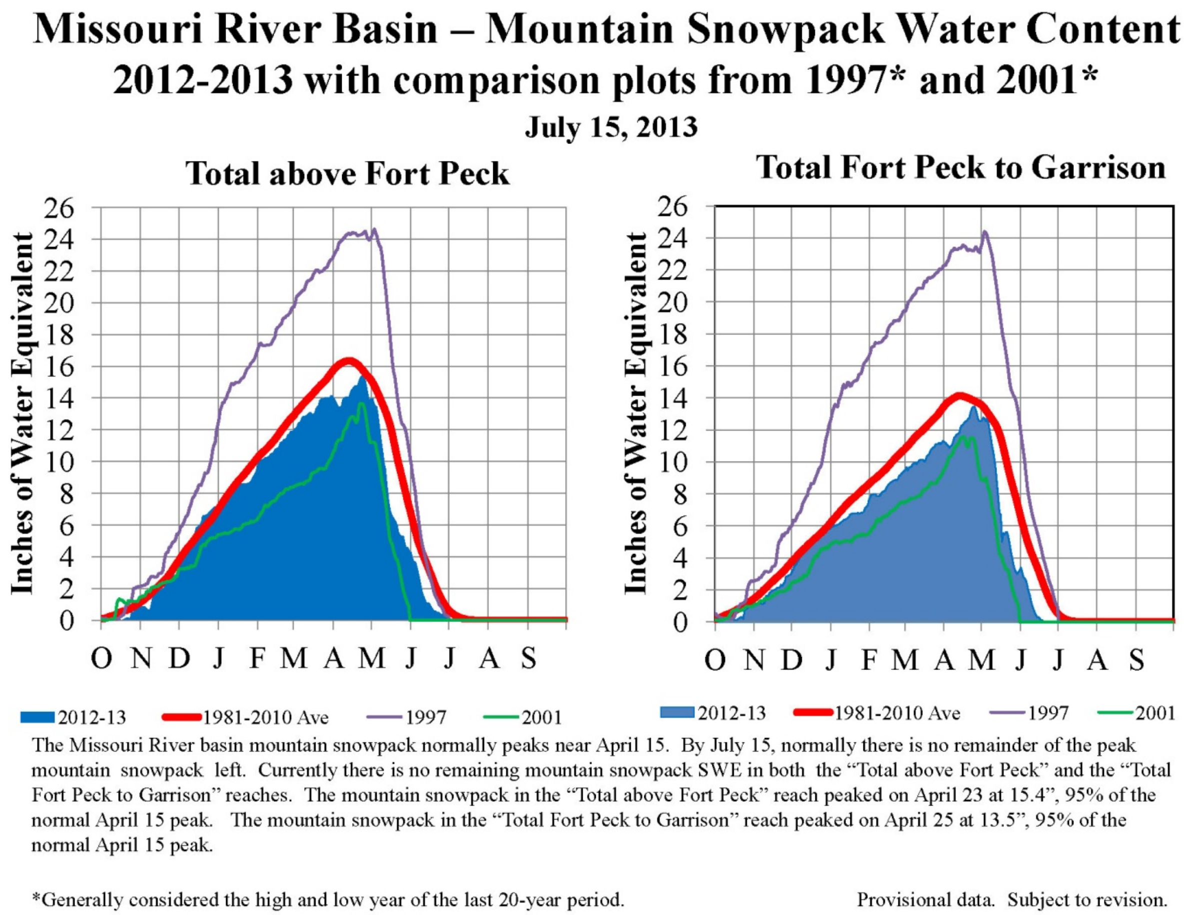


Figure 10. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

<u>Climate Outlook</u>

ENSO-neutral conditions continue in the equatorial Pacific. Equatorial sea surface temperatures are near average across the western and central Pacific Ocean and below average across the eastern Pacific. ENSO-neutral conditions are favored into the Northern Hemisphere fall 2013. During a neutral phase, there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's August temperature outlook shown in Figure 11 indicates equal chances for above normal, normal and below normal temperatures in Montana and Wyoming, while there is an increased chance for below normal temperatures in North and South Dakota, eastern Nebraska, Iowa and Missouri. The CPC's 3-month temperature outlook for August-September-October in Figure 12 indicates increased chances for above normal temperatures in Montana and Wyoming, while there are equal chances for above normal, normal and below normal temperatures in the remainder of the upper Basin. During the November-

December-January outlook period shown in Figure 13 there is an increased chance for above normal temperatures throughout most of the upper Basin.

The CPC's August precipitation outlook shown in Figure 11 is indicating increased chances for above normal precipitation in Montana and northern Wyoming, while there are equal chances for below normal , normal, and above normal precipitation in all other areas of the upper Basin. In the August-September-October forecast period shown in Figure 12, there are equal chances for above normal, normal and below normal precipitation over the entire Basin. The precipitation outlook for the November-December-January period shown in Figure 13 indicated equal chances for above normal, normal, and below normal precipitation.

The drought outlook indicates persistence drought impacts in all areas of the Basin currently classified in drought. Improvements in soil moisture conditions have benefitted runoff in the northern and eastern Montana; however, large soil moisture deficits in western Montana, Wyoming and western South Dakota will continue to limit runoff into the Mainstem system during the summer and fall.

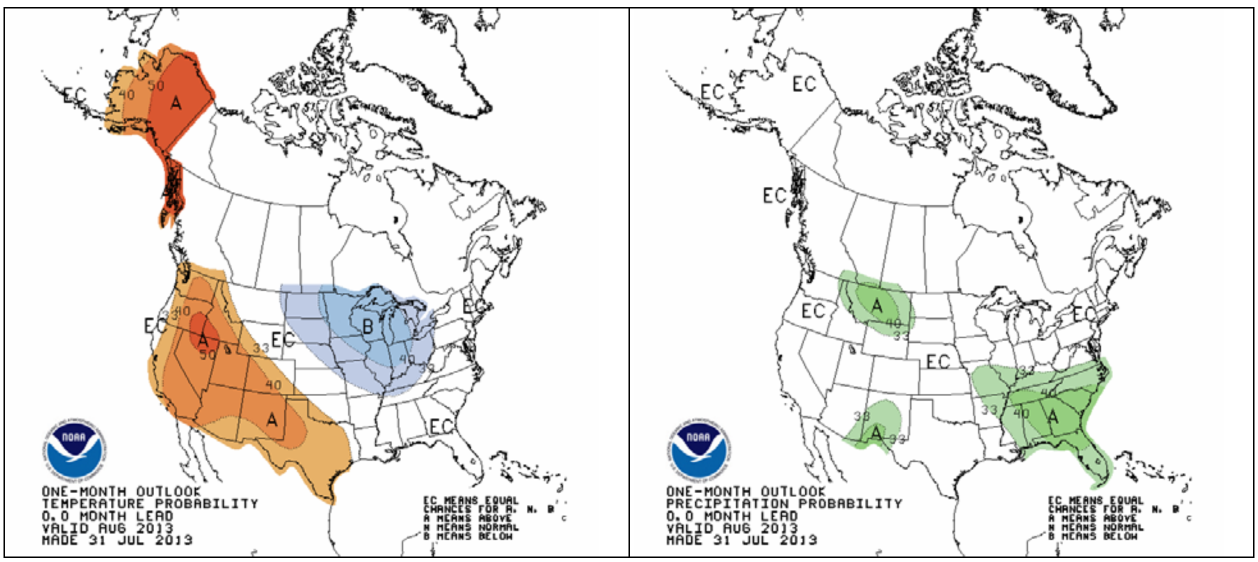


Figure 11. CPC August 2013 temperature and precipitation outlooks.

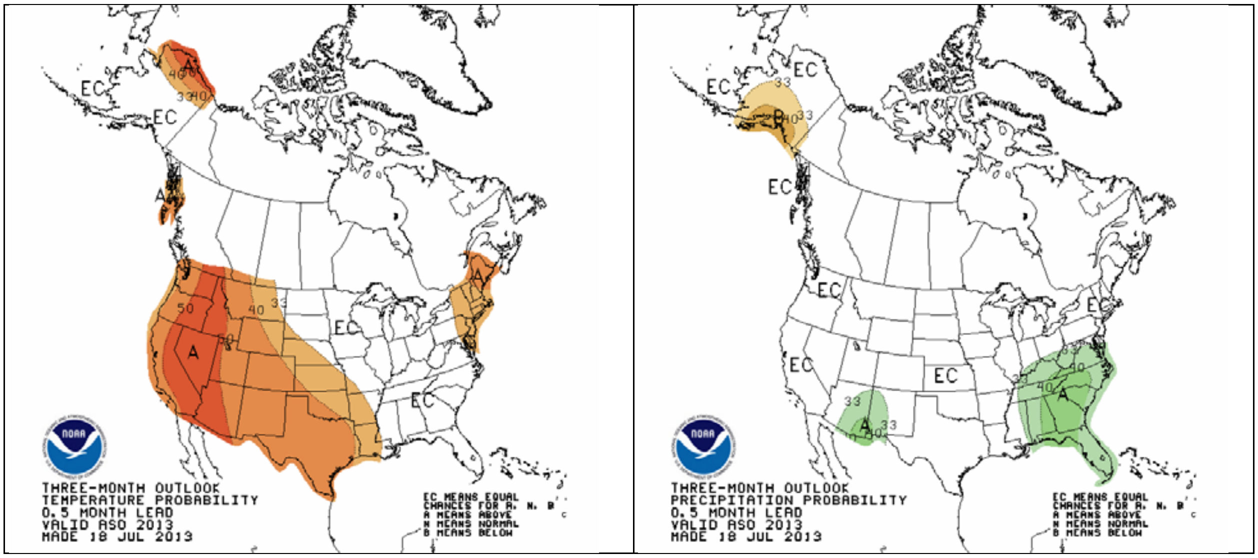


Figure 12. CPC August-September-October 2013 temperature and precipitation outlooks.

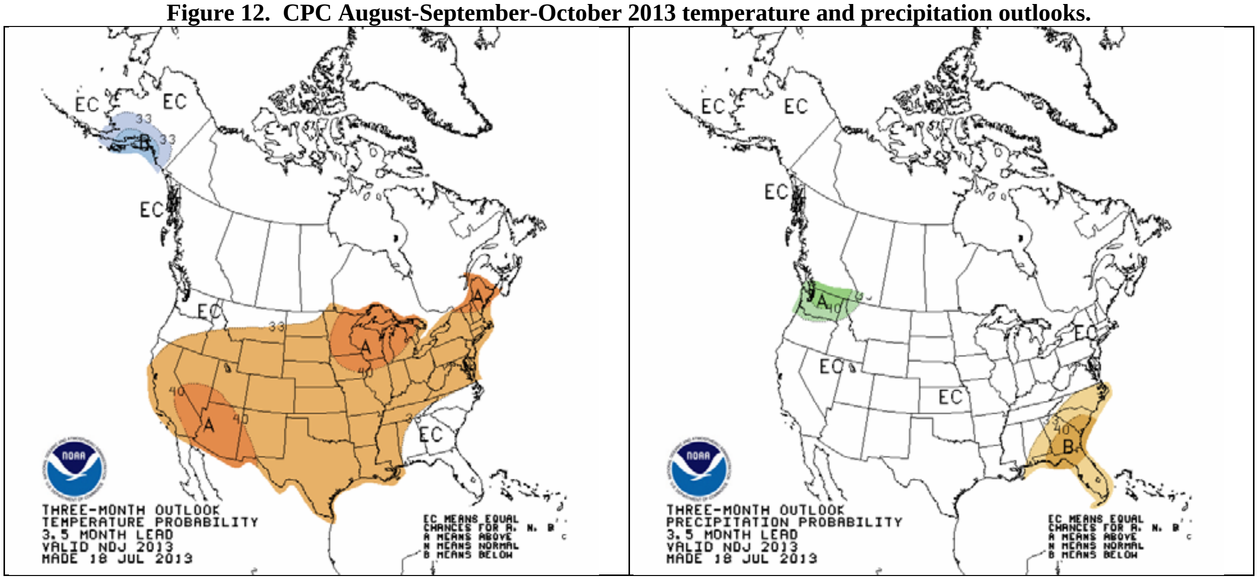


Figure 13. CPC November-December-January 2013-2014 temperature and precipitation outlooks.

Summary

The annual runoff forecast as of July 1, 2013 is 22.7 MAF (90 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.6 MAF (89 percent of normal). Above Sioux City, this is an increase of 0.4 MAF from the July runoff forecast, due to greater than forecast runoff during the month of July. July runoff was 2.5 MAF (78 percent of normal) above Sioux City, IA and 2.2 MAF (73 percent of normal) above Gavins Point. The August runoff forecast is 1.1 MAF (84 percent of normal) above Sioux City and 1.0 MAF (83 percent of normal) above Gavins Point. The runoff forecast for the August through December period was left mostly unchanged because continuing drought conditions and soil moisture deficits in southwest Montana, Wyoming and western South Dakota will continue to limit runoff even if abovenormal precipitation occurs.

Upper Missouri River Basin
Calendar Year Runoff Forecast
September 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of September 1, 2013 is 23.1 MAF (91 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.9 MAF (91 percent of normal).

Above Sioux City, this is an increase of 0.7 MAF from the August runoff forecast. Precipitation in August was generally below normal throughout the eastern portion Missouri River Basin (Basin) and above normal throughout the western portion of the Basin. Observed September runoff was 1.4 MAF (107 percent of normal) above Sioux City, IA and 1.2 MAF (101 percent of normal above Gavins Point. May-June-July runoff was 12.5 MAF (104 percent of normal).

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next six months, the range of expected inflow ranges from the 23.6 MAF upper basic forecast to the 21.8 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's (NDMC) U.S. Drought Monitor for July 30 and August 27, 2013 are shown in Figure 1. Drought conditions as of August 27, 2013 impact a large portion of the upper Basin with the exception of the northern half of Montana and western North Dakota. Drought conditions range from Moderate (D1) to Extreme (D3) with only isolated areas where conditions are Exceptional (D4). The worst drought conditions exist in Wyoming and western Nebraska. Compared to July 27, July 30 Abnormally Dry (D0) conditions continued to expand into western Iowa, Minnesota, and eastern North Dakota during August.

According to the U.S. Seasonal Drought Outlook shown in Figure 2, drought conditions will continue to persist in the drought impact areas through the end of October 2013.

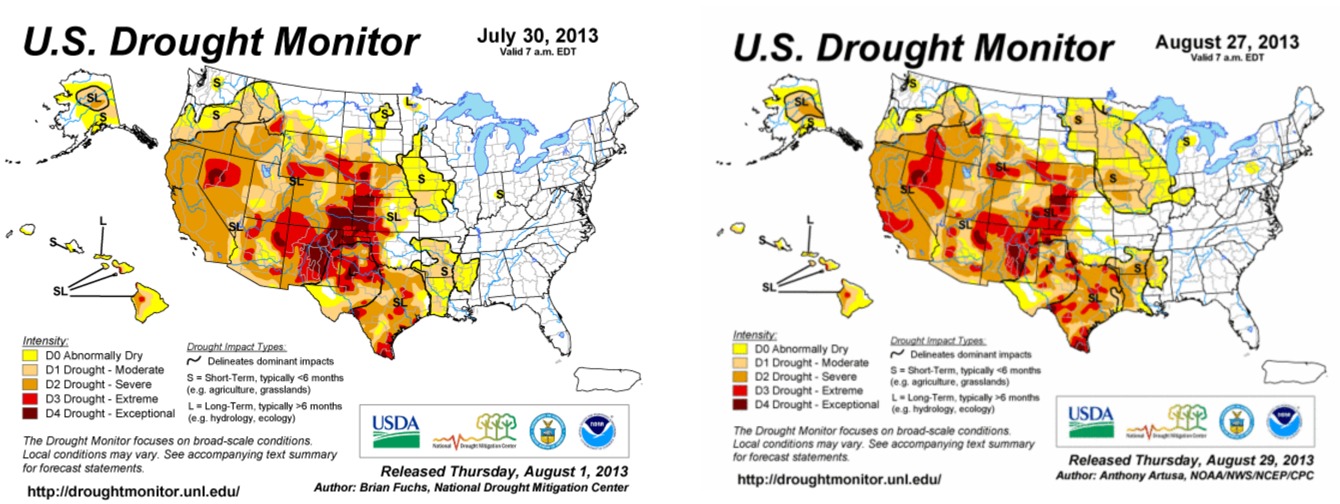


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for July 30 and August 27, 2013.

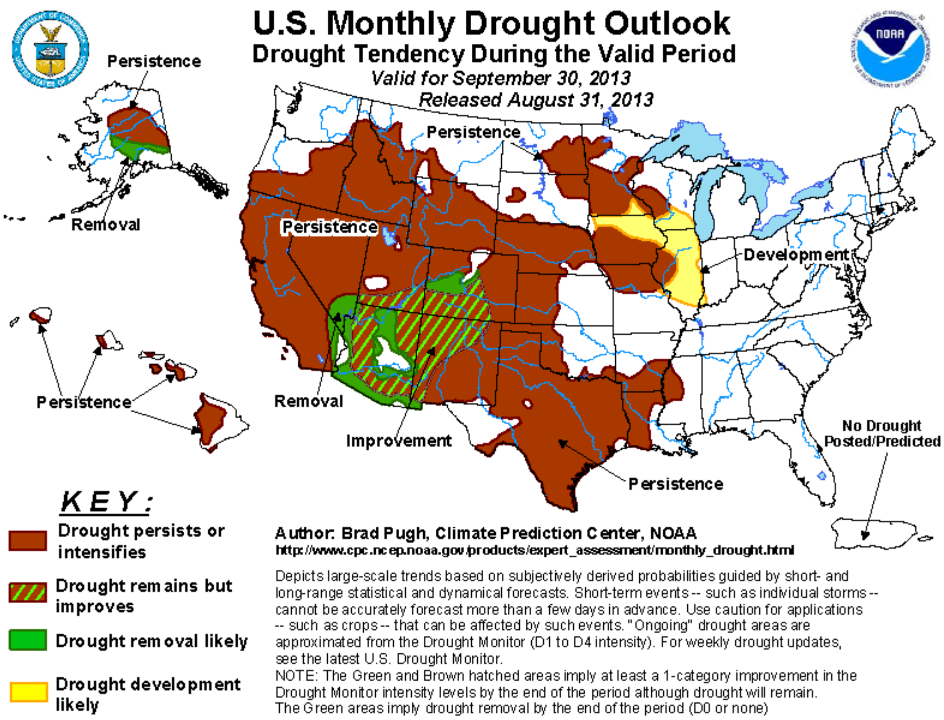


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation during the month of August is shown in Figure 3. Rainfall amounts in basin generally ranged from 0.5 inch to 3 inches (Figure 3). South-central Missouri, primarily over the Gasconade River Basin, received up to 10 inches of precipitation, most of this occurring July 29 through August 8. The storm was so severe that NOAA's Hydrometeorological Design Studies Center conducted an Annual Exceedance Probabilities analysis of the storm, which showed portions of the Gasconade River Basin to have received up to in excess of a 1 in 1000-year storm (Figure 3a).

Rainfall departures for August are shown in Figure 4. The majority of the basin had minimum departures ranging from -2 to 1 inches, with the exception of the south central Missouri storm, which had over 6 more inches than normal.

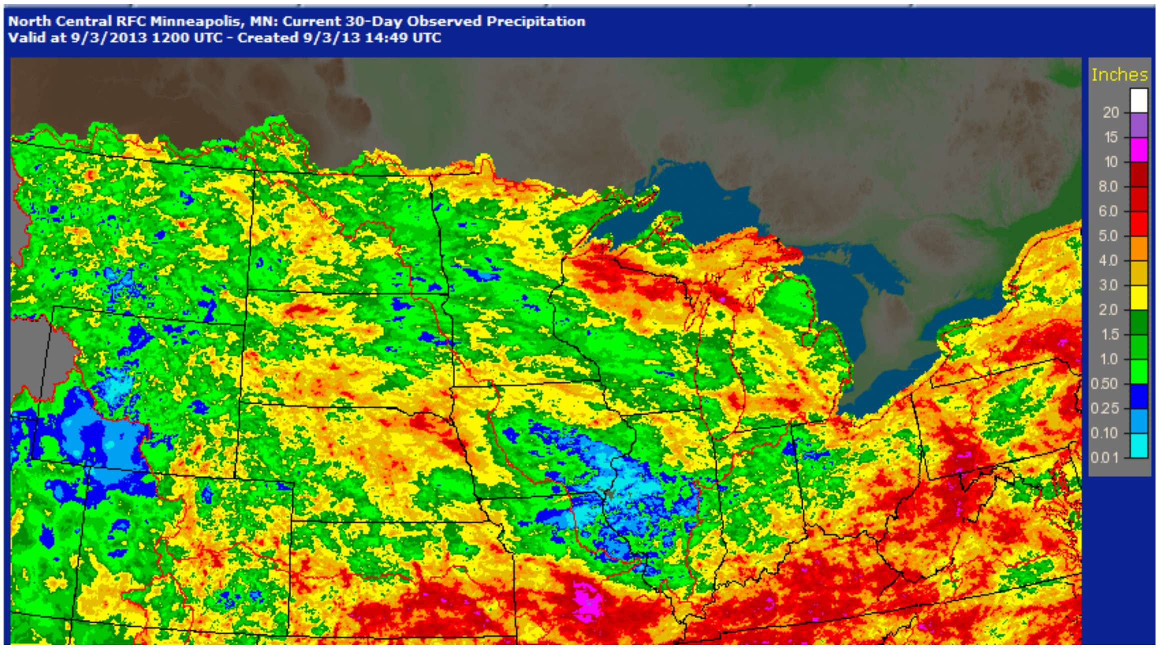


Figure 3. August 2013 precipitation (inches).

