Intermountain West Climate Summary

by The Western Water Assessment

Issued November 20, 2006

November 2006 Climate Summary

Hydrologic Conditions: Most of Utah and Colorado are not in drought status and are in near normal to wet Standardized Precipitation Index, although some areas are in lower drought and SPI categories. Wyoming's drought status is relatively unchanged since September, and drought is expected to persist in much of Wyoming and northwest Colorado.

Temperature: October temperatures were below average for most of the region, following a summer that averaged as one of the warmest on record for much of the region.

Precipitation: October precipitation was much above average for eastern Utah and much of Colorado, leading to record streamflows and flooding in some areas. Much of Wyoming has remained near average to dry.

ENSO: El Niño conditions have developed and are expected to strengthen to moderate conditions that should last into the spring of 2007.

Climate Forecasts: The strengthening El Niño should bring increased moisture to the southern part of the country in the next few months, including the Four Corners region and southern Wyoming, but northwestern Wyoming has a slightly increased risk of below average precipitation.

Scientists Flood Boulder and Rain Floods Utah

NOAA held its 2006 Climate Diagnostics and Prediction Workshop in October in Boulder, CO, bringing in climate scientists from around the country. The scientists discussed the latest research results and ways to improve the quality of climate predictions and provide critical decision support information on climate variability and change for planners and managers to make decisions and manage risk. The developing El Niño was a big topic and this month's feature article describes the evolution of ENSO conditions over the past year and where to get information about the workshop.

Another event in October was heavy rain in Utah which caused flooding in several areas and raised levels in Lake Powell by about one foot per day for several days, raising storage by over 600,000 acre-feet, a very unusual occurrence for October. In the photo at right, USGS employee surveyed the high water marks on the Dirty Devil River and estimated a provisional peak flow of 42,000 cubic feet/second. *(See Utah Water Availability Page (p. 12) for more information.)*

In This Issue

On the Web: http://wwa.colorado.edu

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 This publication was prepared by CIRES/WWA with support in part from the U.S. Department of Commerce/NOAA, under cooperative agreement NA17RJ1229 and other grants.

The Intermountain West Climate Summary is published monthly by Western Water Assessment (WWA), a joint project of the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES) and the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory, researching water, climate and societal interactions.

A Review of Monthly/ Seasonal Climate Variability for 2005-2006: The ENSO Cycle

By Vern Kousky, NOAA/CPC with Andrea Ray, NOAA/ESRL/PSD

This article based on a presentation by Dr. Kousky, Chief of the Development Branch at NOAA's Climate Prediction Center, that was made at the recent 31st Climate Diagnostics and Prediction workshop in Boulder, Colorado. Kousky's full presentation, and many others, can be found at the Workshop website: http://www.cpc.ncep.noaa.gov/products/outreach/proceedings/cdw31_proceedings.

The seasonal climate of calendar year 2006 has been an interesting one because it began with weak La Niña conditions in the first part of the year, and is ending with weak but strengthening El Niño conditions. This article summarizes the recent El Niño evolution, and describes the various indicators that seasonal forecasters use to assess ENSO conditions and place this event in historical perspective compared to events in the past half-century. Finally, we discuss the outlook for ENSO into the spring 2007 and its likely magnitude.

Recent Evolution of Conditions in the ENSO Region

During late 2005-early 2006 sea surface temperature (SST) anomalies decreased and below-average temperatures developed throughout most of the central and eastern equatorial Pacific (Figure 1a). This figure is called a Hovmöller diagram, after Swedish scientist and meteorologist, Ernest Hovmöller, who first demonstrated its usefulness for visualizing data in time and space in a paper published in 1949. These plots are commonly used by seasonal climate forecasters to look at the evolution of a variable over time, such as SST across the equatorial Pacific Ocean. In February 2006 positive SST anomalies developed in the extreme eastern equatorial Pacific, similar to what occurred during the La Niña years 1999, 2000 and 2001. Since May 2006, positive SST anomalies have increased across the equatorial Pacific between 160E and the South American coast.

NOAA's definition of an ENSO anomaly requires anomalies of 0.5ºC or greater for three months in the area of the equatorial Pacific from 120º to 170ºW (between green lines in Figure 1a) and between 5ºN and 5ºS (known as the "Niño 3.4 region"), based on the 1971-2000 base period. This three-month running average is called the "Oceanic Niño Index" (ONI), which recently has reached the threshold of the El Niño definition and is expected to remain above it into the spring of 2007 (Figure 1b).

Other Indicators of a Developing El Niño

Seasonal climate forecasters look at a suite of variables

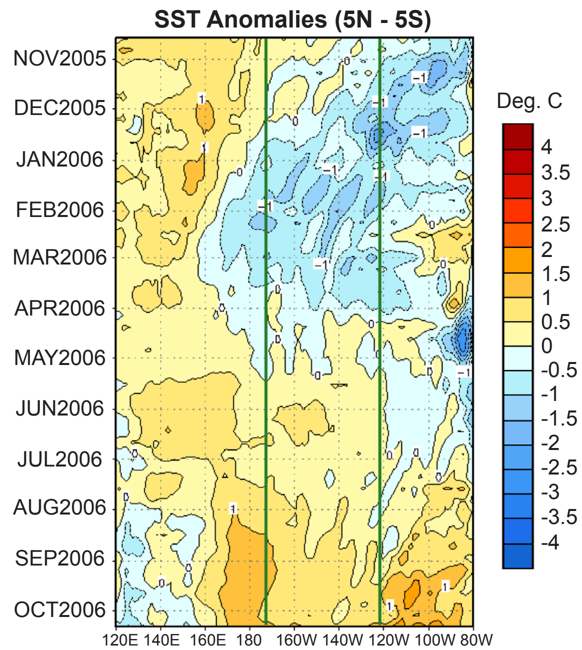


Figure 1a. Equatorial SST anomalies November 2005-October 2006 with the Nino 3.4 region deliniated by the vertical green lines. Time is on the vertical axis and longitude across the Pacific is on the horizontal axis. Cool temperatures (blue shades) dominated the eastern Pacific from November 2005 through around April 2006 (upper area of the graphic), then conditions shifted to warmer temperatures (lower area). The labeling is somewhat counterintuitive because longitudes are measured relative to Greenwich, England: eastern Pacific longitudes are 80-180W and western Pacific longitudes are 120-180E. 180E and 180W are the same, and are often referred to as the "date line," because it is the imaginary line on the Earth that separates two consecutive calendar days.

indicating the state of ENSO conditions. In addition to SSTs, these include outgoing longwave radiation (OLR), winds, and the heat content in the upper ocean. OLR is a measure of the radiative character of energy radiated from the warmer earth surface to cooler space, derived from polar-orbiting satellites. This measurement provides information on cloud-top temperature, which indicates convection or raining clouds that can then be used to estimate tropical precipitation amounts. Recently, OLR anomalies have been negative, indicating enhanced convection and precipitation, between 180W (the date line) and Papua/ New Guinea, and over the southwest North Pacific (Figure 1c). Posi-

On the Web

- Climate Diagnostics and Prediction workshop website: http://www.cpc.ncep.noaa.gov/products/outreach/proceedings/cdw31_proceedings.

tive OLR anomalies (suppressed convection and precipitation) were observed over western Indonesia, portions of Malaysia and the eastern Indian Ocean. The pattern of anomalous OLR over the equatorial Pacific during the last 30 days reflects the early stages of El Niño.

Wind anomalies (not shown) also indicate the early stages of El Niño. In the early part of 2005, there were easterly wind anomalies in the equatorial Pacific, i.e., stronger than average winds from the east to the west. Recent winds, however, have shown westerly anomalies (weaker-than-average easterly winds near the equator between Papua New Guinea and the Date Line (180W). Equatorial low-level winds were near average east of the Date Line.

Finally, the heat content in the equatorial upper ocean (0-300 m depth) is a key indicator of the energy available to support a developing El Niño (Figure 1d). Heat anomalies are measured as a function of depth, by buoys anchored in the ocean with temperature sensors down to 300m or deeper. As a precursor to weak La Niña conditions that developed in late 2005 (a year ago), the upper-ocean heat content gradually decreased across the eastern and central Pacific Basin in mid-2005, while the heat content increased in the extreme western equatorial Pacific. Then during March-April 2006 the upper-ocean heat content increased as La Niña conditions weakened and ENSO-neutral conditions became established. During August-September 2006 positive subsurface temperature anomalies were observed throughout the equatorial Pacific, as upper-ocean heat content continued to build along the equator. A pattern of basin-wide positive subsurface temperature departures along the equator is usually observed prior to and in the early stages of El Niño, and in fact, the most recent analysis shows positive anomalies, between the surface and 200 m depth, across most of the equatorial Pacific (not shown).