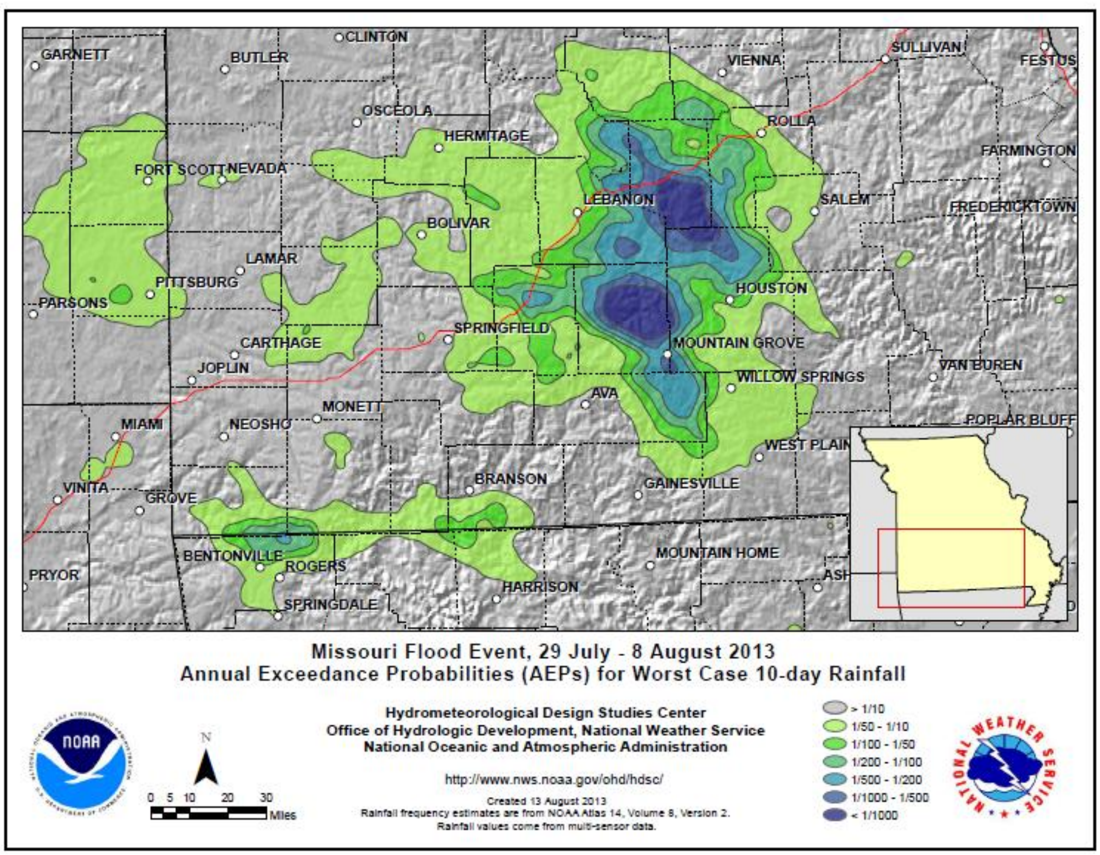


Figure 4a. 29 July – 8 August South-Central Missouri Storm

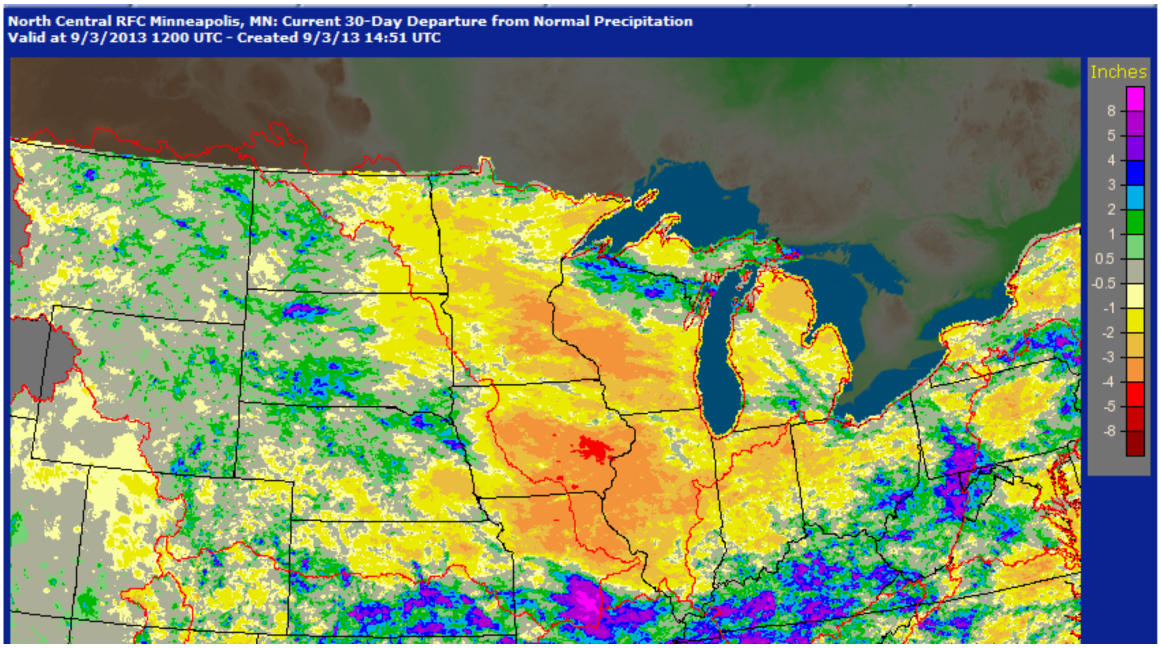


Figure 5. August 2013 precipitation departure (inches) from normal.

Temperature

Average temperatures throughout most of the upper Basin during the past month ending August 31 were generally 1 to 2 degrees F below (Figure 5) across the plains, while temperatures in the mountains were 1 to 4 degrees F above normal. The 90-day temperature departure map indicates temperatures ranged from normal to 1e degree F below normal in the plains, while temperatures in the mountains were normal to 3 degrees F above normal.

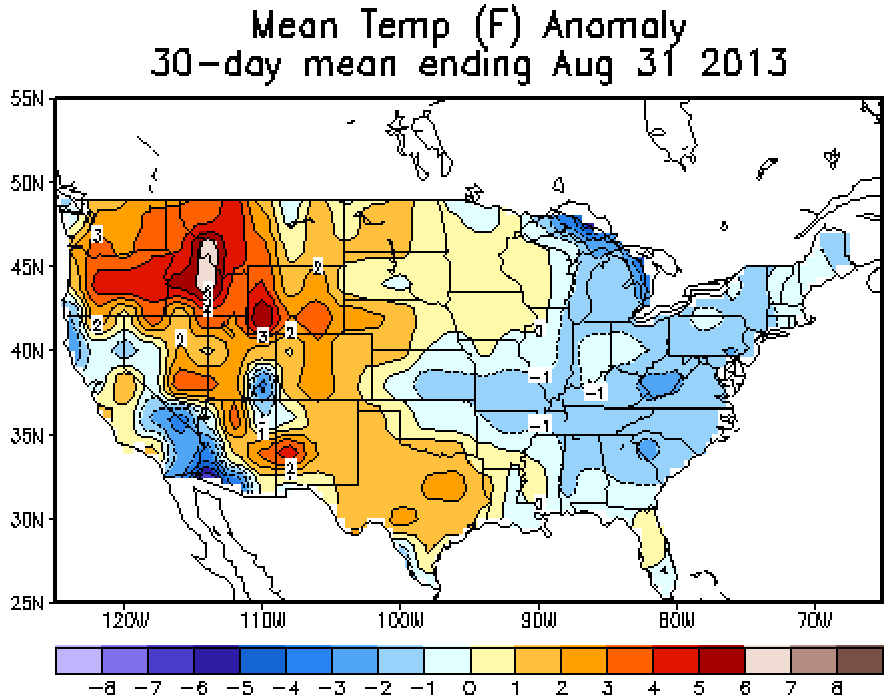


Figure 6. 30-day temperature departures (degrees F) from normal.

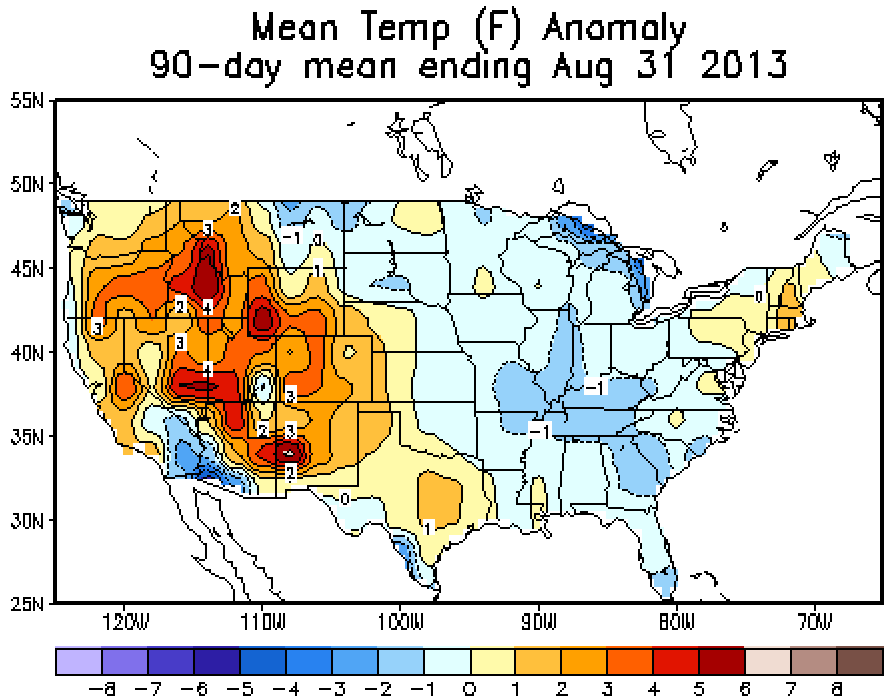


Figure 7. 90-day temperature departures (degrees F) from normal.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet, or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry, or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

Two independent estimates of soil moisture are presented in this report. Figures 7 and 8 illustrate the soil moisture ranking percentiles developed by the NOAA Climate Prediction Center's (CPC) in Figure 7 and the University of Washington's Variable Infiltration Capacity (VIC) model in Figure 8. The CPC's calculated soil moisture anomaly is shown in Figure 9.

The current status of the soil is represented by the soil moisture percentile ranking in Figure 7 and Figure 8. The soil moisture rankings depict dry soil moisture conditions in much of Nebraska. Wet soil moisture conditions are present in northern and eastern Montana and much of North Dakota. According to the VIC model soil moisture ranking percentile in Figure 8, the driest conditions (less than the 5^{th} percentile) are present in north central and south central Wyoming. Furthermore, dry soil moisture conditions below the 20^{th} percentile ranking are present in western Montana. The VIC soil moisture percentiles also show wetter than average conditions in northern and eastern Montana and northwest North Dakota. It also indicates drier-than-average conditions in portions of the lower Basin.

As an indicator of future monthly runoff, above normal soil moisture ranking percentiles in Montana and the Dakotas indicate that soil moisture conditions have improved significantly and normal runoff is more likely assuming normal precipitation. Below normal soil moisture ranking percentiles in Wyoming, western Montana, and Nebraska indicate soil moisture conditions are still dry and below normal runoff will likely to occur. Normal to above normal rainfall will be needed in the dry areas in order to restore soil moisture to more normal conditions before normal runoff can occur.

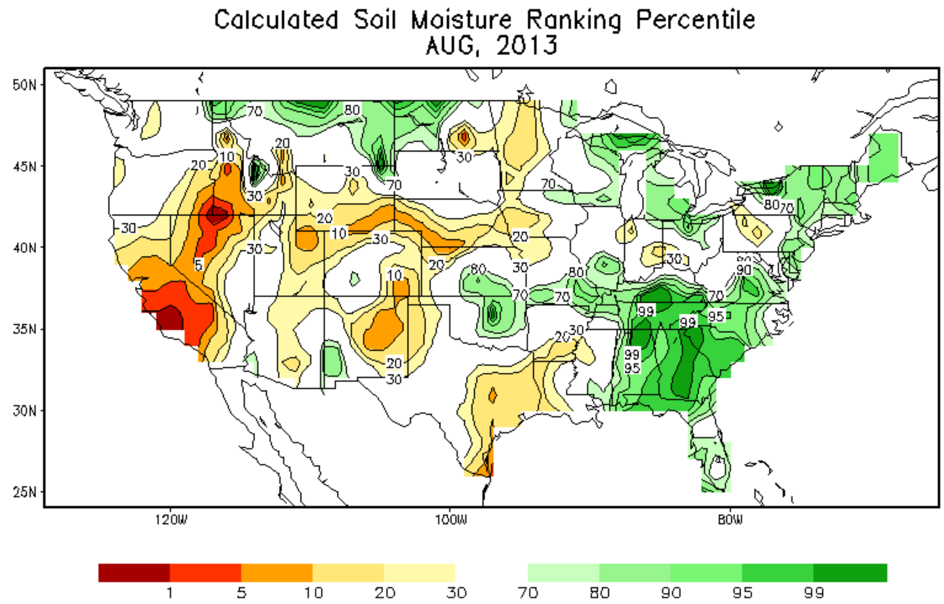


Figure 8. Calculated Soil Moisture Ranking Percentile on Jul 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

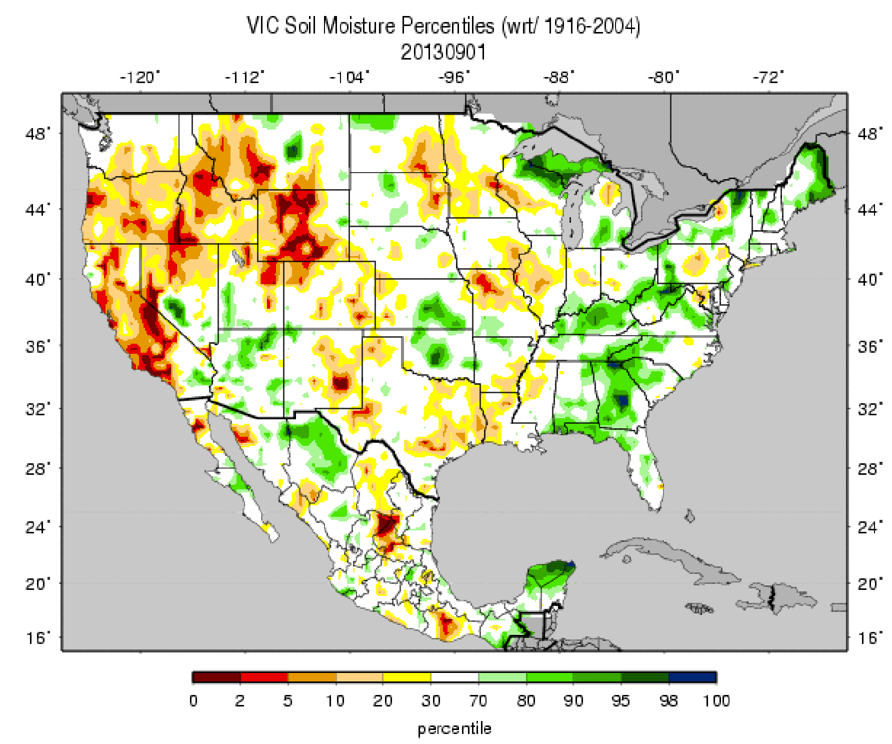


Figure 9. VIC modeled soil moisture percentiles as of July 29, 2013. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/index.shtml

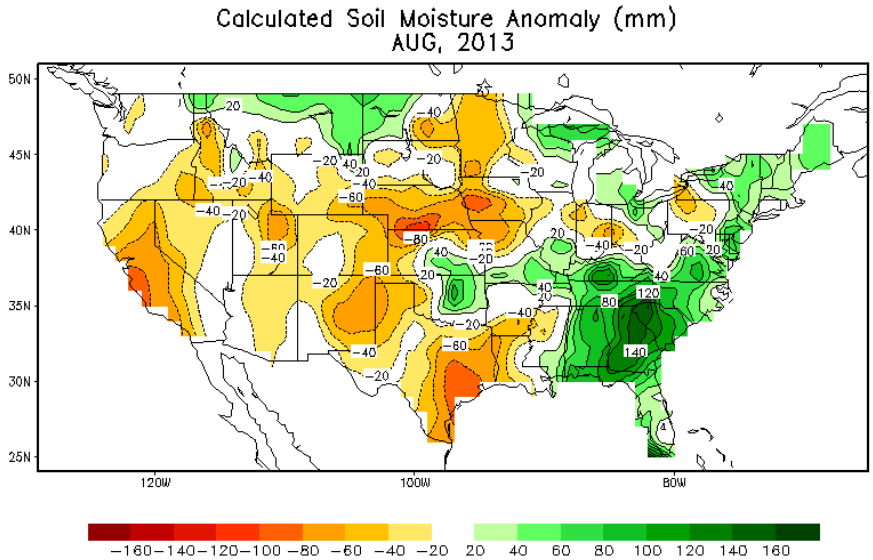


Figure 10. Calculated Soil Moisture Anomaly on Jul 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. The Missouri River Basin mountain snowpack normally peaks on April 15.

The mountain snowpack, in snow water equivalent (SWE), above Fort Peck peaked on April 23 at 15.4 inches, 95 percent of the normal April 15 peak (Figure 14). The mountain snowpack SWE between Fort Peck and Garrison peaked on April 25 at 13.5 inches, 95 percent of the normal April 15 peak. On July 15, 2013 there was effectively no measureable mountain snowpack remaining in the reach above Fort Peck and in the Garrison reach.

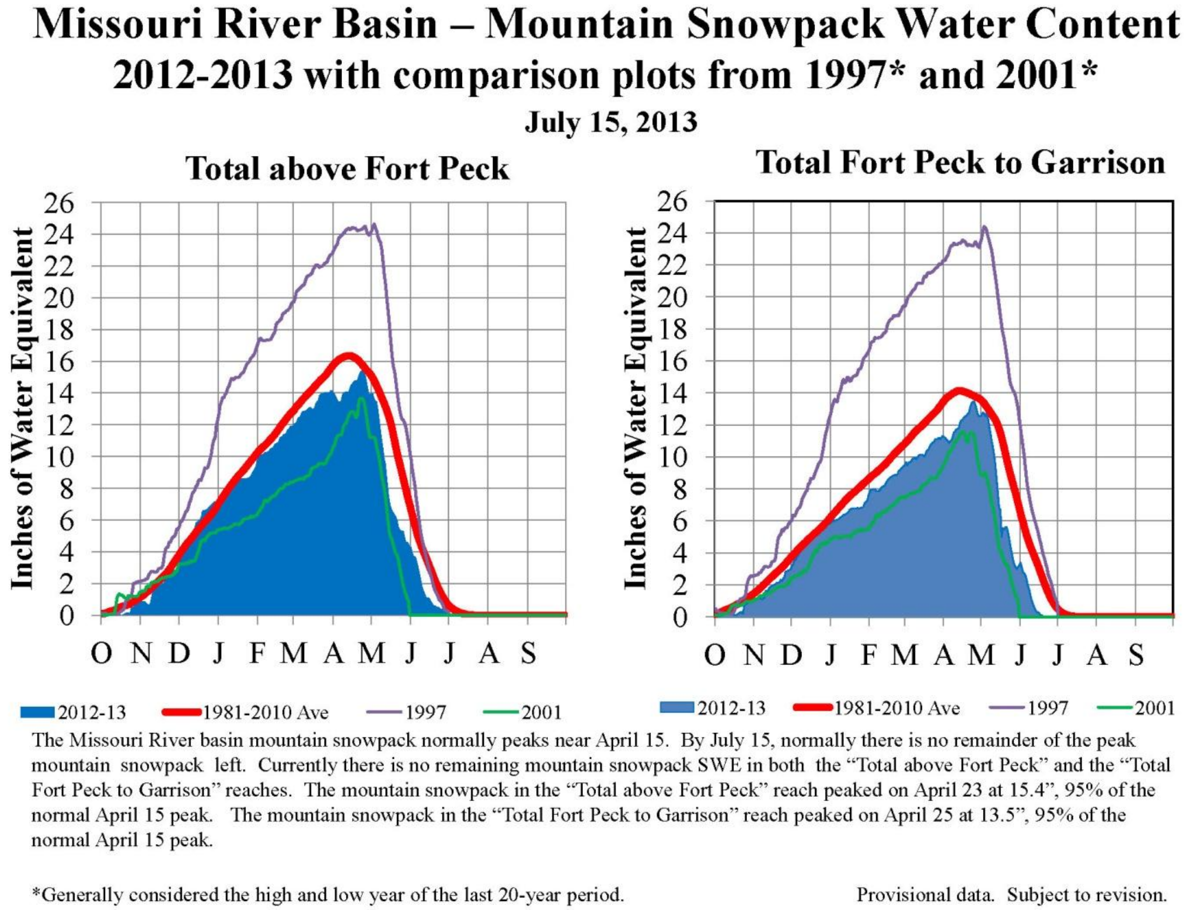


Figure 11. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific. Equatorial sea surface temperatures are near average across the western and central Pacific Ocean and below average across the eastern Pacific. ENSO-neutral conditions are favored into the Northern Hemisphere fall 2013. During a neutral phase there is not a strong indicator of winter weather conditions related to El Nino/La Nina.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's September temperature outlook shown in Figure 11 indicates equal chances for above normal, normal and below normal temperatures in North and South Dakota, Nebraska, Kansas, and Missouri and probability for above normal temperatures in Montana, Wyoming and Colorado. The CPC's 3-month temperature outlook for September-October-November in Figure 12 indicates equal chances for above normal, normal and below normal temperatures in the upper Basin. During the November-December-January outlook period shown in Figure 13 there is an increased chance for above normal temperatures throughout most of the upper Basin.