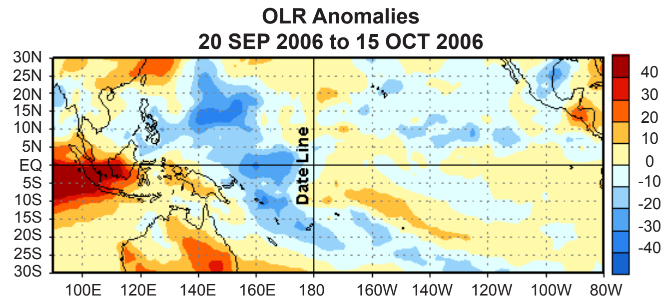


Figure 1c. Outgoing longwave radiation anomalies, Sep. 20 - Oct. 15, 2006. Positive OLR anomalies (orange/red shading, suppressed convection and precipitation) were observed over western Indonesia, portions of Malaysia and the eastern Indian Ocean. Negative OLR anomalies (blue shading, enhanced convection and precipitation) were observed between the date line and Papua/ New Guinea, and over the southwest North Pacific.

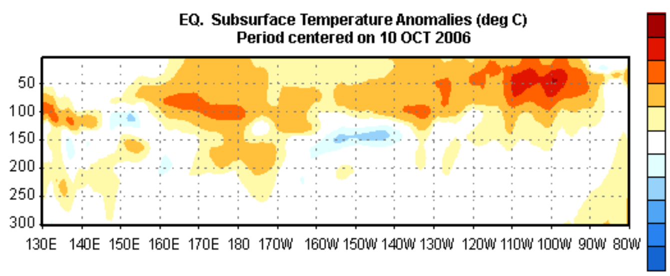


Figure 1d. Equatorial (EQ) Upper ocean temperature anomalies, 0-300m depth on the vertical axis. Warm anomalies (orange/red shades) are observed across most of the Pacific for a recent 5-day period (pentad), centered on 10 October 2006, with few areas of cool anomalies (blue shades).

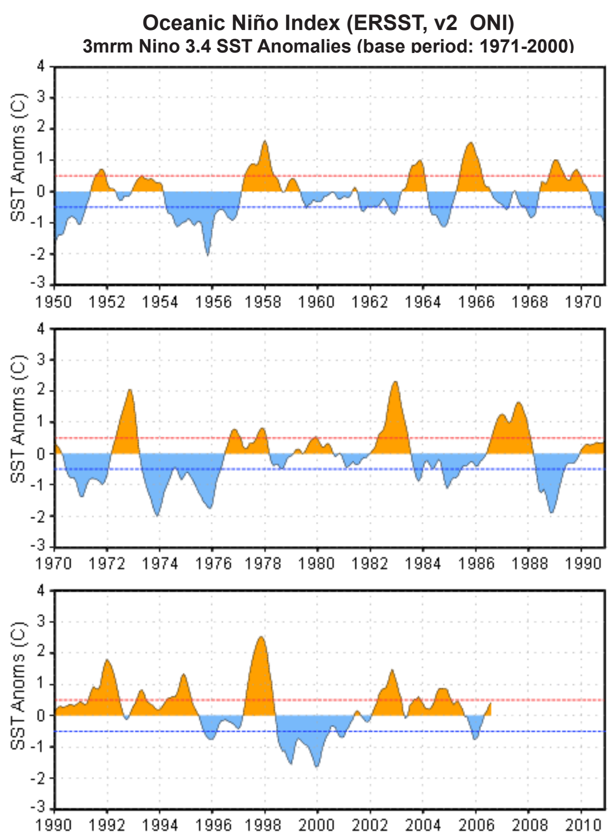


Figure 1b. Oceanic Niño Index, 1950-2006. ONI is the three-month running average (3mrm) for satellite-derived (ERSST.v2) SST in the Nino 3.4 region. Orange indicates a positive SST anomaly, blue a negative anomaly. The thresholds for the definition of ENSO anomalies are shown by red (El Niño) and blue (La Niña) lines.

Historical Perspective and Pacific SST Outlook

This event appears to be relatively weak compared to others in the past. Recent SST values for the Niño 3.4 region, compared to values for 14 historical El Niño episodes show that this event lies in the lower half of the distribution of historical El Niño episodes since 1950 (Figure 1e) which indicates that this event is likely to be of weak or moderate intensity.

Seasonal forecasters also think that this event is getting started too late in the year and the upper ocean heat content is too small for this event to become a strong El Niño. The strongest El Niño events began in the northern hemisphere's spring season (March-May) and featured much greater upper-ocean temperature anomalies than those currently being observed.

NOAA Climate Forecast System calculates SSTs and other variables across the globe. These model runs indicate that weak or moderate El Niño conditions will likely continue through April-June 2007 (Figure 1f). When this event will end is less certain, because the forecast techniques used have a difficult time with transitions between warm, neutral, and cold states of ENSO, especially 6 months or more in advance. However, El Niño events usually die away within 12 months of onset.The ENSO status outlook is also described on page 16. The bottom line is, based on recent trends and a majority of the statistical and coupled model forecasts, including those by other climate centers, NOAA/CPC forecasts that El Niño conditions should intensify during the next 2-3 months, and continue through April-July of 2007.

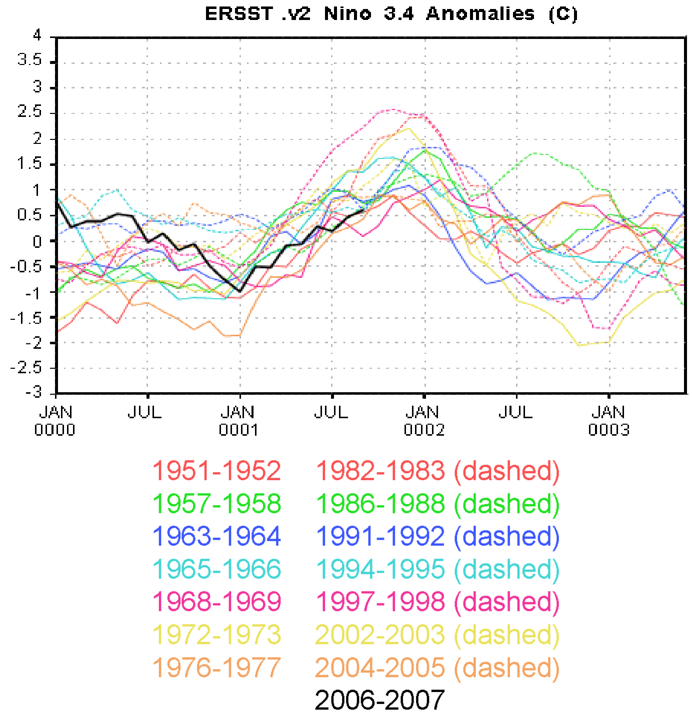


Figure 1e. 2006 event in historical perspective degrees Celsius on the vertical axis. Most recent Niño 3.4 values for the 2006 event (heavy black line) compared to 14 historical El Niño events since 1950. On the time axis year 0001 is the first year that ended up having a warm episode.

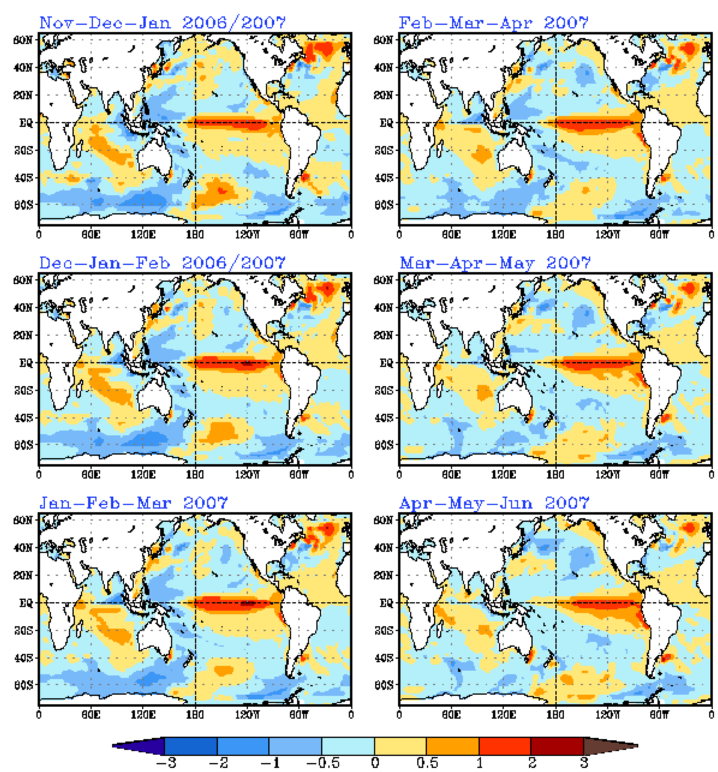


Figure 1f. SST outlook. SST's forecast based on the mean of NOAA Climate Forecast System runs. The Nino 3.4 region and other areas of the eastern tropical Pacific are likely to continue to have anomalously warm SSTs through the period April-June 2007