The CPC's September precipitation outlook shown in Figure 11 is indicating equal chances for above normal, normal and below normal precipitation over the entire Basin. In the September-October-November forecast period shown in Figure 12, there are equal chances for above normal, normal and below normal precipitation the majority of the Basin, except for Montana which has a probability for above-normal precipitation. The precipitation outlook for the November-December-January period shown in Figure 13 shows equal chances for above normal, normal and below normal precipitation the majority of the Basin, except for Montana which has a probability for above-normal precipitation.

The drought outlook indicates persistence drought impacts in all areas of the Basin currently classified in drought. Improvements in soil moisture conditions have benefitted runoff in the northern and eastern Montana; however, large soil moisture deficits in western Montana and Wyoming are expected to continue limiting runoff into the System during the fall.

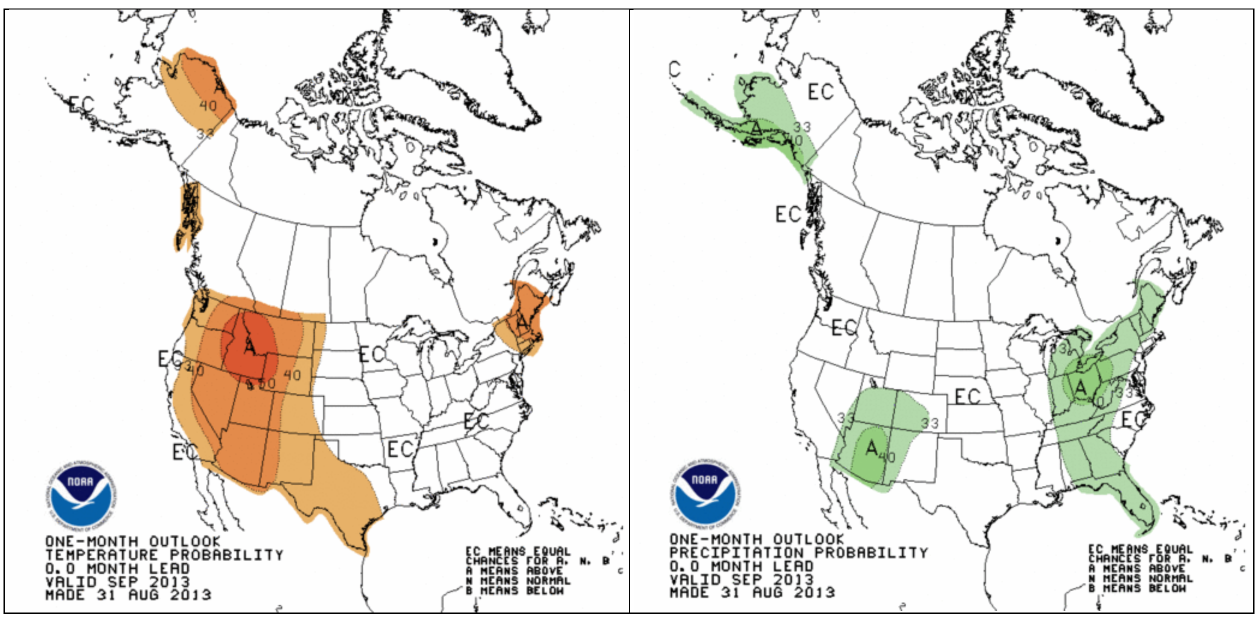


Figure 12. CPC September 2013 temperature and precipitation outlooks.

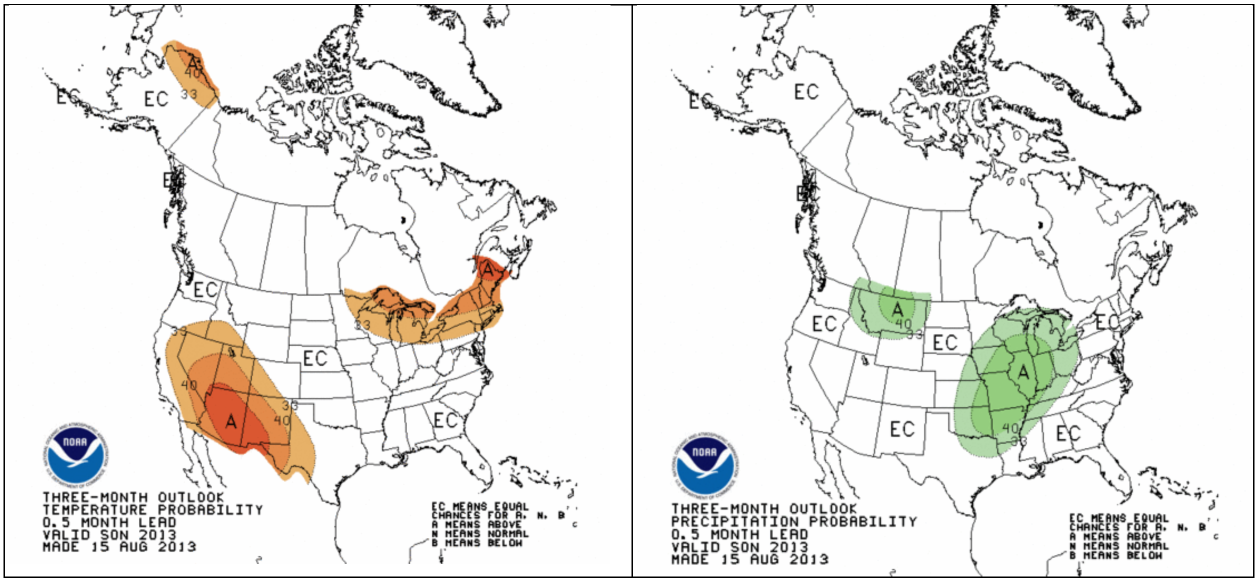


Figure 13. CPC September-October-November 2013 temperature and precipitation outlooks.

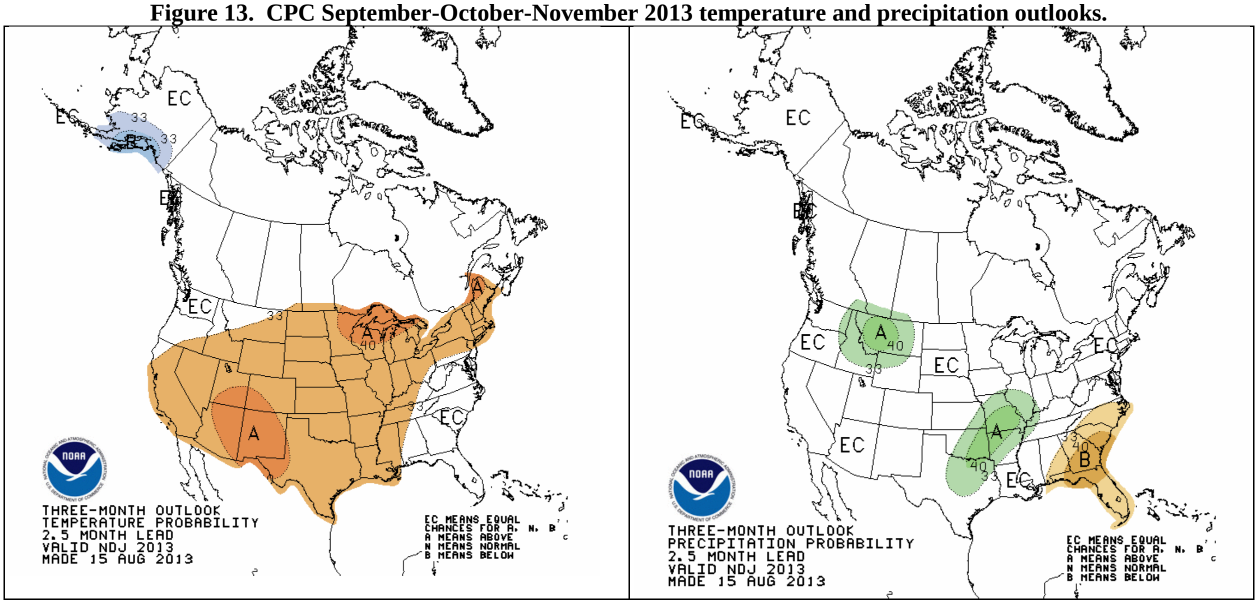


Figure 14. CPC November-December-January 2013-2014 temperature and precipitation outlooks.

Summary

The annual runoff forecast as of July 1, 2013 is 23.1 MAF (91 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.9 MAF (91 percent of normal). Above Sioux City, this is an increase of 0.3 MAF from the August runoff forecast, due to greater than forecast runoff during the month of August. August runoff was 1.4 MAF (107 percent of normal) above Sioux City, IA and 1.2 MAF (101 percent of normal) above Gavins Point. The September runoff forecast is 1.0 MAF (88 percent of normal) above Sioux City and 0.9 MAF (87 percent of normal) above Gavins Point. The runoff forecast for the October through December period was left mostly unchanged because continuing drought conditions and soil moisture deficits in southwest Montana, Wyoming and western South Dakota will continue to limit runoff even if above normal precipitation occurs.

Upper Missouri River Basin
Calendar Year Runoff Forecast
October 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of October 1, 2013 is 23.2 MAF (92 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.9 MAF (91 percent of normal). The October runoff forecast is 1.04 MAF (88 percent of normal) above Sioux City and 0.95 MAF (87 percent of normal) above Gavins Point. Precipitation in September was generally above normal throughout the Rocky Mountains and the Northern Plains, stimulating better-than-forecast runoff in the Garrison and Oahe reaches. Observed September runoff was 1.04 MAF (91 percent of normal) above Sioux City, IA, and 0.88 MAF (85 percent of normal) above Gavins Point. May-June-July runoff was 12.5 MAF (104 percent of normal).

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next three months, the range of expected inflow ranges from the 23.7 MAF upper basic forecast to the 22.7 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's (NDMC) U.S. Drought Monitor for September 24, 2013 is shown in Figure 1 and the Drought Monitor for August 27, 2013 is shown in Figure 2. While drought conditions as of September 24, 2013 have eased in Montana, western North Dakota and northwest South Dakota, drought conditions still impact the eastern Dakotas, southwest Montana, much of Wyoming, Nebraska and Iowa. Comparison of Figures 1 and 2 indicate that basin-wide drought coverage has not experienced much change. Since August 27, southeast South Dakota slipped back into Abnormally Dry (D0) and Moderate Drought (D1) conditions. Additional intensification has occurred in eastern South Dakota and Iowa. In contrast southeast Wyoming and north central Colorado no longer are experiencing drought due to the heavy rain that occurred over these areas in September.

According to the U.S. Monthly Drought Outlook shown in Figure 3, drought conditions will continue to persist in Wyoming, Nebraska and Iowa through October 2013. Removal of drought conditions is forecast for western Montana, a small region of north central Wyoming and the eastern Dakotas.

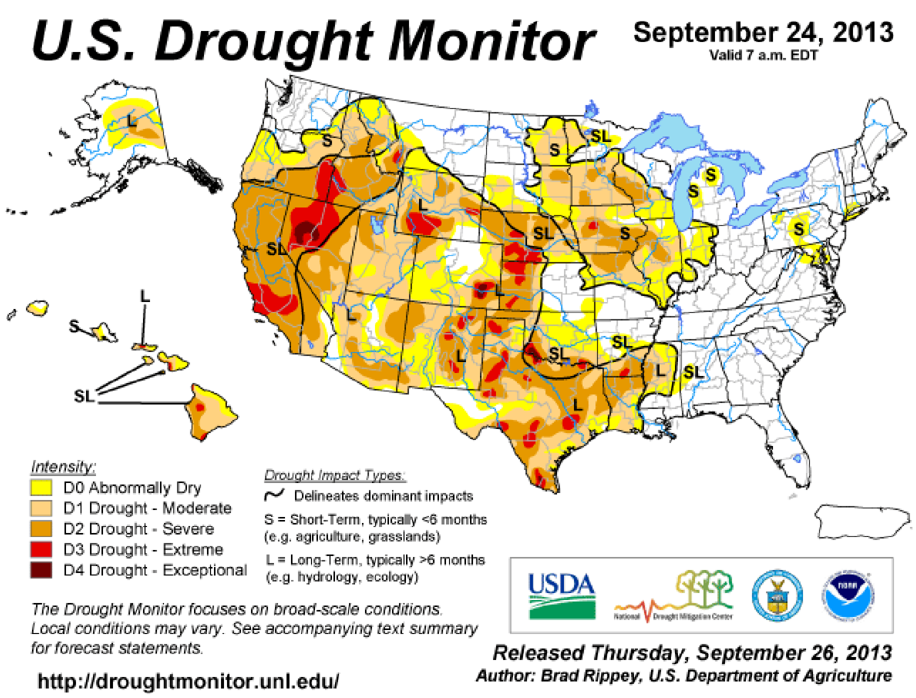


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for September 24, 2013.

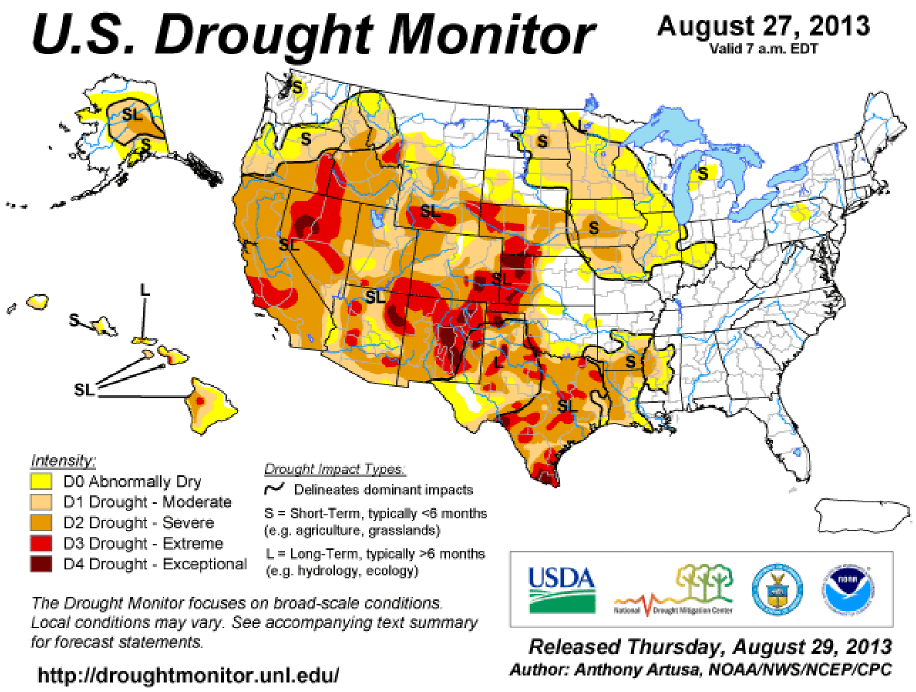


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for August 27, 2013.

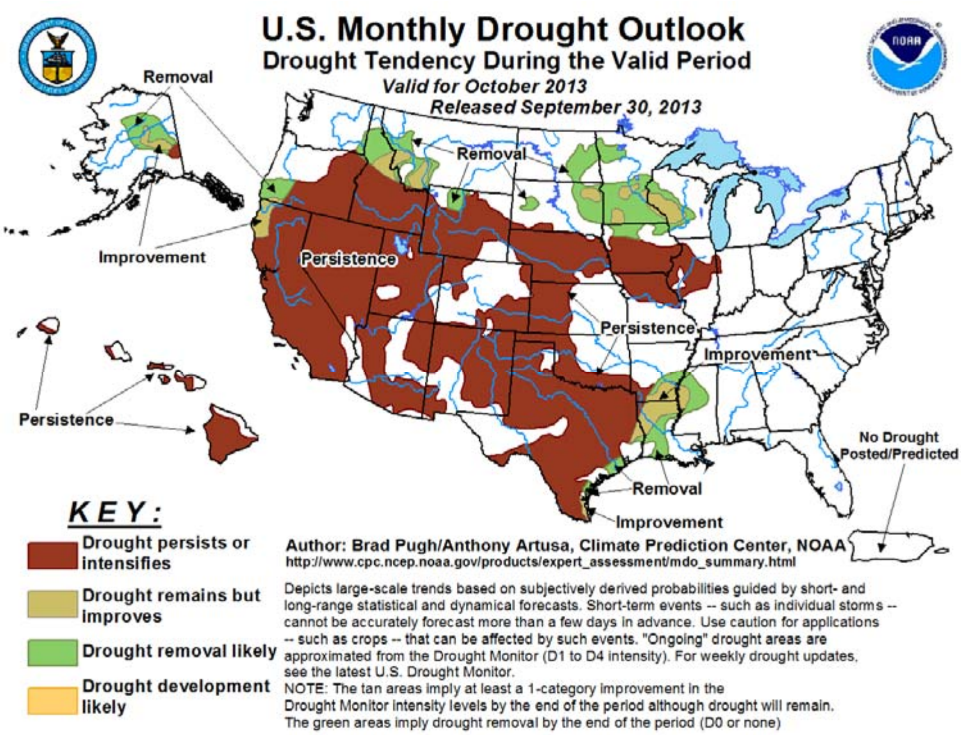


Figure 3. National Drought Mitigation Center U.S. Monthly Drought Outlook.

Precipitation

Accumulated precipitation during the month of September is shown in Figure 4. Rainfall amounts in the upper Missouri River basin exceeded 2 inches in many parts of Montana, Wyoming and the Dakotas. Rainfall was particularly abundant, ranging from 3 inches up to 6 inches in central Wyoming, southern Montana, southern North Dakota, and northern South Dakota. Addition heavy monthly precipitation ranging from 6 to 15 inches occurred over north central Colorado. The bulk of this precipitation occurred September 10-16 and caused severe flooding on tributaries of the South Platte River in Colorado. Boulder, CO set a September precipitation record of 17.18 inches; the previous record was 5.5 inches in September 1940. The precipitation would also set an annual precipitation record of 30.14 inches, with three months remaining in the calendar year. The preliminary annual exceedence probability analysis for 24-hour rainfall indicated that this was a 1 in 1000 year rainfall event for some locales.

Figure 5, September 2013 precipitation as a percent of normal, reveals much more vividly the contrasting precipitation departures that occurred over the Missouri River basin. Precipitation amounts ranging from 150 to over 300 percent of normal occurred over much of Colorado, Wyoming, Montana and the western Dakotas, while precipitation amounts less than 75 percent of normal dominated central and eastern South Dakota, Iowa, eastern Nebraska and Kansas.

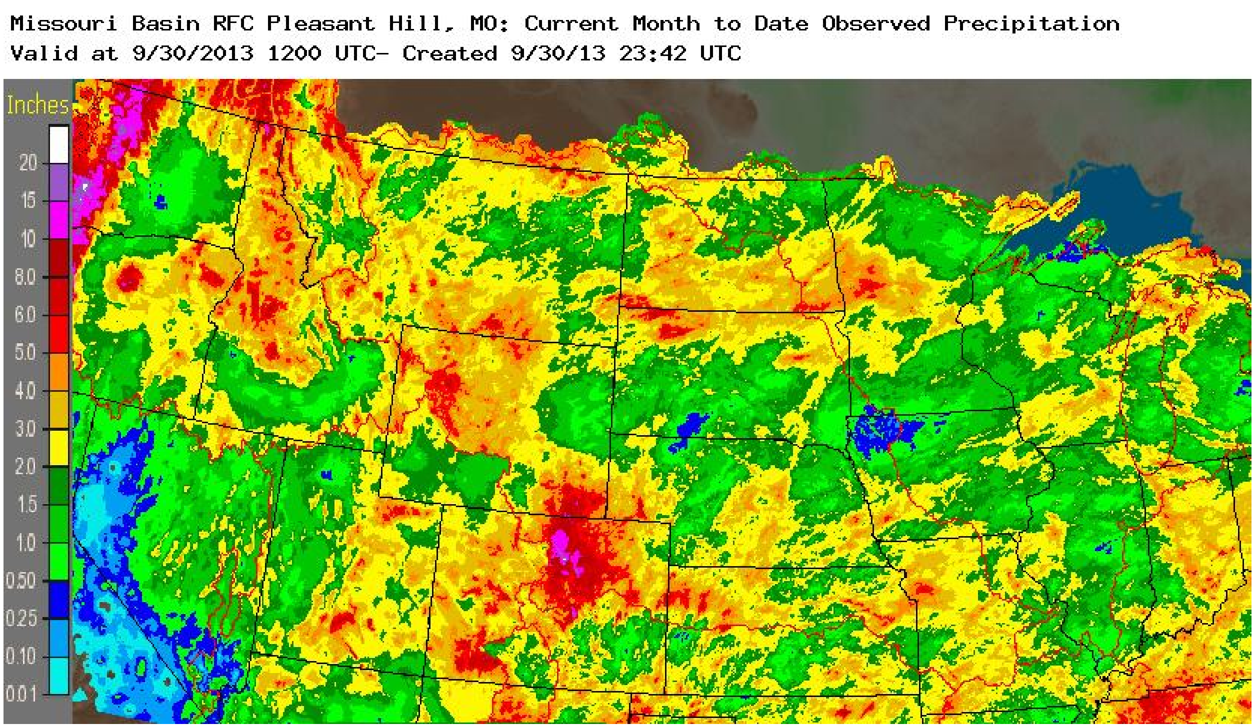


Figure 4. September 2013 precipitation (inches).

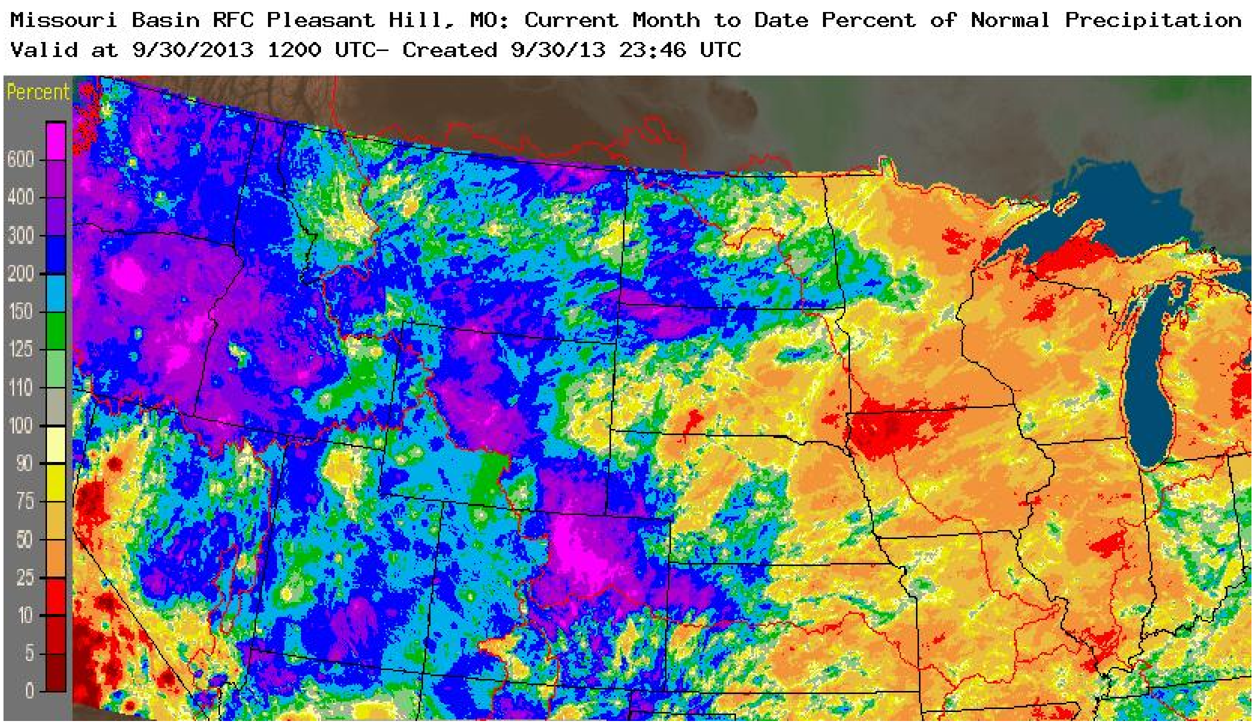


Figure 5. September 2013 precipitation (percent of 1981-2010 average).

Temperature

Average temperatures throughout most of the upper Basin during the past 30 days ending September 29 were generally 2 to 4 degrees F above normal (Figure 6) in Montana and Wyoming, while temperatures in the plains were 3 to 5 degrees F above normal. The 90-day temperature departure map (Figure 7) indicates temperatures ranged from normal to 3 degrees F above normal in Montana and Wyoming, while temperatures in the plains were normal to 2 degrees F above normal.

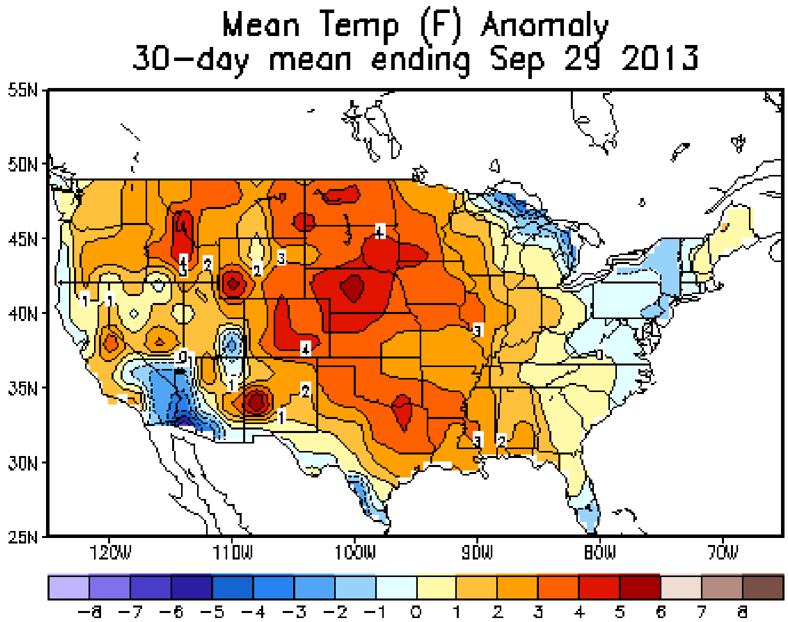


Figure 6. 30-day temperature departures (degrees F) from normal.

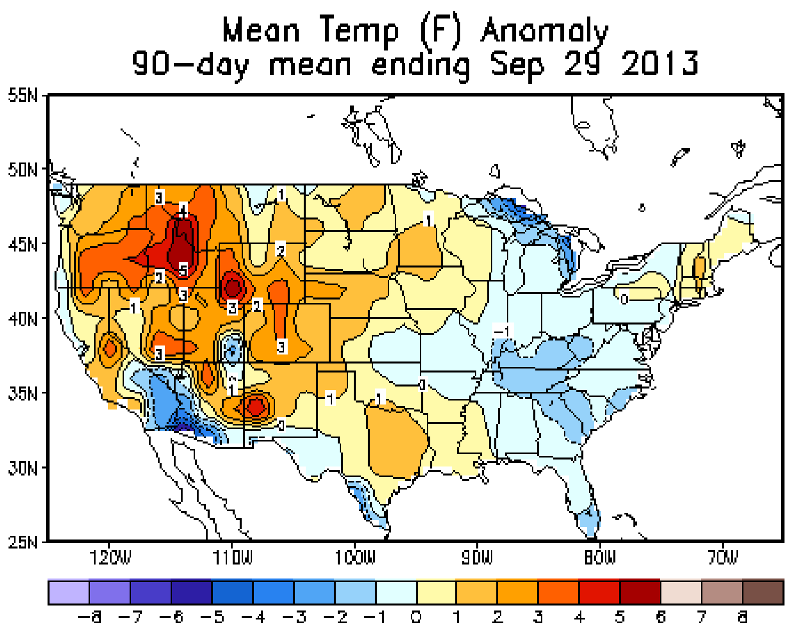


Figure 7. 90-day temperature departures (degrees F) from normal.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet, or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry, or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

Two independent estimates of soil moisture are presented in this report. Figures 8 and 9 illustrate the soil moisture ranking percentiles developed by the NOAA Climate Prediction Center (CPC) for the most recent analysis day in Figure 7 and for the month of August in Figure 9. Figure 10 illustrates soil moisture ranking percentiles as determined by the University of Washington's Variable Infiltration Capacity (VIC) model.

The current status of the soil as of September 30 is represented by the soil moisture percentile ranking in Figure 8. The soil moisture rankings depict slightly drier than average soil moisture conditions in southern and eastern Nebraska, Iowa and northern Missouri. In contrast wetter than normal conditions have continued to develop over Montana, northern Wyoming, western North Dakota and northwest South Dakota, while normal conditions (30^{th} to 70^{th} percentile) are present between these two areas. Compared to the soil moisture conditions for August 2013 illustrated in Figure 9, wetter than normal conditions have expanded into western Montana, southern Montana and northern Wyoming. The VIC model soil moisture ranking percentile in Figure 10, shows similar wetter than normal conditions from central Montana into the Dakotas and in central Wyoming; however, drier than normal regions remain in western Montana and northwest Wyoming. The VIC model also shows drier than normal conditions in eastern South Dakota, eastern Nebraska and Iowa.

As an indicator of future monthly runoff, above normal soil moisture ranking percentiles in Montana and the Dakotas give a signal that runoff conditions could begin to return to more normal volumes in the next few months given normal precipitation. Below normal soil moisture ranking percentiles in eastern Nebraska, Iowa and northern Missouri indicate soil moisture conditions below normal runoff is likely to occur given normal precipitation conditions.

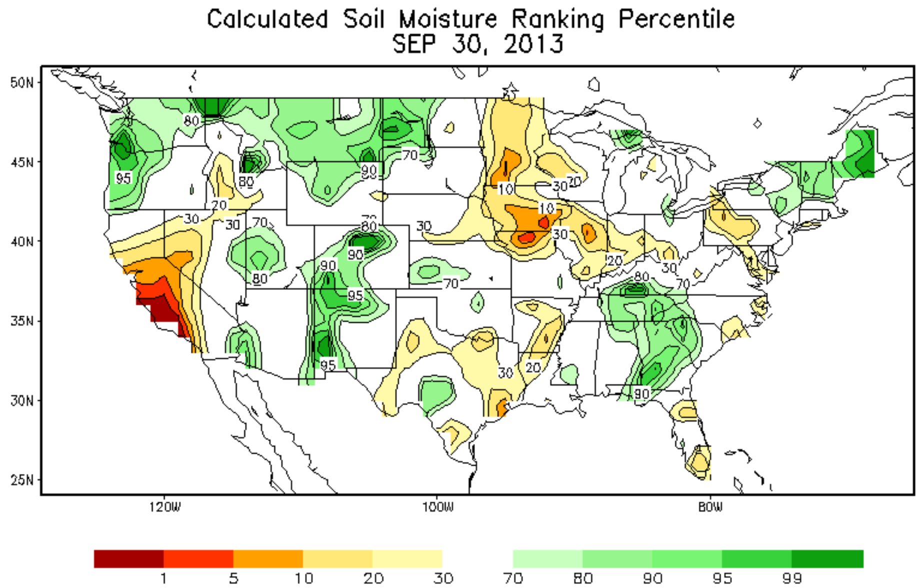


Figure 8. Calculated Soil Moisture Ranking Percentile on September 30, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

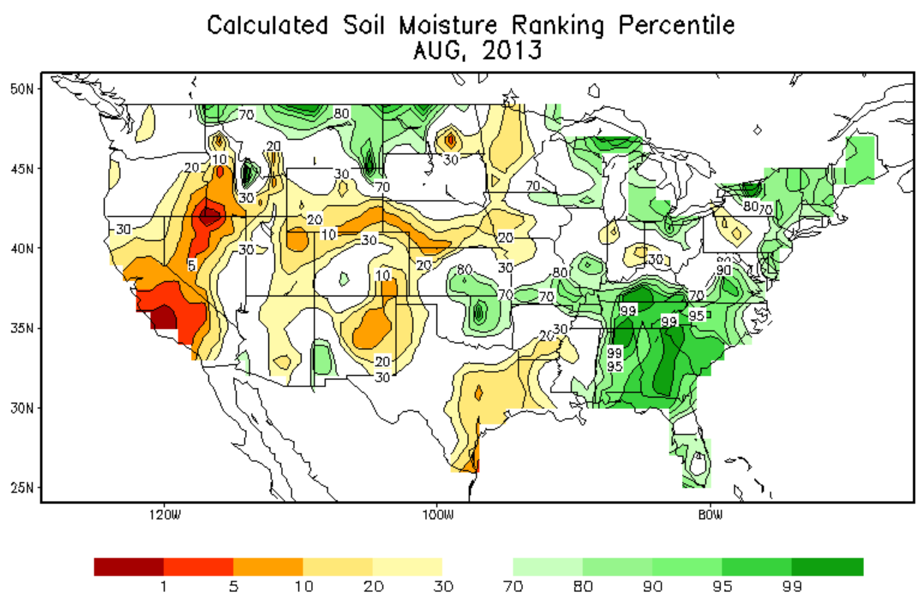


Figure 9. Calculated Soil Moisture Ranking Percentile for August, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

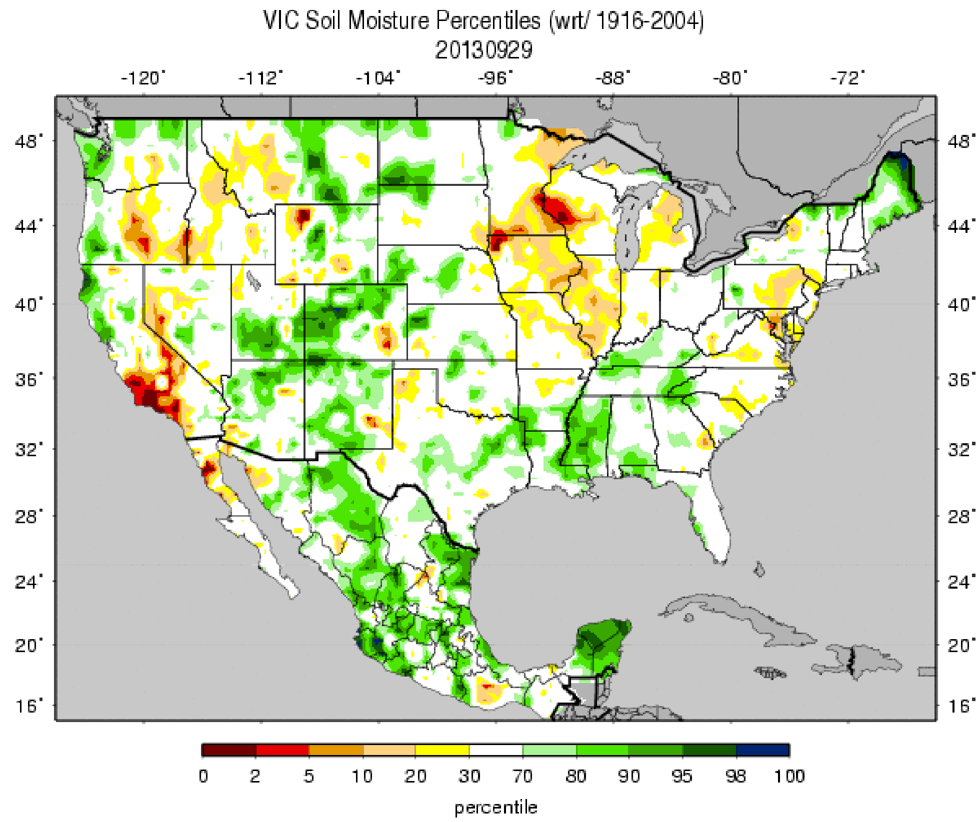


Figure 10. VIC modeled soil moisture percentiles as of September 29, 2013. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/index.shtml

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific. Equatorial sea surface temperatures are near average across much of the equatorial Pacific Ocean. ENSO-neutral conditions are favored through the Northern Hemisphere winter 2013-14. During a neutral phase there is not a strong indicator of winter weather conditions related to El Niño/La Niña.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's October temperature outlook shown in Figure 11 indicates equal chances for above normal, normal and below normal temperatures in the upper Missouri River Basin above Sioux City, IA, most of Nebraska and Colorado. An above normal probability for above normal temperatures exists in Iowa and Missouri. The CPC's 3-month temperature outlook for October-November-December in Figure 12 indicates equal chances for above normal, normal and below normal temperatures in the upper Basin with the exception of above normal chances for above normal temperatures in southwest Montana and a portion northwest Wyoming. During the January-February-March outlook period shown in Figure 13 there is an increased chance for above normal temperatures throughout the entire upper Basin.

The CPC's October precipitation outlook (Figure 11) indicates equal chances for above normal, normal and below normal precipitation in the upper Missouri River Basin. In the October-November-December forecast period shown in Figure 12, there are equal chances for above normal, normal and below normal precipitation in the majority of the Basin, except for Montana which has an increased probability for above normal precipitation. The precipitation outlook in Figure 13 for the January-February-March period shows equal chances for above normal, normal and below normal precipitation over the entire Basin.

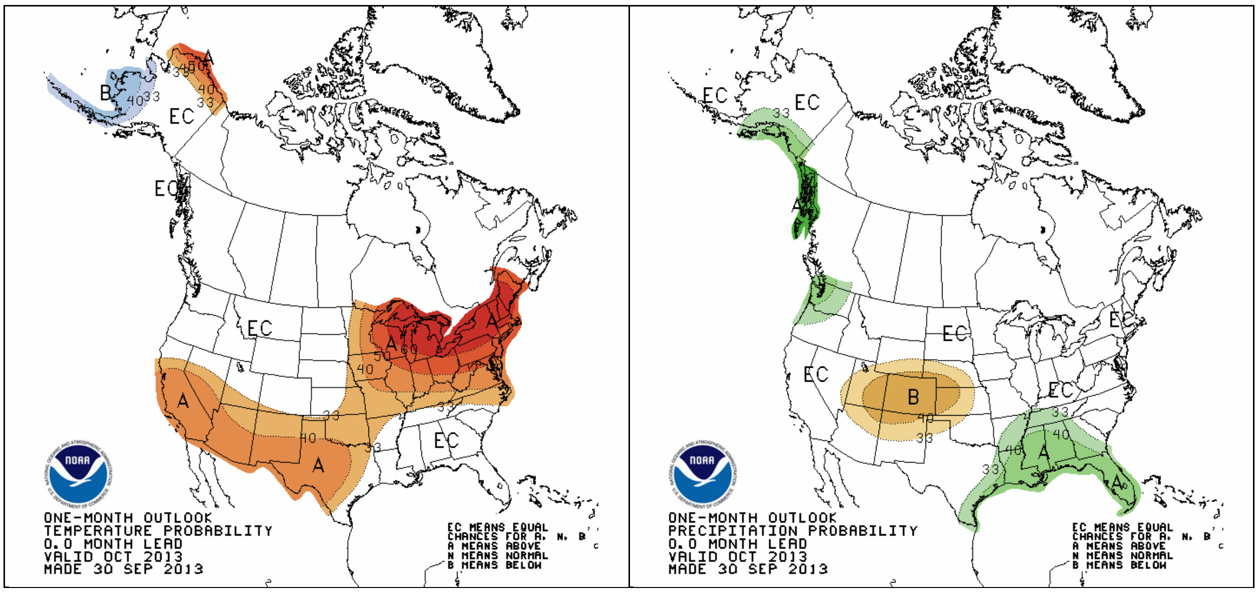


Figure 11. CPC October 2013 temperature and precipitation outlooks.

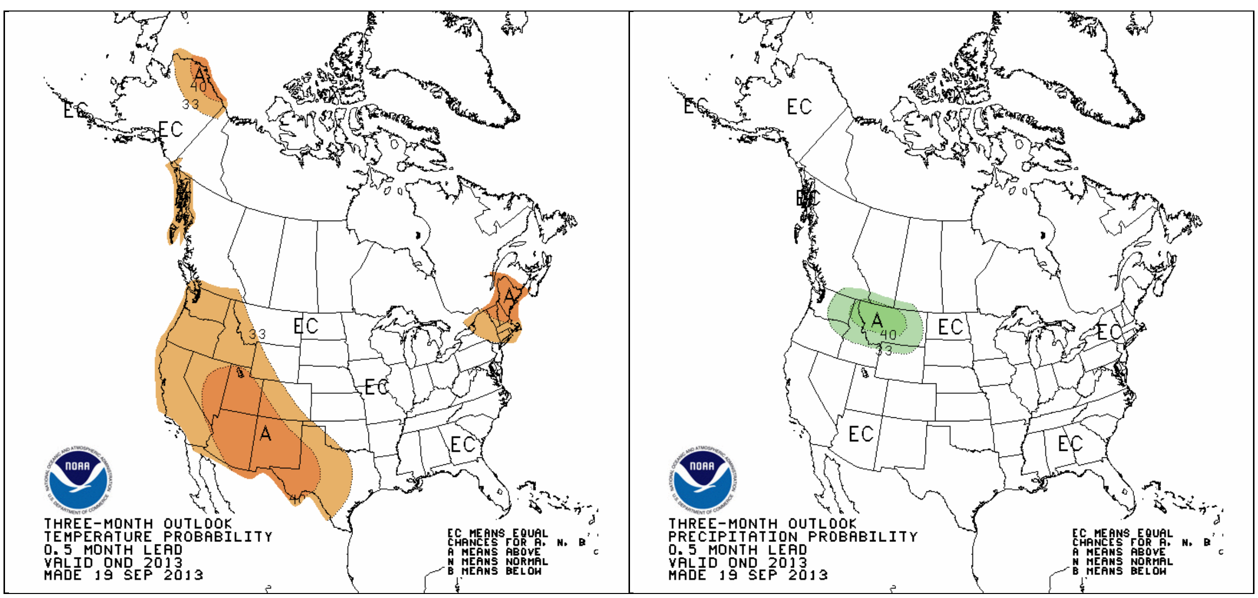


Figure 12. CPC October-November-December 2013 temperature and precipitation outlooks.