References

Hovmöller, E. 1949. The trough and ridge diagram. Tellus 1, 62-66. Kousky, V. 2006. A review of monthly/seasonal climate variability for 2005-2006. Available at: http://www.cpc.ncep.noaa.gov/products/outreach/proceedings/cdw31_proceedings

Temperature data through 10/31/06

Monthly average temperatures for October 2006 for the Intermountain West region ranged from lows in the mid-30s in western and south central **Wyoming** and north central **Colorado** mountains to highs in the mid-50s in southeast **Utah** (Figure 2a). Southwestern **Wyoming** and the northwest corner of **Utah** had the highest departure from average with temperatures ranging 2 - 6+°F above average, while south central **Wyoming** recorded the lowest departure from average of 4 - 6°F below average (Figure 2b). Overall, eastern **Colorado** and northern **Wyoming** had temperatures closest to average.

In comparison to October 2005 (Figure 2c) temperatures for October 2006 were, on average, lower for the entire Intermountain West region. Central **Wyoming** and northern **Colorado** had the largest difference between years, with temperatures above average by 0 – 4 °F in October 2005, whereas in October 2006, nearly the entire Intermountain West region was below average by 0 – 6 °F.

Some additional temperature data reported by NWS **Utah**, in a summary of the three summer month's temperatures, indicates that June – August, 2006 were the fourth hottest on record in Salt Lake City. The average temperature was 77.6° compared to the average of 73.9°. The record warmest summer was 78.6° degrees in 1994, followed by 78.2° in 2003 and 77.7° in 1988.

Notes

Average refers to the arithmetic mean of annual data from 1971-2000. Departure from average temperature is calculated by subtracting current data from the average. The result can be positive or negative.

These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known points to produce continuous categories. Interpolation procedures can cause aberrant values in data- sparse regions. For maps with individual station data, please see web sites listed below.

Figures 2a-c are experimental products from the High Plains Regional Climate Center. These data are considered experimental because they utilize the newest data available, which are not always quality controlled.

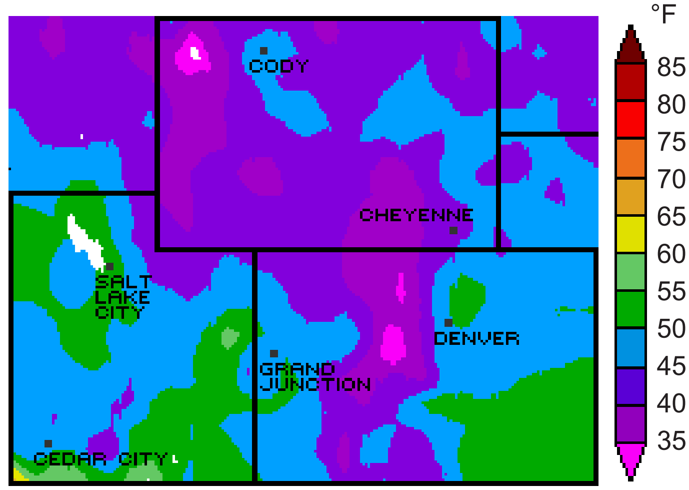


Figure 2a. Average temperature for the month of October 2006 in °F.

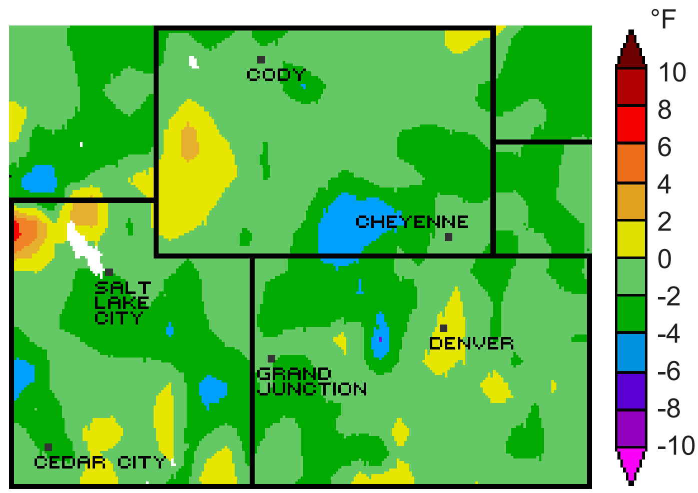


Figure 2b. Departure from average temperature for the month of October 2006 in °F.