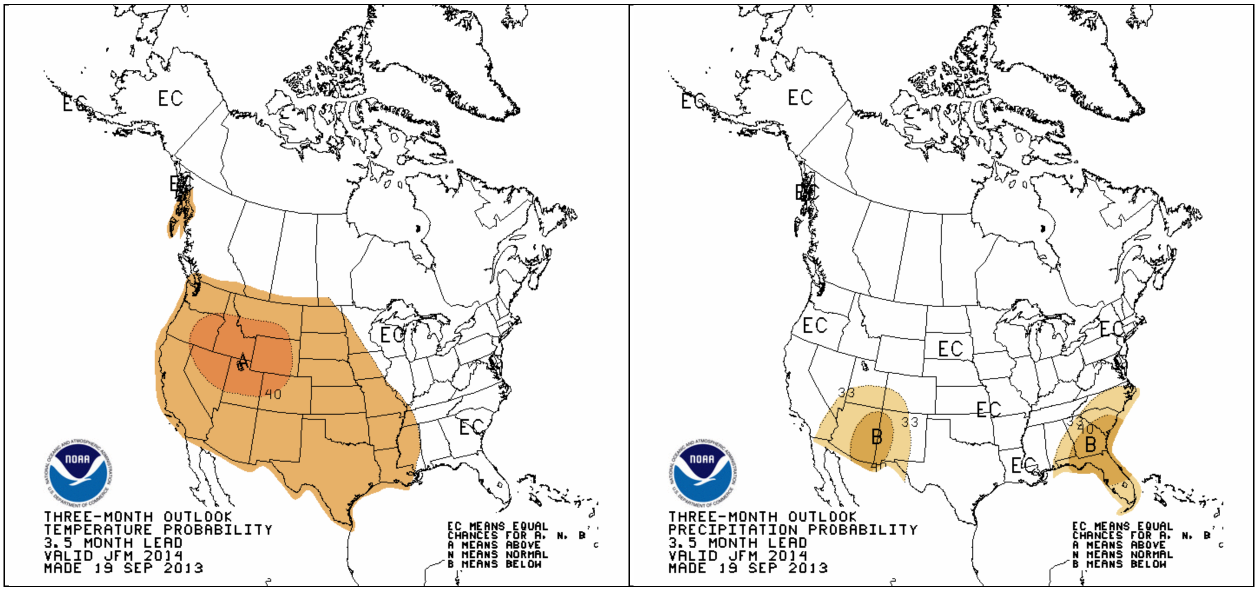


Figure 13. CPC January-February-March 2014 temperature and precipitation outlooks.

Summary

The annual runoff forecast as of October 1, 2013 is 23.2 MAF (92 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 20.9 MAF (91 percent of normal). The October runoff forecast is 1.04 MAF (88 percent of normal) above Sioux City and 0.95 MAF (87 percent of normal) above Gavins Point.

Upper Missouri River Basin
Calendar Year Runoff Forecast
November 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of November 1, 2013 is 25.9 MAF (102 percent of normal) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 23.4 MAF (102 percent of normal). The November runoff forecast is 1.45 MAF (139 percent of normal) above Sioux City and 1.34 MAF (139 percent of normal) above Gavins Point. Precipitation in October was well-above normal in Montana, Wyoming, North Dakota and South Dakota. The October runoff above Sioux City was 2.8 MAF, the second highest on record, exceeded only in 1923 when a October runoff of 3.2 MAF was recorded. The Oahe October runoff was 1.2 MAF, over twice the previous historic October runoff, which was also occurred 1923.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next two months, the range of expected inflow ranges from the 26.3 MAF upper basic forecast to the 25.4 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each reach, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's (NDMC) U.S. Drought Monitor for October 29, 2013 is shown in Figure 1 and the Drought Monitor for September 24, 2013 is shown in Figure 2. The high fall precipitation has greatly decreased the percentage of the basin that falls within the extreme drought category. All of Montana, North and South Dakota are out of any Drought condition, with soil moisture in the three states actually in the upper 90 percentile, i.e. very moist soil conditions. Soil and drought conditions in the lower basin have also improved, though not as dramatically. Western Kansas and Nebraska are abnormally dry or in moderate drought conditions as well as parts of southern Iowa and northern Missouri.

According to the U.S. Monthly Drought Outlook shown in Figure 3, drought conditions will continue to persist in central Nebraska, western Kansas, and western Iowa through November 2013. Removal of drought conditions is forecast for northern Missouri.

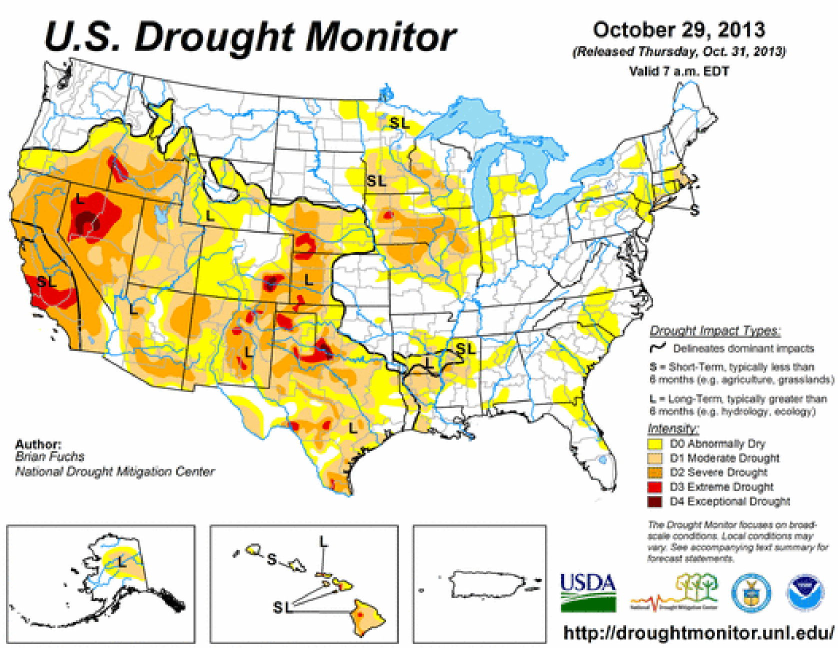


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for October 29, 2013.

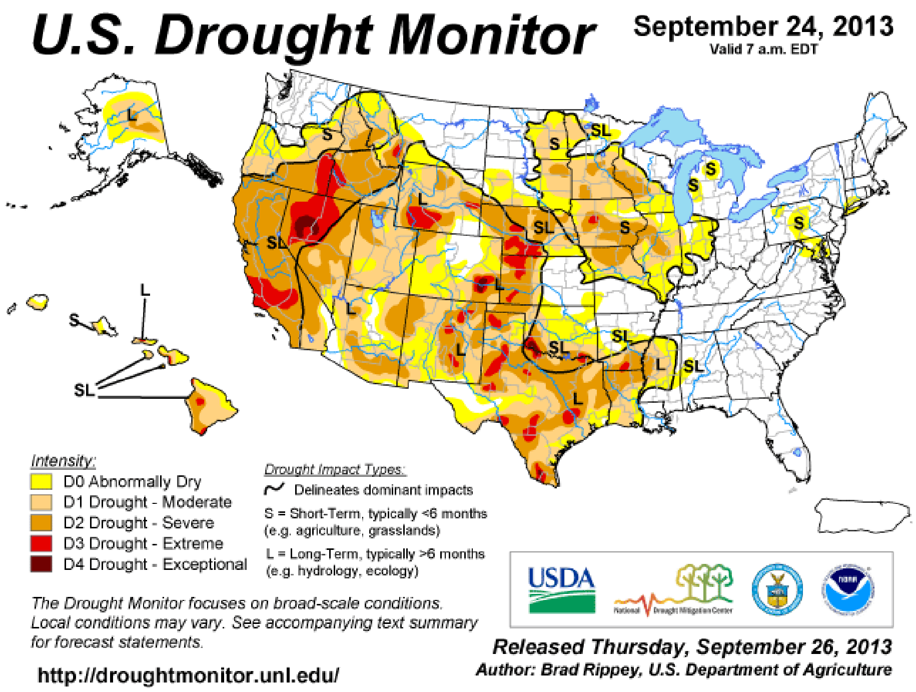


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for September 24, 2013.

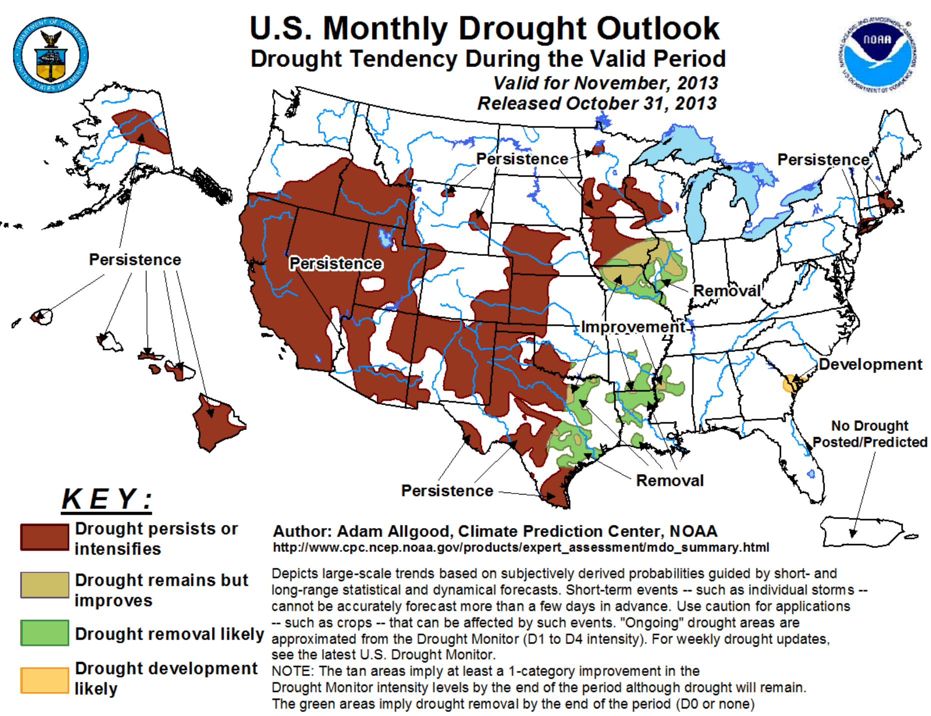


Figure 3. National Drought Mitigation Center U.S. Monthly Drought Outlook.

Precipitation

Accumulated precipitation during the month of October is shown in Figure 4. Rainfall amounts in the upper Missouri River basin exceeded 2 inches in all of North and South Dakota, eastern Nebraska, western Iowa, eastern Kansas, and all of Missouri. Precipitation (a mix of rain and snow) was particularly abundant, ranging from 5 inches up to 10 inches, in western and central South Dakota, south central part of North Dakota, and northeast Nebraska.

Figure 5, October 2013 precipitation as a percent of normal, reveals much more vividly the contrasting precipitation departures that occurred over the Missouri River basin. Precipitation amounts ranging from 400 to over 600 percent of normal occurred over much of the western Dakotas, while precipitation amounts less than 25 percent of normal occurred over northeast Montana and southwest Nebraska.

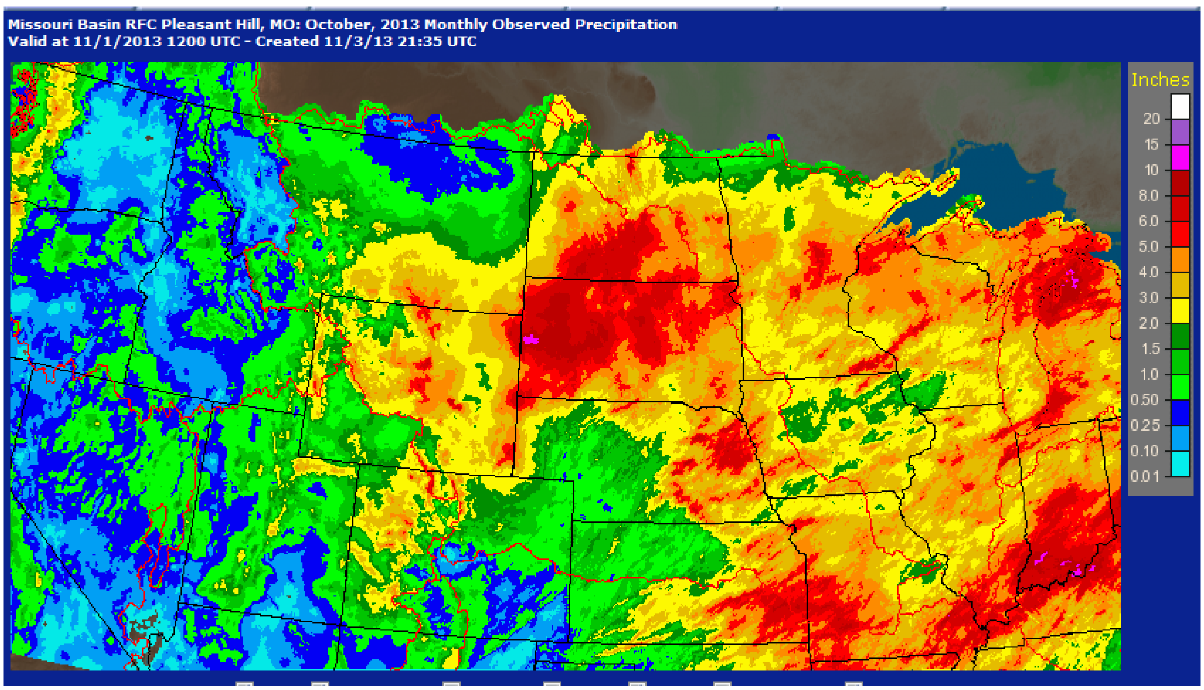


Figure 4. October 2013 precipitation (inches).

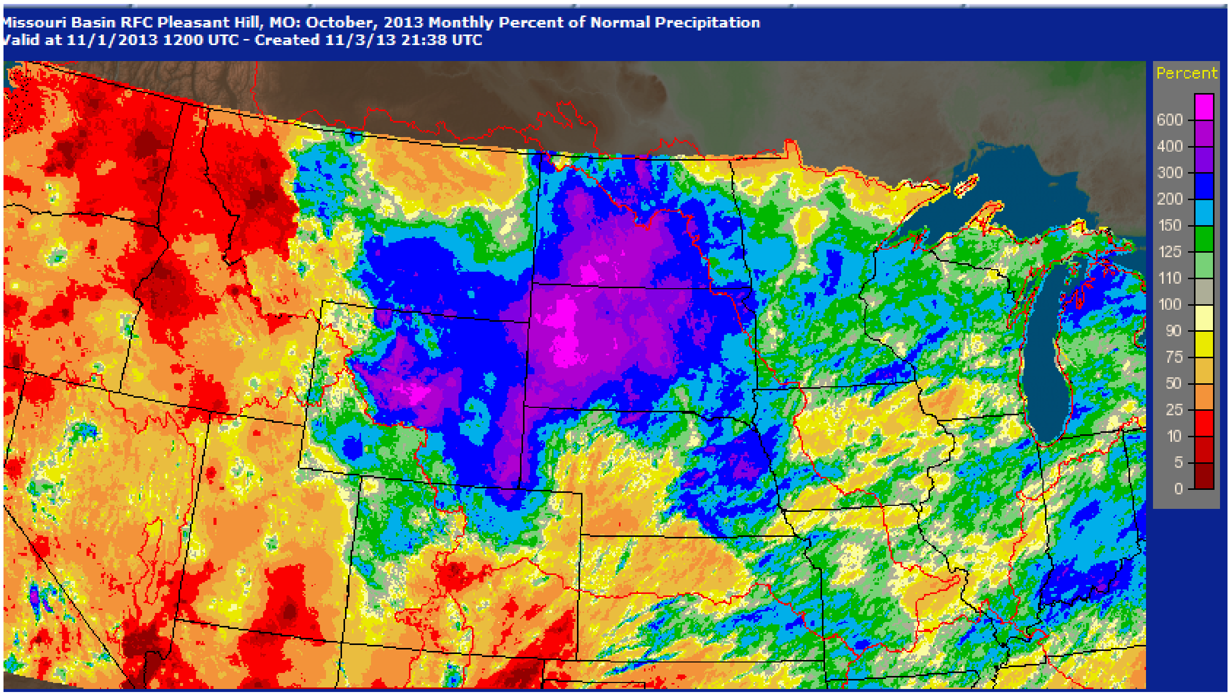


Figure 5. October 2013 precipitation (percent of 1981-2010 average).

Temperature

Average temperatures throughout most of the upper Basin during the past 30 days ending October 31 were generally 1 to 4 degrees F below normal (Figure 6) throughout the basin. The 90-day temperature departure map (Figure 7) indicates temperatures ranged from normal to 2 degrees F above throughout the basin.

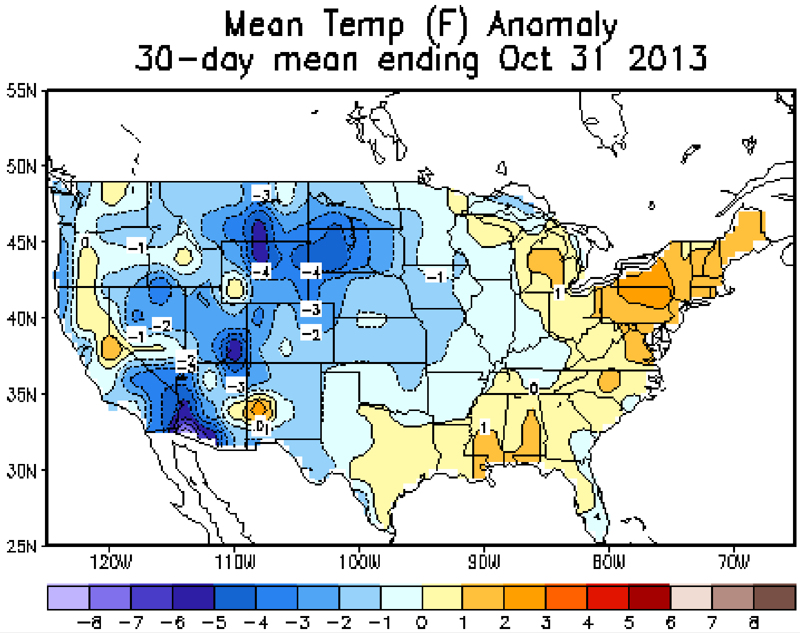


Figure 6. 30-day temperature departures (degrees F) from normal.

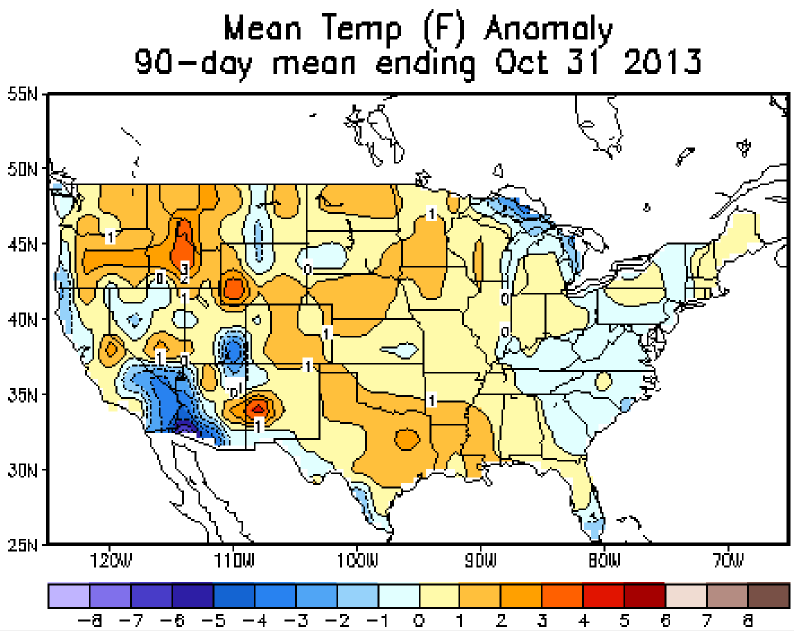


Figure 7. 90-day temperature departures (degrees F) from normal.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet, or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry, or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

Two independent estimates of soil moisture are presented in this report. Soil moisture ranking percentiles developed by the NOAA Climate Prediction Center (CPC) for the most recent analysis day and for the month of September are shown in Figures 8 and 9, respectively. Figure 10 illustrates soil moisture ranking percentiles as determined by the University of Washington's Variable Infiltration Capacity (VIC) model.

The current status of the soil as of October 31 is represented by the soil moisture percentile ranking in Figure 8. All of Montana, North and South Dakota have soil moisture in the in the upper 70 percentile, i.e. very moist soil conditions. Soil moisture in the lower basin has not as changed as dramatically as compared to September 2013, illustrated in Figure 9. The VIC model soil moisture ranking percentile (Figure 10) shows similar wetter-than-normal conditions for the majority of the Dakotas.

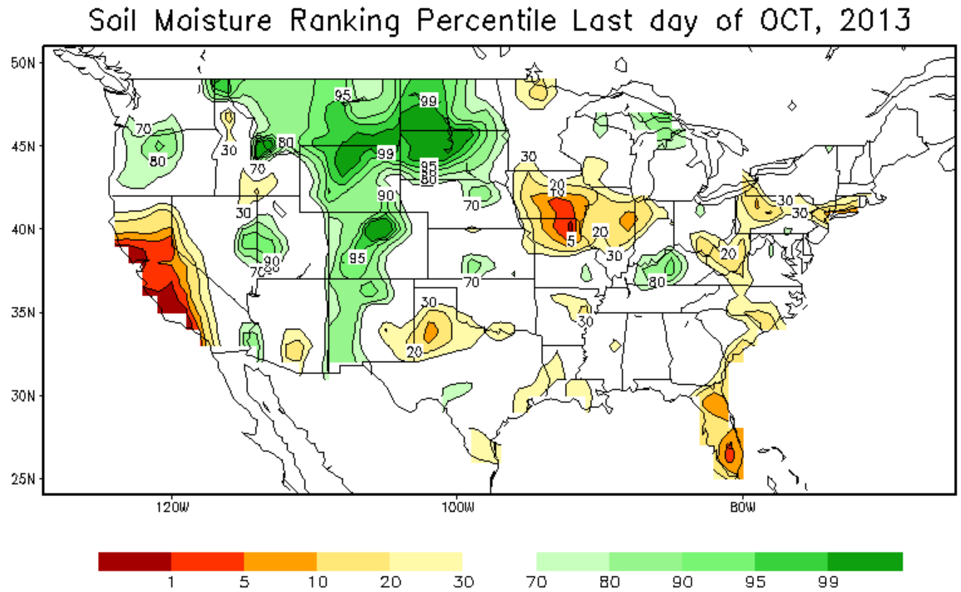


Figure 8. Calculated Soil Moisture Ranking Percentile on October 31, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

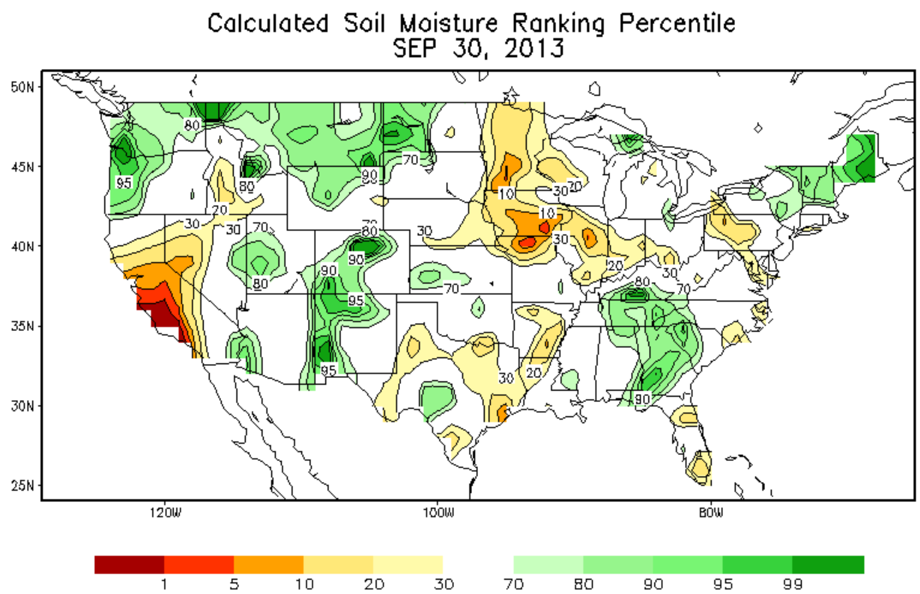


Figure 9. Calculated Soil Moisture Ranking Percentile for September, 2013. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

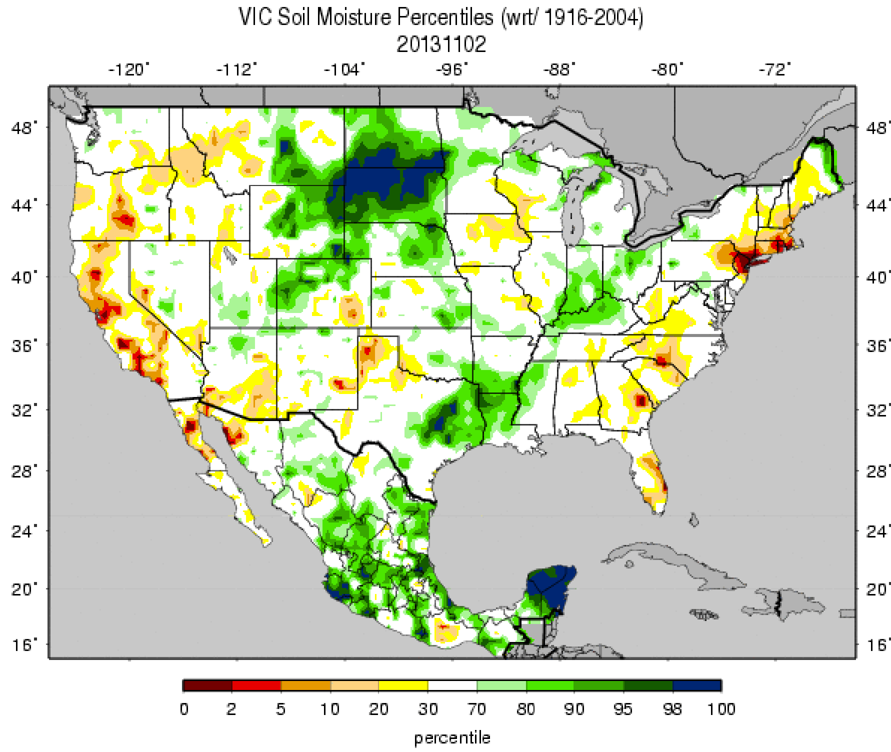


Figure 10. VIC modeled soil moisture percentiles as of November 2, 2013. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/index.shtml

The potential impacts of having higher-than-normal fall soil moisture in the upper basin on the following year's runoff was qualitatively evaluated by examining similar fall soil moisture conditions and the resulting year's runoff above Sioux City, IA. From VIC-archived soil moisture maps from the period 1915 to 2010, the seven years with similar soil moisture conditions for November 1 were: 1941, 1946, 1970, 1982, 1996, 1998, and 2010. The years were considered "similar" to 2013 current conditions if comparative geographical areas had soil moisture percentiles of 80% or higher. Out of the seven years identified, all had higher than normal water year runoff (e.g. Oct. 1, 1941 to Sep. 30, 1942). The mean water year runoff above Sioux City, IA is 25.2 MAF and the respective "similar" years' water-year runoffs were: 26.2 (1942), 29.2 (1947), 32.3 (1971), 28.8 (1983), 49.0 (1997), 32.8 (1999), and 60.7 (2011) MAF. It should be noted that this should be considered an anecdotal analysis at this point. A full-fledged technical review involving the entire upper basin, climate conditions (e.g. El Niño, La Niña, ENSO-neutral), observed precipitation, plains and mountain snowpack, long-term precipitation and temperature outlooks, etc. over the period of record (1898-2013) would need to be conducted to ascertain the correlation between fall conditions and the resulting water and/or calendar year runoff.

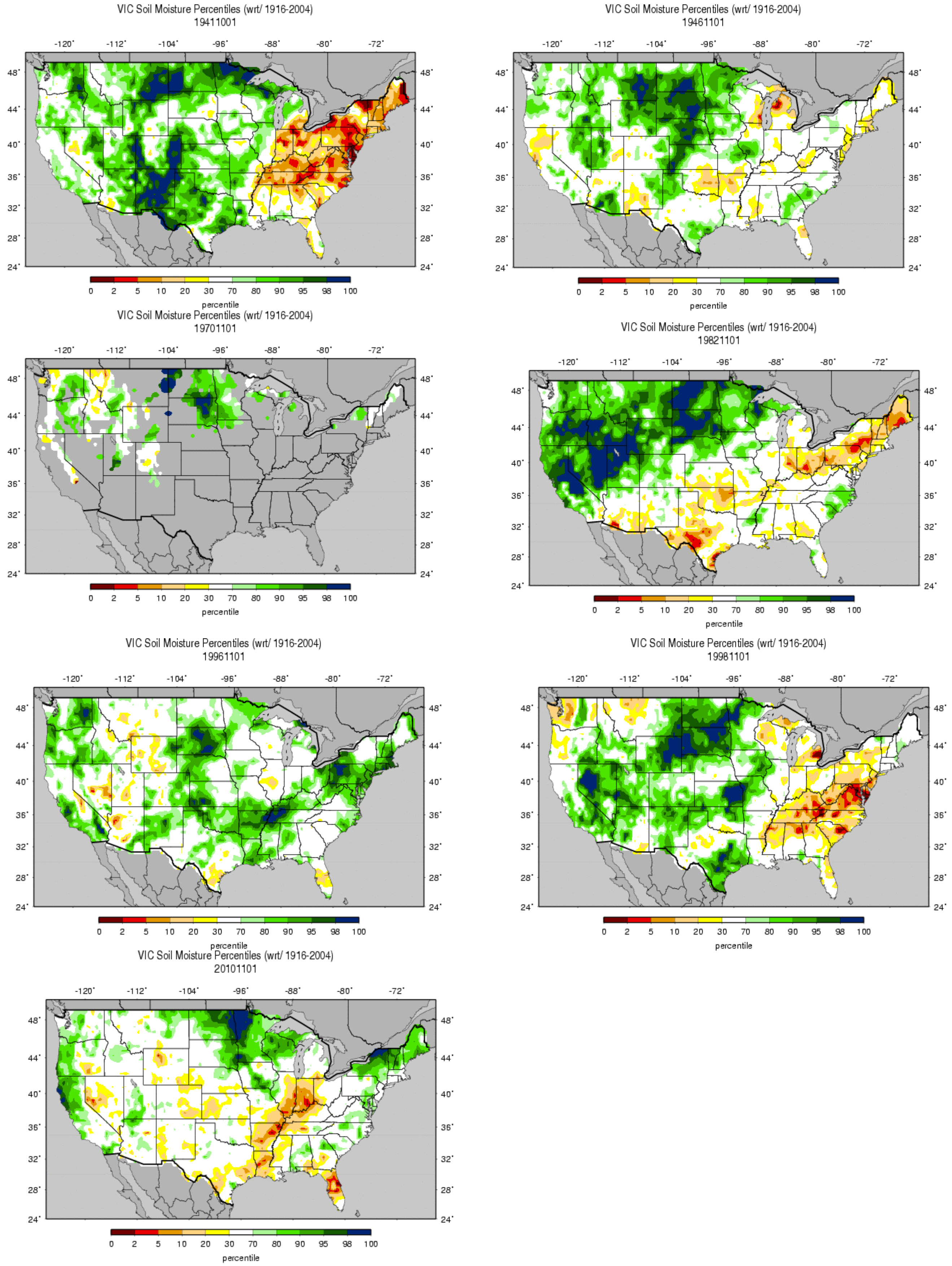


Figure 11. VIC modeled soil moisture percentiles as of November 1 for similar Years to 2013
Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/archive/htm/arch_grid.htm

Climate Outlook

ENSO-neutral climate conditions continue in the equatorial Pacific. Equatorial sea surface temperatures are near average across much of the equatorial Pacific Ocean. ENSO-neutral conditions are favored through the Northern Hemisphere winter 2013-14. During an ENSO neutral phase, there are no strong indicators of temperature and precipitation as opposed to El Niño or La Niña conditions.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's November temperature outlook shown in Figure 12 indicates equal chances for above normal, normal and below normal temperatures in the majority of the Missouri River Basin with the exception of Montana, which is forecasted to have below normal temperatures. The CPC's 3-month temperature outlook for November-December-January in Figure 13 indicates equal chances for above normal, normal and below normal temperatures in the upper Basin with above normal temperatures forecasted for the lower basin. During the January-February-March outlook period shown in Figure 14, there are equal chances for above normal, normal and below normal temperatures in the entire basin.

The CPC's November precipitation outlook (Figure 12) indicates equal chances for above normal, normal and below normal precipitation in the upper Missouri River Basin with the exception for Missouri which is forecasted to have above normal temperatures. In the November-December-January forecast period shown in Figure 13, there are equal chances for above normal, normal and below normal precipitation in the majority of the Basin, except for Montana which has an increased probability for above normal precipitation. The precipitation outlook in Figure 14 for the January-February-March period shows equal chances for above normal, normal and below normal precipitation over the entire Basin.

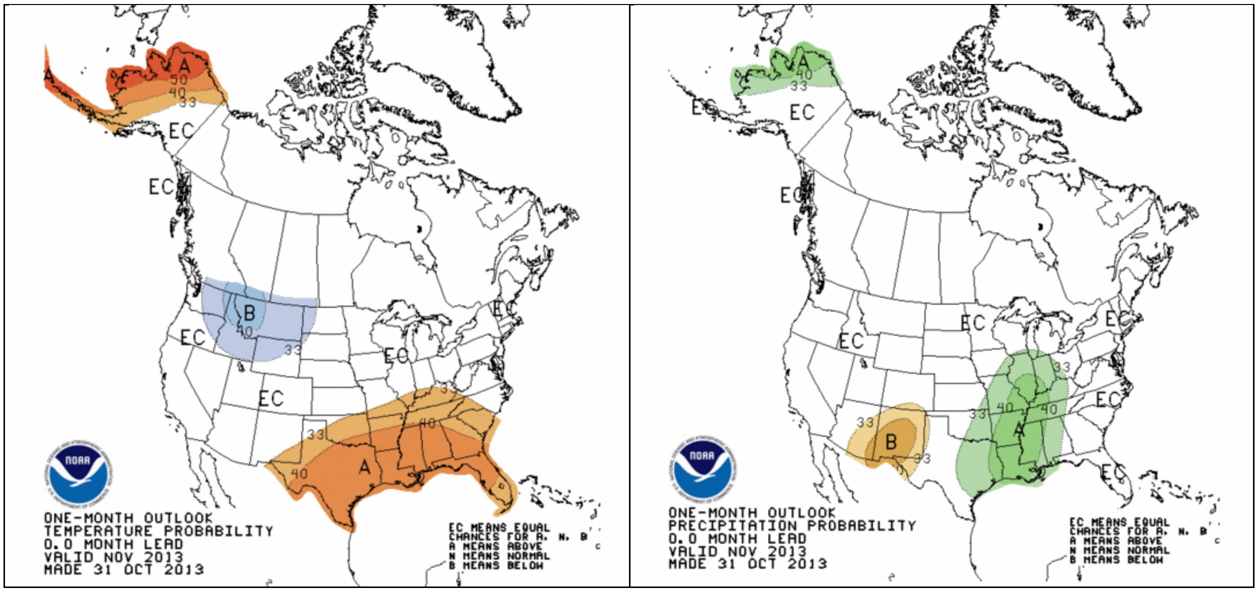


Figure 12. CPC November 2013 temperature and precipitation outlooks.

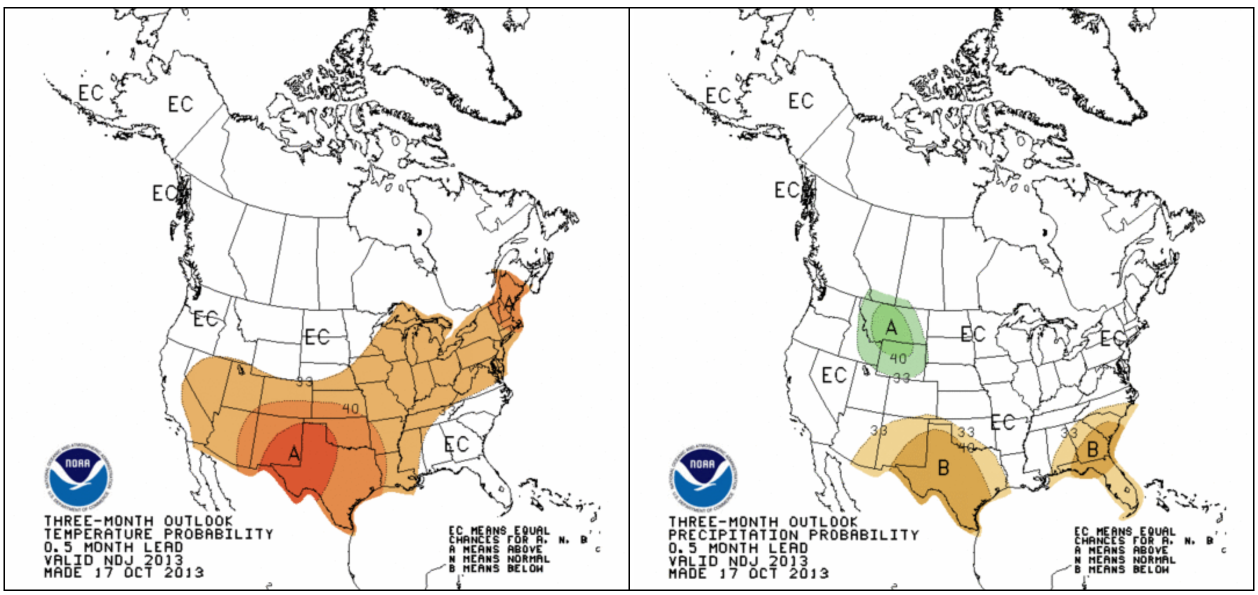


Figure 13. CPC November-December-January 2013 temperature and precipitation outlooks.

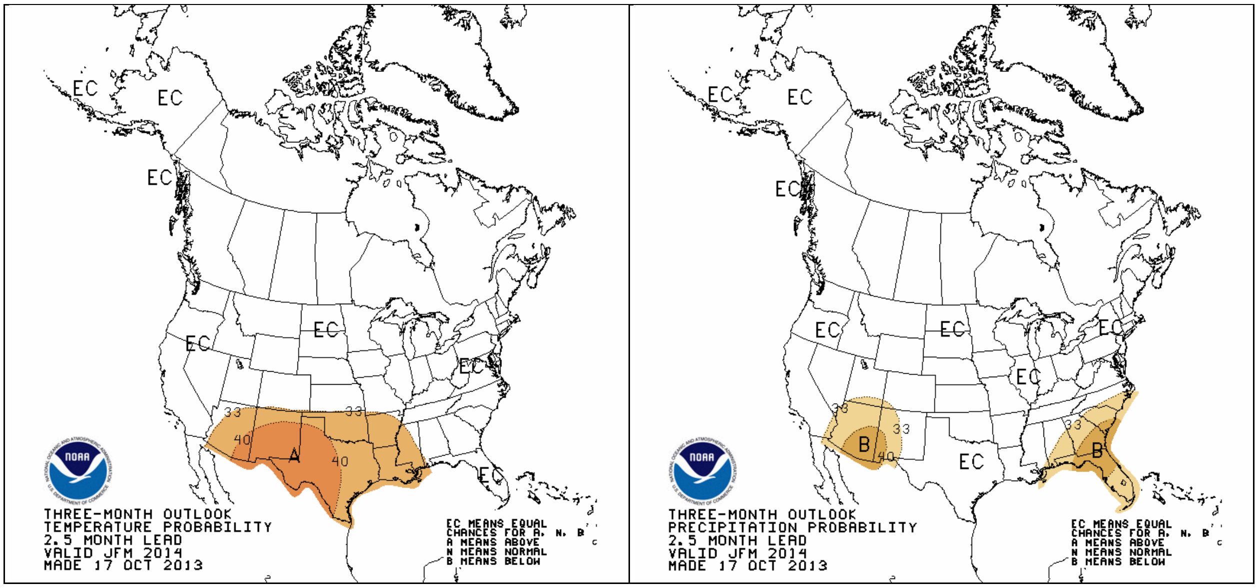


Figure 11. CPC January-February-March 2014 temperature and precipitation outlooks.

Summary

In summary, high fall precipitation has greatly eased the severe drought conditions in the basin and 2013 runoff forecast for the Missouri River Basin above Sioux City, IA is 25.9 MAF (102 percent of normal). Basin conditions, temperature, precipitation, and mountain and plains snowpack accumulation will be closely monitored during the fall and winter months.

Upper Missouri River Basin
Calendar Year Runoff Forecast
December 1, 2013

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the five incremental drainage areas above Gavins Point Dam and for the total of the six Missouri River drainage areas above Sioux City, often referred to the upper Missouri River Basin or upper Basin. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

2013 Calendar Year Forecast Synopsis

The annual runoff forecast as of December 1, 2013 is 25.1 MAF (99 percent of average) above Sioux City, IA. Above Gavins Point Dam, the runoff forecast is 22.8 MAF (99 percent of average). The December runoff forecast is 0.7 MAF (94 percent of average) above Sioux City and 0.65 MAF (94 percent of average) above Gavins Point. The forecast for much colder than normal temperatures could decrease runoff into the reservoir drainage areas during the winter months due to ice formation.

November runoff above Sioux City was 0.92 MAF (88 percent of average) and 0.85 MAF (88 percent of average) above Gavins Point Dam. Below average November runoff followed October runoff, which 240 percent of average. November runoff was less than the November forecast of 1.45 MAF (139 percent of average) above Sioux City. The below average runoff was due in part to below normal November precipitation in most areas of the upper Basin.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next two months, the range of expected inflow ranges from the 25.2 MAF upper basic forecast to the 24.9 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. The result is a large range or “bracket” for each drainage area, and thus for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

<u>Current Conditions</u>

Drought Analysis

The National Drought Mitigation Center’s (NDMC) U.S. Drought Monitor for November 26, 2013 is shown in Figure 1. High October precipitation greatly decreased the percentage of the basin that falls within the extreme drought category. As of November 26, most of Montana, North and South Dakota are out of any Drought condition. Southwest Montana continues to be impacted by Abnormally Dry (D0) to Severe (D2) drought conditions. Soil and drought conditions in the lower basin have also improved, though not as dramatically. Western Kansas and Nebraska are in Moderate (D1) to Severe (D2) drought conditions with some lingering areas of Extreme (D3) drought conditions. Portions of Iowa are also impacted by D0 to D2 conditions.

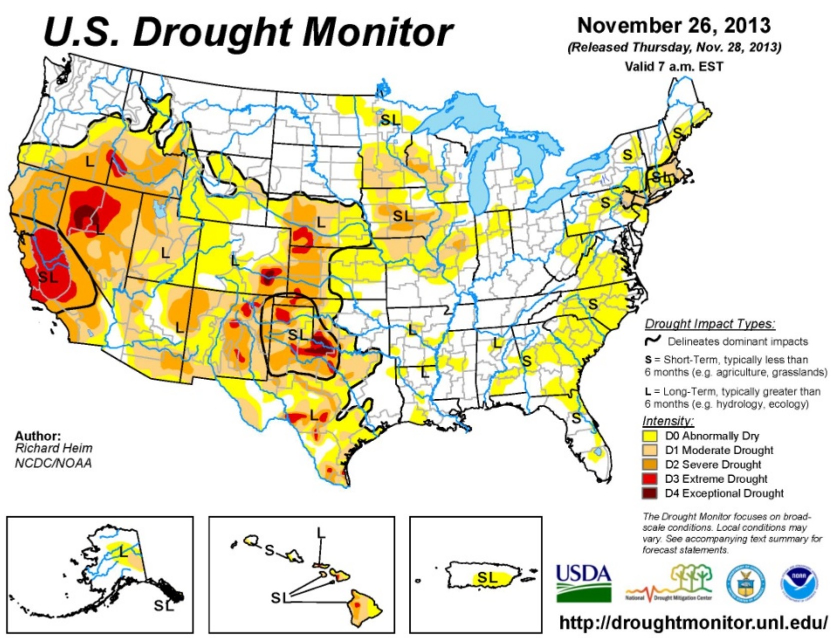


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for November 26, 2013.

According to the U.S. Seasonal Drought Outlook shown in Figure 2, drought conditions will continue to persist in central Nebraska, western Kansas, and western Iowa through February 2014. Improvement to drought conditions is forecast to occur in southwest Montana.

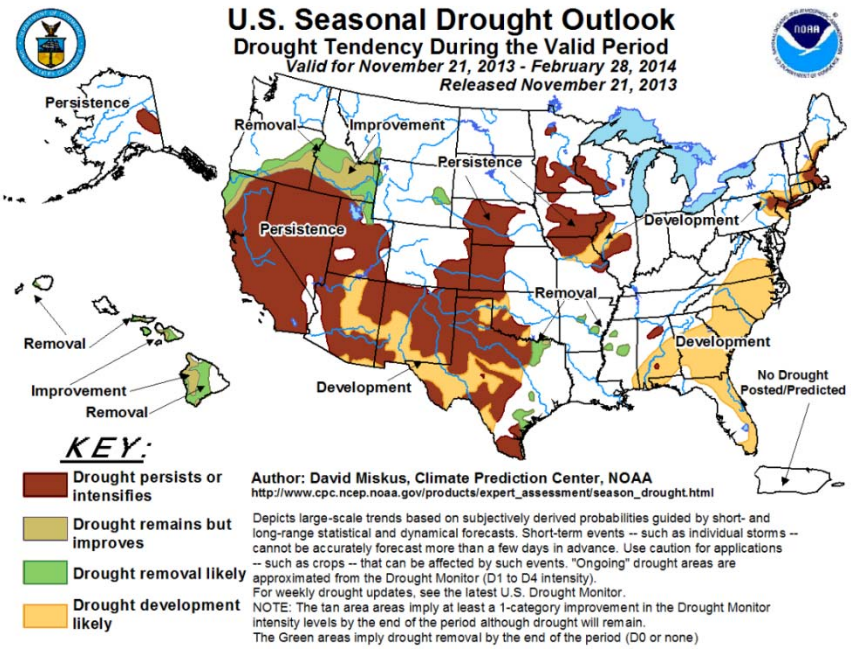


Figure 2. National Drought Mitigation Center U.S. Monthly Drought Outlook.

Precipitation

Accumulated precipitation during the month of November is shown in Figure 3. Rainfall amounts ranged from 1 to 1.5 inches in eastern South Dakota and portions of northern Montana. Slightly heavier amounts occurred in northwest Montana, while the mountainous regions received amounts ranging from 2 to 5 inches. As a percent of normal, precipitation amounts were generally below normal as shown in Figure 4, with the exception of a few areas. Northeast and northwest Montana received from 150 to 300 percent of normal precipitation. Also, precipitation in the Black Hills region of South Dakota received from 110 to 150 percent of normal precipitation. Some areas received greater than 150 percent of normal precipitation.

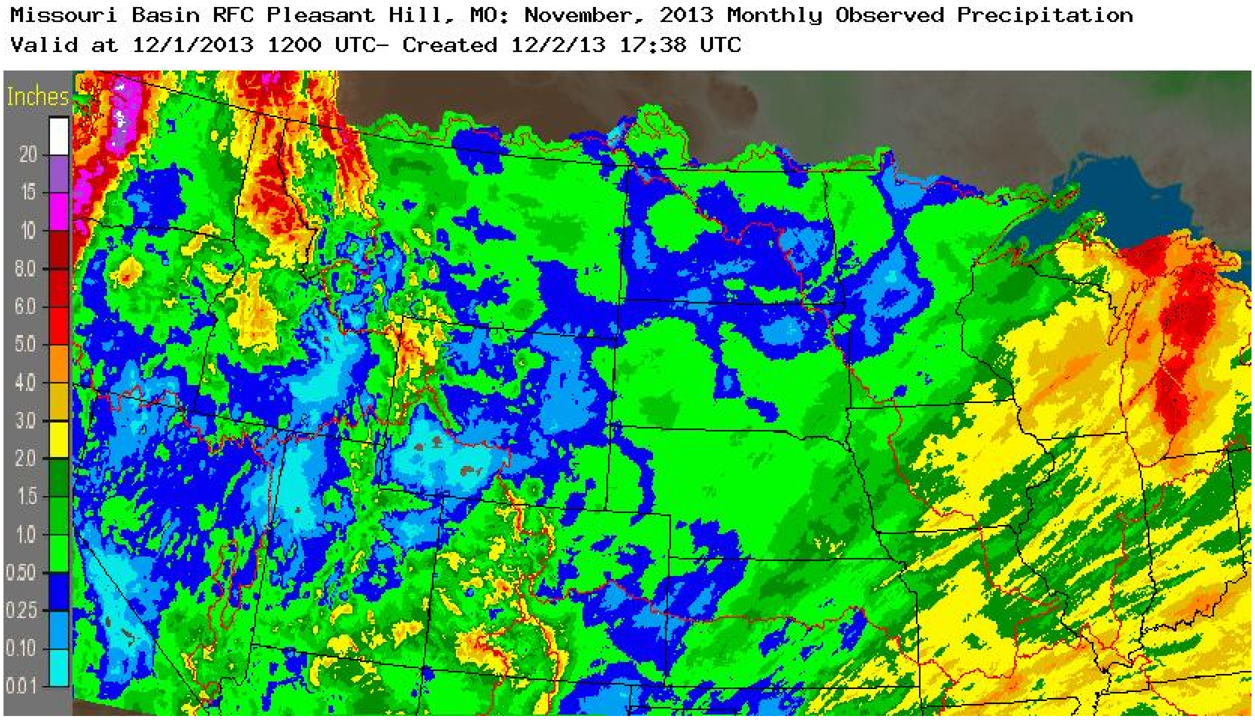


Figure 3. November 2013 precipitation (inches).

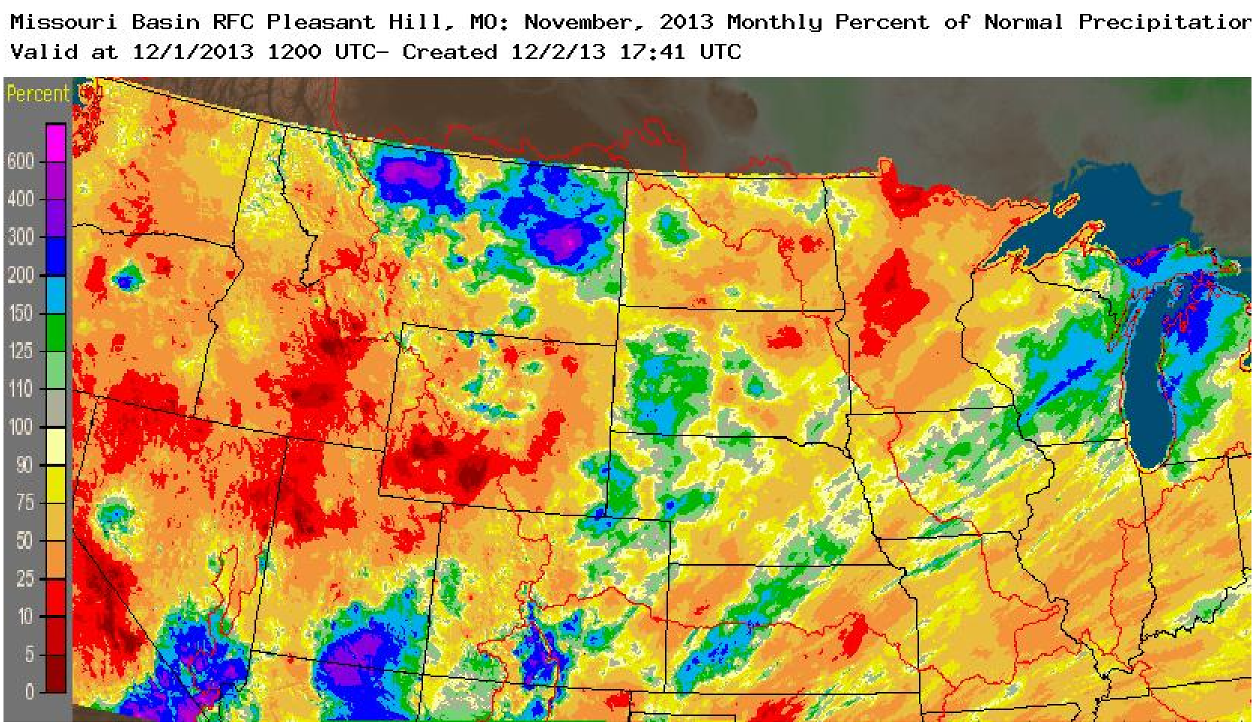


Figure 4. November 2013 precipitation (percent of 1981-2010 average).

Temperature

Average temperatures throughout most of the upper Basin during the past 30 days ending November 30 shown in Figure 5 were generally normal in the plains. Temperatures were normal to 4 degrees Fahrenheit above normal in the Rocky Mountains. The 90-day temperature departure map shown in Figure 6 indicates temperatures were normal with minor deviations above and below normal.

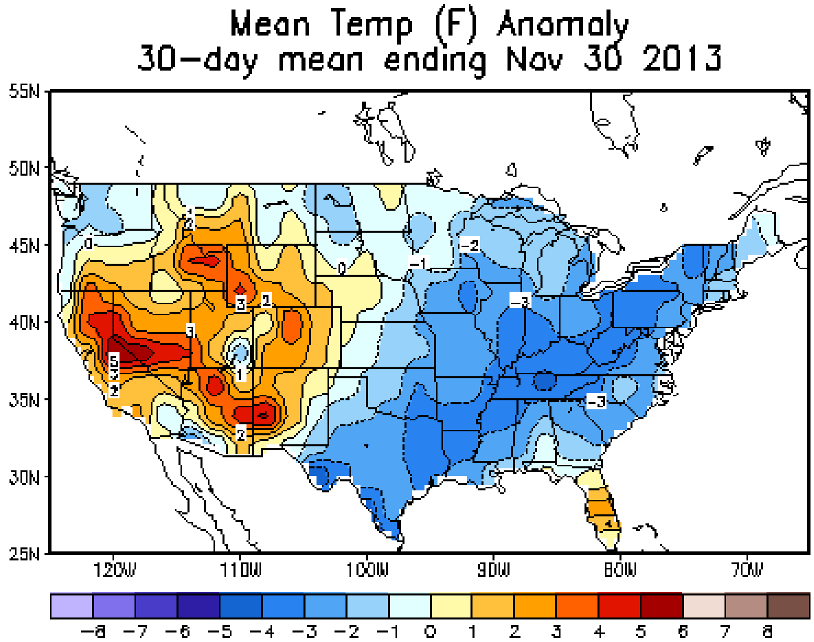


Figure 5. 30-day temperature departures (degrees F) from normal.

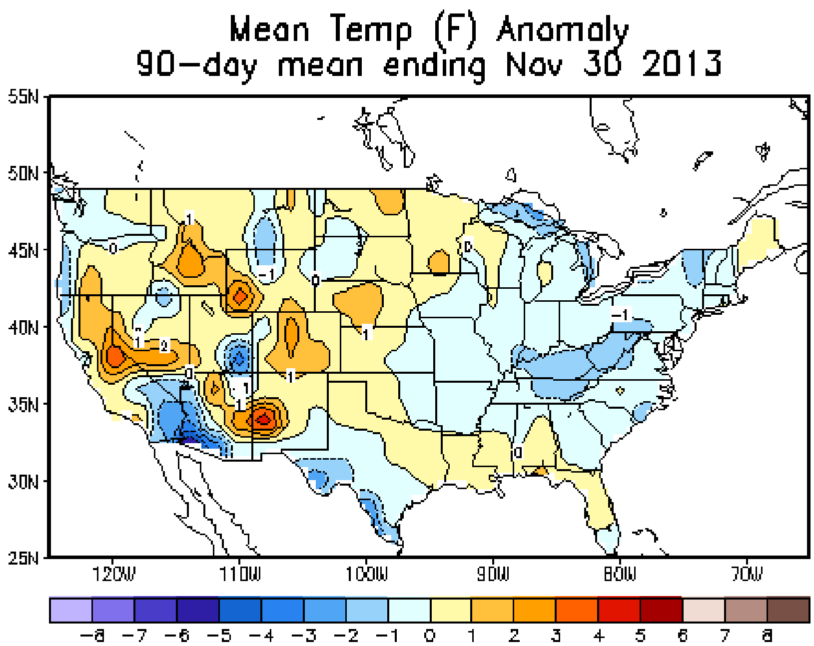


Figure 6. 90-day temperature departures (degrees F) from normal.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff in the form of baseflow.

Two independent estimates of soil moisture are presented in this report. Soil moisture ranking percentiles developed by the NOAA Climate Prediction Center (CPC) for the end of November 2013 and October 2013 are shown in Figures 7 and 8, respectively. Figure 9 illustrates soil moisture ranking percentiles determined by the University of Washington's Variable Infiltration Capacity (VIC) model.

The current status of the soil on the last day of November 2013 is represented by the soil moisture percentile ranking in Figure 7. Montana and much of North and South Dakota have soil moisture in the upper 70th percentile, which is representative of wetter than normal soil conditions. Much wetter than normal soil moisture conditions ranking in the 95th to 99th percentile are present in northwest Montana, north central and northeast Wyoming, southwest North Dakota, and northern and western South Dakota. Soil moisture conditions in the upper Basin when compared to the end of October 2013 (Figure 8) have not changed substantially, with the exception of increased soil moisture in northwest Montana at the end of November 2013.

The VIC model soil moisture ranking percentile in Figure 9 shows similar wetter than normal conditions in the Dakotas and northeast Wyoming; however, it depicts drier than normal conditions in western Montana.

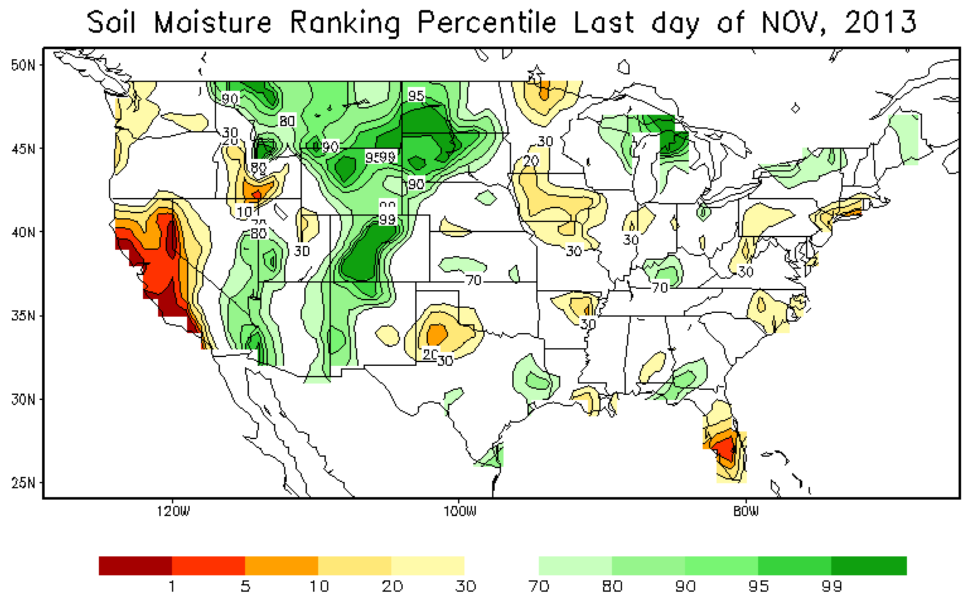


Figure 7. Calculated Soil Moisture Ranking Percentile on the last day of November 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

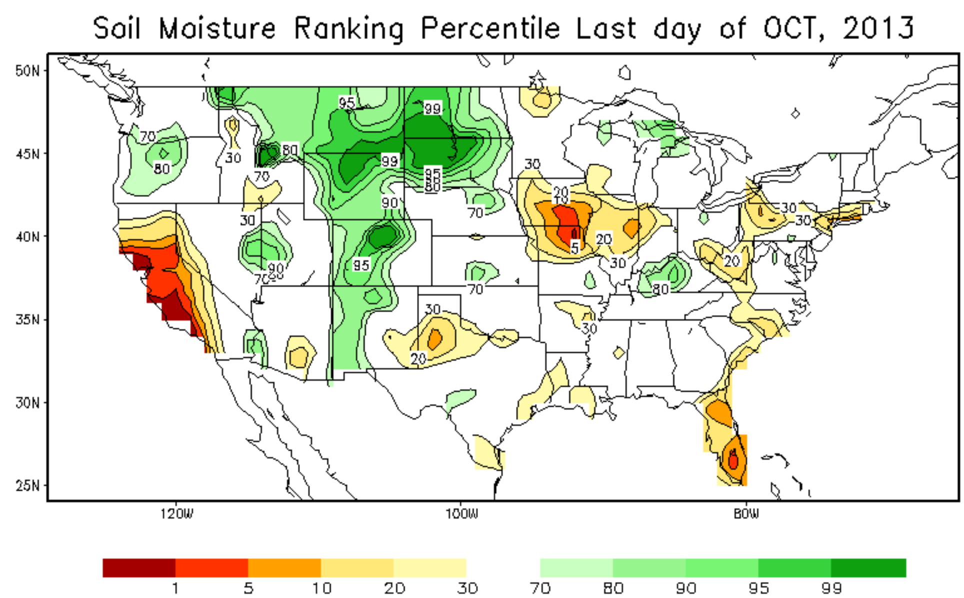


Figure 8. Calculated Soil Moisture Ranking Percentile on the last day of October 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

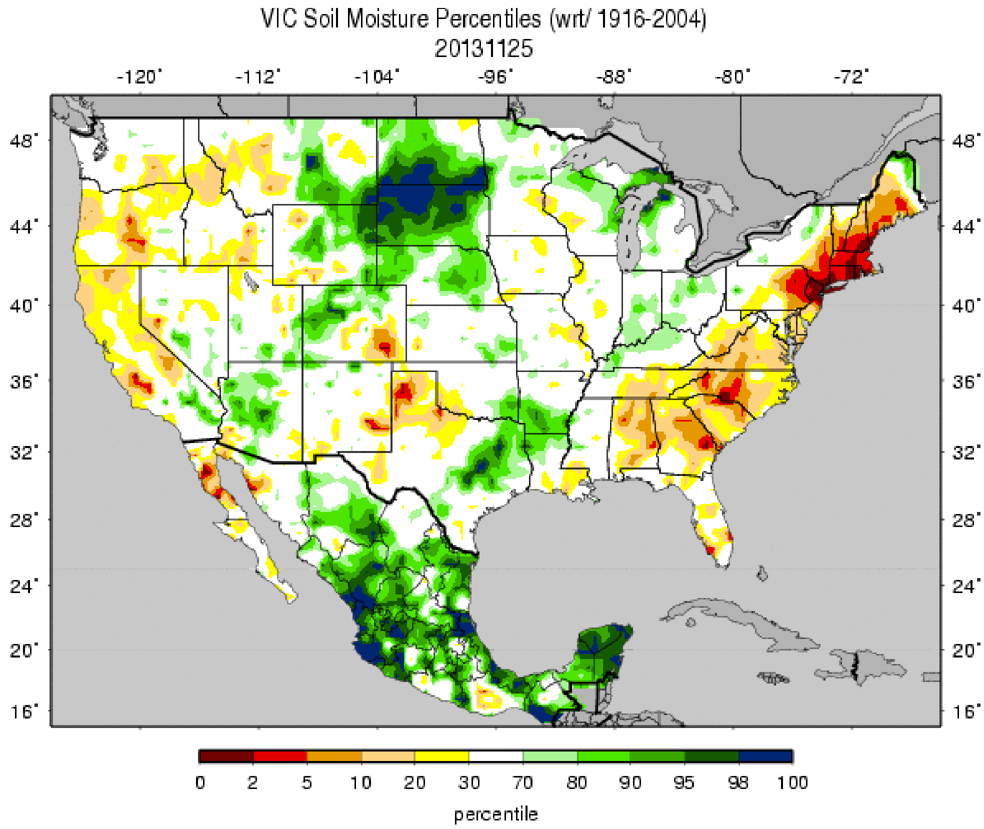


Figure 9. VIC modeled soil moisture percentiles on November 25, 2013. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/index.shtml

The potential impacts of having higher than normal fall soil moisture in the upper basin on the following year's runoff was qualitatively evaluated by examining similar fall soil moisture conditions and the resulting year's runoff above Sioux City, IA. Using archived VIC soil moisture maps from the period 1915 to 2010, the seven years with similar soil moisture conditions for November 1 were: 1941, 1946, 1970, 1982, 1996, 1998, and 2010 (see Figure 10). The years were considered similar to 2013 current conditions if comparative geographical areas had soil moisture percentiles of 80% or higher. Out of the seven years identified, all had higher than normal water year runoff (e.g. Oct. 1, 1941 to Sep. 30, 1942). The mean calendar year runoff above Sioux City, IA is 25.2 MAF and the respective similar calendar year runoffs were: 26.2 (1942), 29.2 (1947), 32.3 (1971), 28.8 (1983), 49.0 (1997), 32.8 (1999), and 60.7 (2011) MAF. It should be noted that this should be considered an anecdotal analysis at this point. A full-fledged technical review involving the entire upper basin, climate conditions (e.g. El Niño, La Niña, ENSO-neutral), observed precipitation, plains and mountain snowpack, long-term precipitation and temperature outlooks, etc. over the period of record (1898-2013) would need to be conducted to ascertain the correlation between fall conditions and the resulting water and/or calendar year runoff.

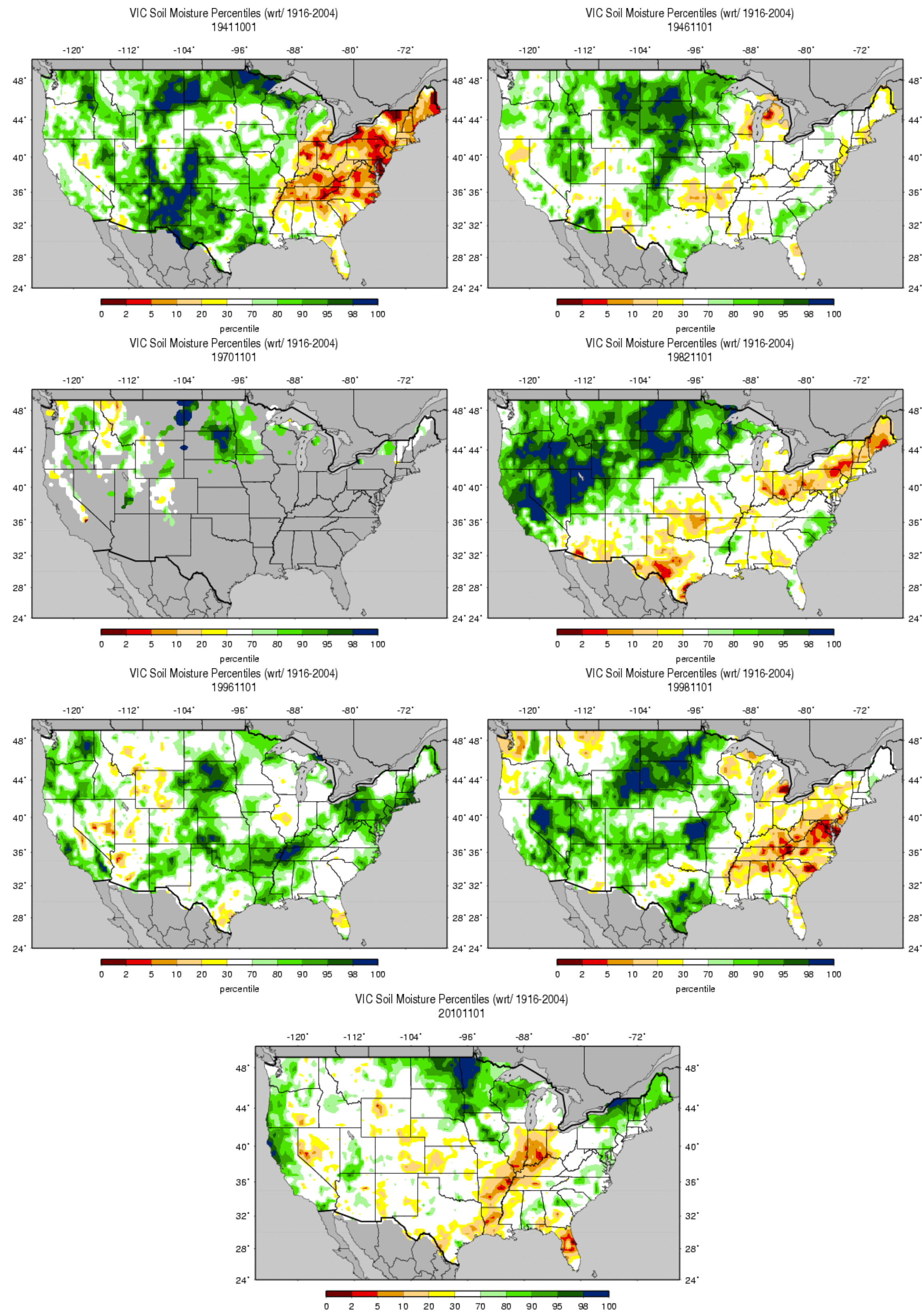


Figure 10. VIC modeled soil moisture percentiles as of November 1 for model years similar to 2013. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/archive/htm/arch_grid.htm.

Plains Snowpack

Plains snowpack is an important hydrologic input that influences the volume of runoff occurring in the basin during the months of March and April. The March-April 2014 forecast is not part of the 2013 calendar year forecast; however, plains snowpack, which is used in the 2014 forecast, is presented here for informational purposes only. Any conclusions made about the March-April 2014 runoff forecast based on the December 1, 2013 snowpack would be premature because plains snow has just begun to accumulate with three to four months of plains snow accumulation yet to occur.

According to the National Operational Hydrologic Remote Sensing Center (NOHRSC), most plains snow water equivalent (SWE) amounts range from trace to 1-inch amounts throughout northeast Montana and much of North Dakota. Snow depths were generally trace to 2 inches. As of December 1, a winter storm was moving across the plains, and it was forecast to produce significant amounts of snow in Wyoming, Montana, North Dakota and South Dakota.

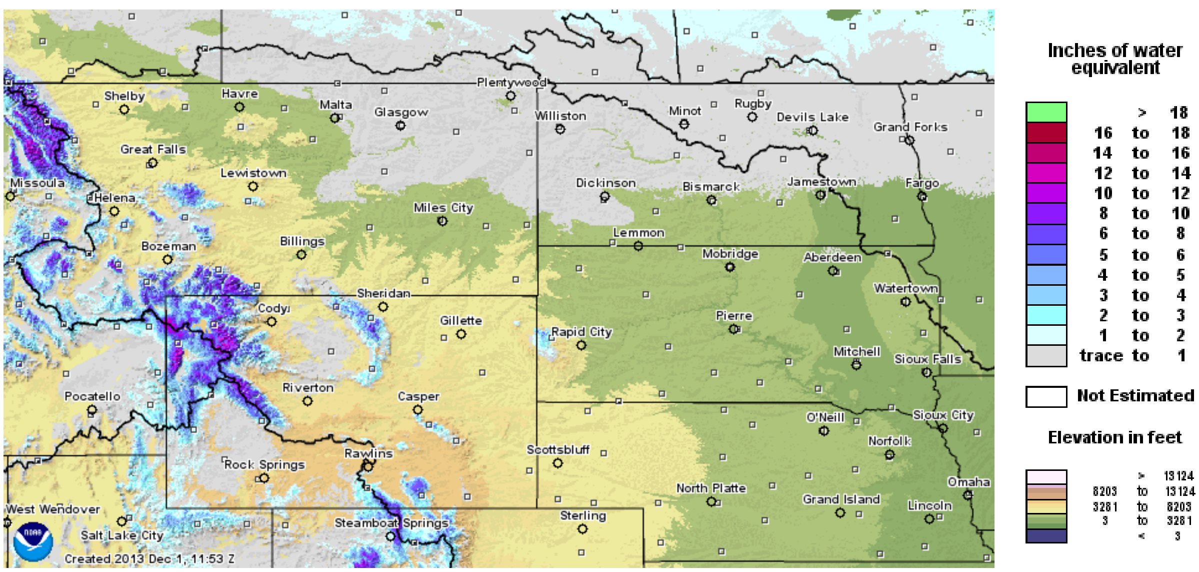


Figure 11. December 1, 2013, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison Mainstem reaches. During the 3-month May-July runoff period, about 50 percent of the annual runoff enters the Mainstem reservoirs as a result of mountain snowmelt and rainfall runoff. Greater than average mountain snow accumulations are usually associated with greater than average May-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions.

Based on SNOTEL data through November 30, 2013, the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 4.3 inches, which is 112 percent of the 1981-2010 average SWE. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 4.3 inches, which is 113 percent the 1981-2010 average SWE. Normally by December 1, 26 percent of the peak snow accumulation has occurred in the mountains.

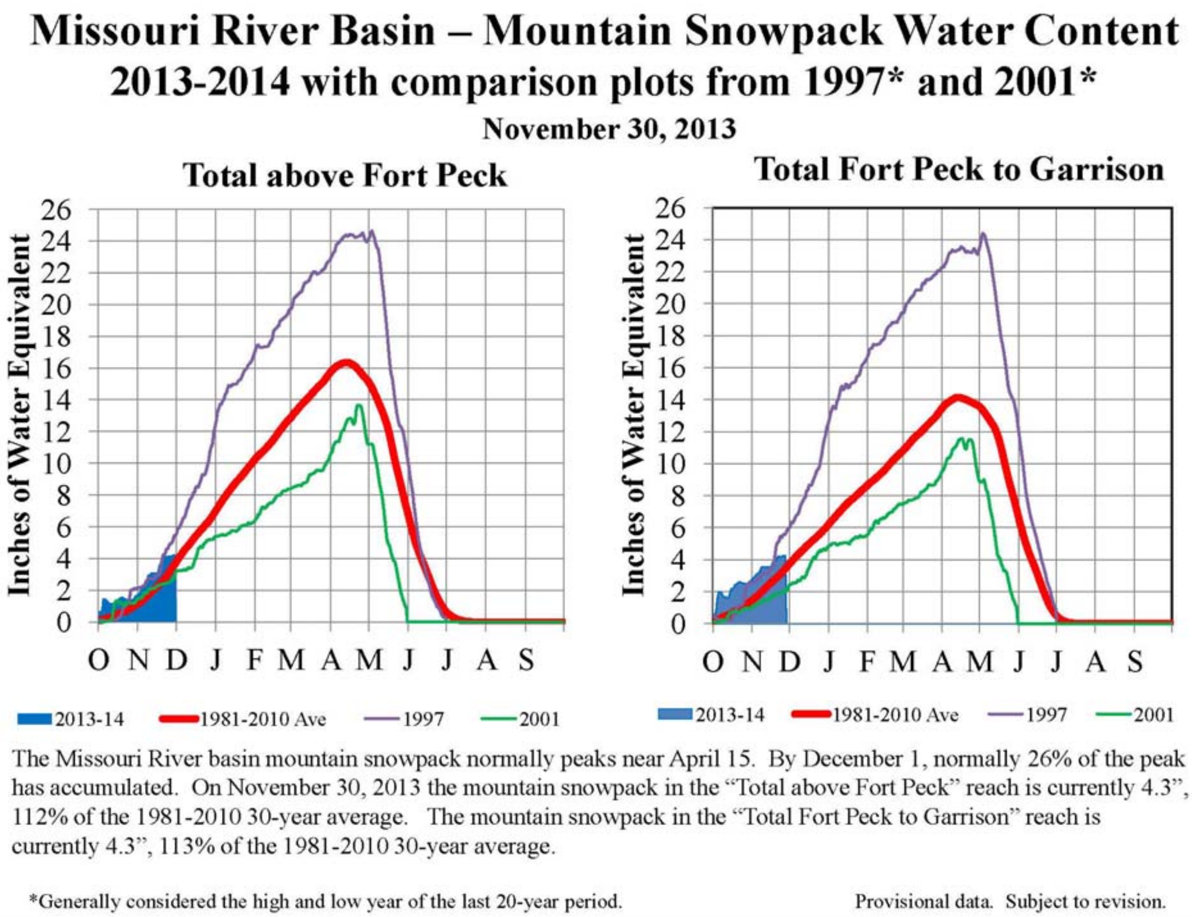


Figure 12. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral climate conditions continue in the equatorial Pacific. Equatorial sea surface temperatures are near average across much of the equatorial Pacific Ocean. ENSO-neutral conditions are favored through the Northern Hemisphere Spring 2014. During an ENSO neutral phase, there are no strong indicators of temperature and precipitation as opposed to El Niño or La Niña conditions.

The NOAA Climate Prediction Center (CPC) produces monthly and seasonal temperature and precipitation outlooks. The CPC's December temperature outlook shown in Figure 13 indicates increased chances for below normal temperatures in the upper Missouri River Basin, while the December-January-February outlook in Figure 14 indicates increased chances for below normal temperatures in northern and eastern Montana, North Dakota and northern South Dakota. The March-April-May temperature outlook in Figure 15 indicates equal chances for above normal, normal and below normal temperatures in the upper Missouri River Basin.

The CPC's December precipitation outlook in Figure 13 indicates increased chances for above normal precipitation in most of the upper Missouri River Basin, while the December-January-February outlook in Figure 14 indicates increased chances for above normal precipitation over Montana and northern Wyoming. The March-April-May precipitation outlook in Figure 15 indicates equal chances for above normal, normal and below normal precipitation in the upper Missouri River Basin.

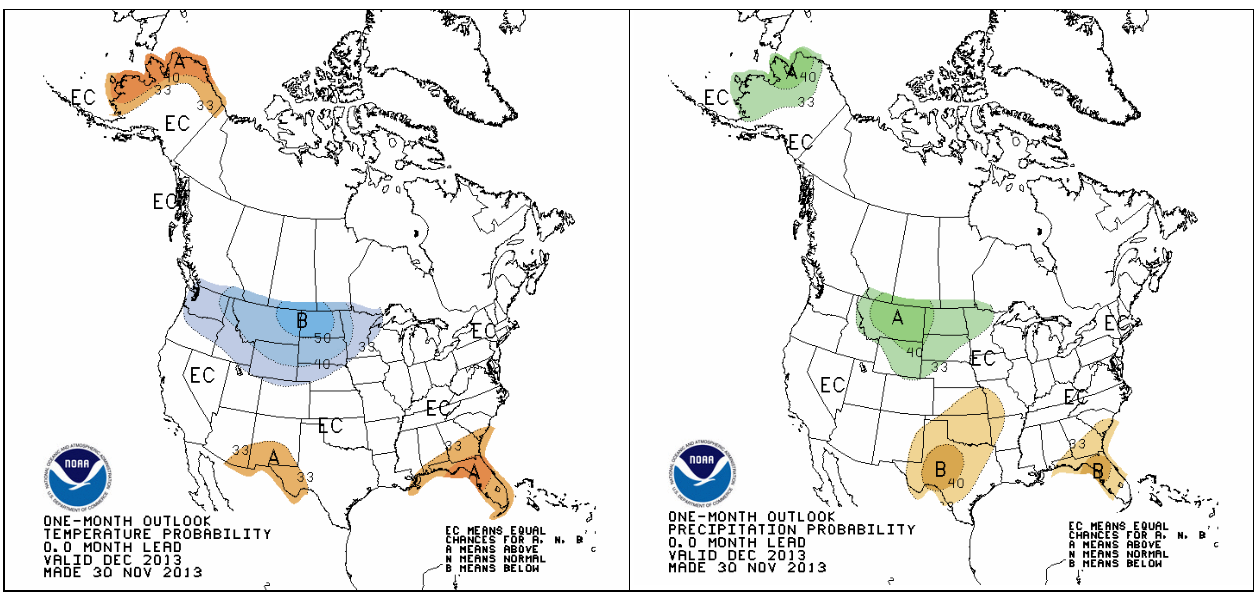


Figure 13. CPC December 2013 temperature and precipitation outlooks.

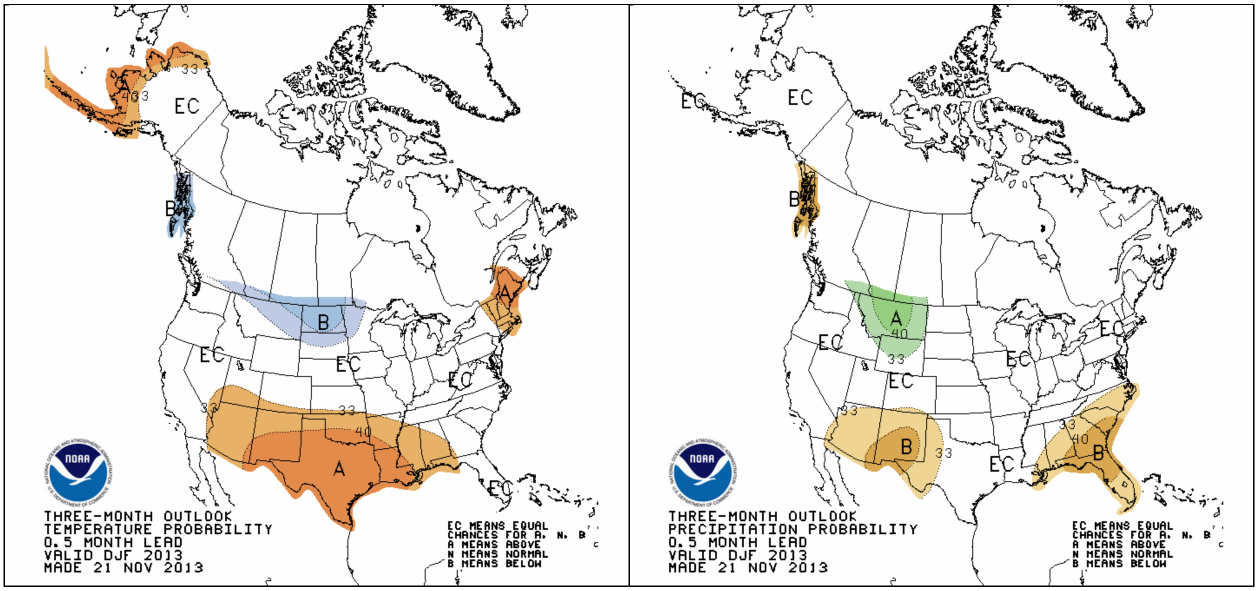


Figure 14. CPC December-January-February 2013 temperature and precipitation outlooks.

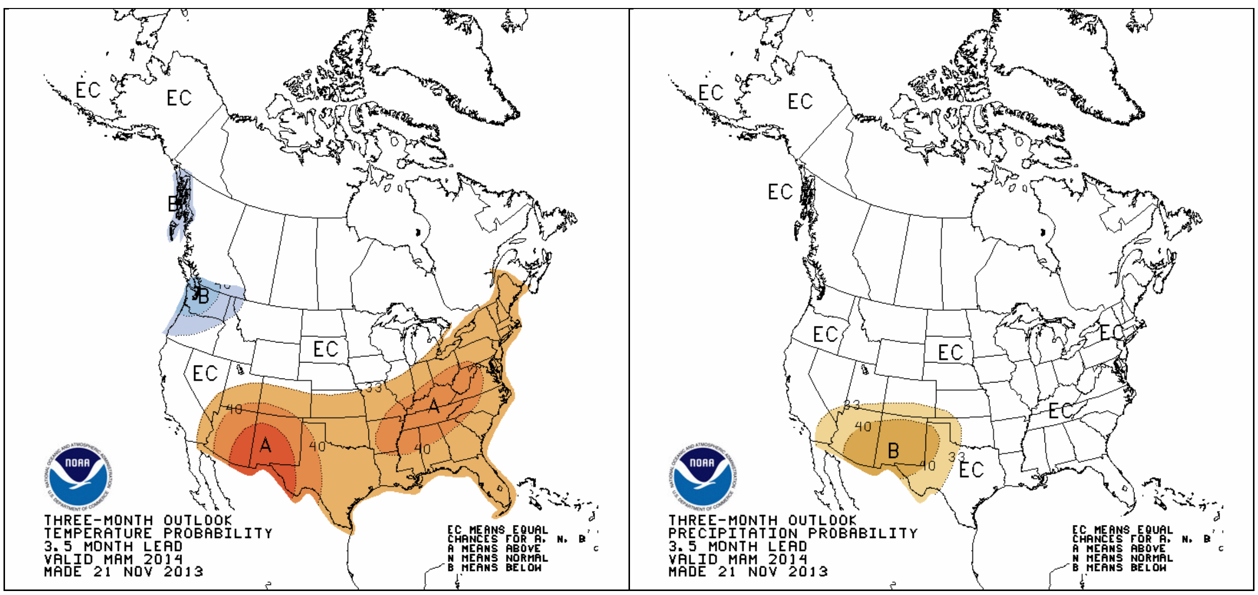


Figure 15. CPC March-April-May 2014 temperature and precipitation outlooks.

Summary

In summary, low November runoff and the forecast of cold temperatures has tempered the December runoff forecast. As a result the 2013 calendar year runoff forecast for the upper Basin is 25.1 MAF (99 percent of normal). Basin conditions, temperature, precipitation, and mountain and plains snowpack accumulation will be closely monitored during the fall and winter months.