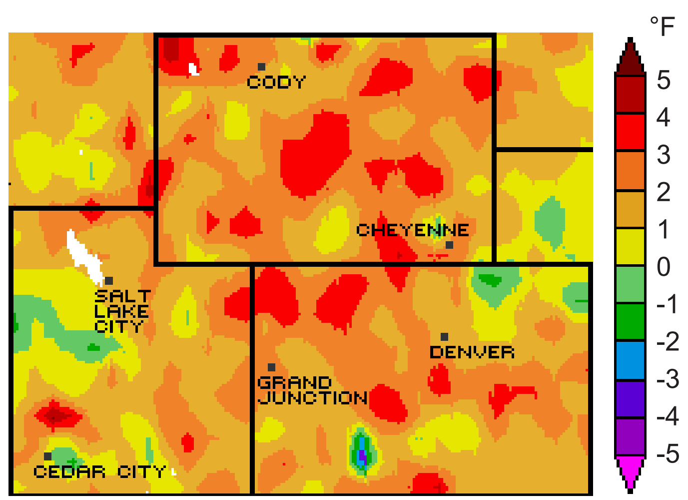


Figure 2c. Departure from average temperature in °F for last year, October 2005.

On the Web

- For the most recent versions these and maps of other climate variables including individual station data, visit: http://www.hprcc.unl.edu/products/current.html.
- For information on temperature and precipitation trends, visit: http://www.cpc.ncep.noaa.gov/trndtext.htm.
- For a list of weather stations in Colorado, Utah, and Wyoming, visit: http://www.wrcc.dri.edu/summary.

Precipitation data through 10/31/06

Because the water year began the first of October, we only present two precipitation graphs this month. The percent average precipitation for October also represents the percent average for the first month of water year 2007. Total precipitation for October 2006 in the Intermountain West regions ranged from 0.5 to 3+ inches (Figure 3a). Eastern **Utah**, western **Colorado** and northwest **Wyoming** received the highest totals of 4+ inches of precipitation, In contrast, eastern **Wyoming** received 0.5 to 1 inch. The rest of the Intermountain West region received from 1 to 4+ inches.

The NWS Salt Lake City, reports that from October 6-8, a large upper level storm system interacted with abundant amounts of subtropical moisture, producing widespread, heavy rain across **Utah**, especially in the south central and east central regions (Figure 3a). The system produced record-breaking rainfall events along with widespread flooding. The flooding was worst in Hanksville, where an all-time 24-hour rainfall record was set of 3.00 inches. The old record for 24 hours was 1.80 inches set on August 14th, 1952. There were also many other 24-hour record rainfall totals for the date set during that storm system. See more on extreme **Utah** precipitation events for the month of October on page 11. The NWS Denver/Boulder reports that October 2006 ended with 1.03 inches of precipitation or 0.04 inch above the average of .99 inch, which ended the consecutive dry spell of 11 months. The last time Denver had above average precipitation was October 2005.

Due to the rain and snow throughout October, percent of average precipitation for the month of October (Figure 3b) is now at 120% - 200+% of average for much of **Utah** and **Colorado**. In **Wyoming**, the percent of average precipitation for parts of central and southern has improved to near average to above average. However, dry conditions continue for much of eastern **Wyoming** where percent of average precipitation is at < 40% - 80%.

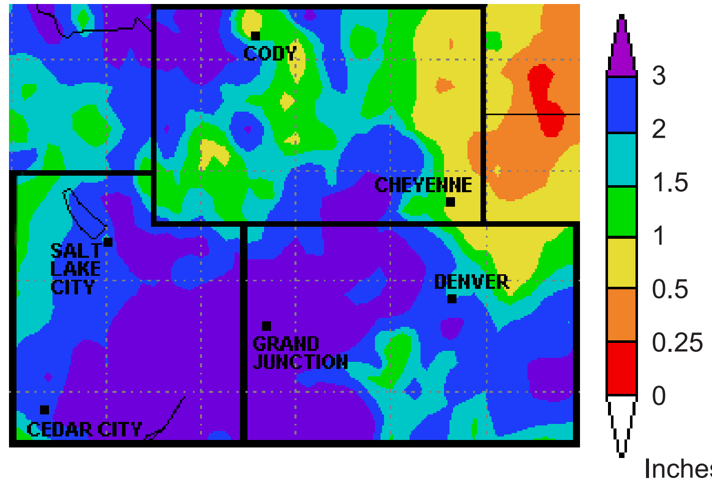


Figure 3a. Total precipitation in inches for the month of October 2006.

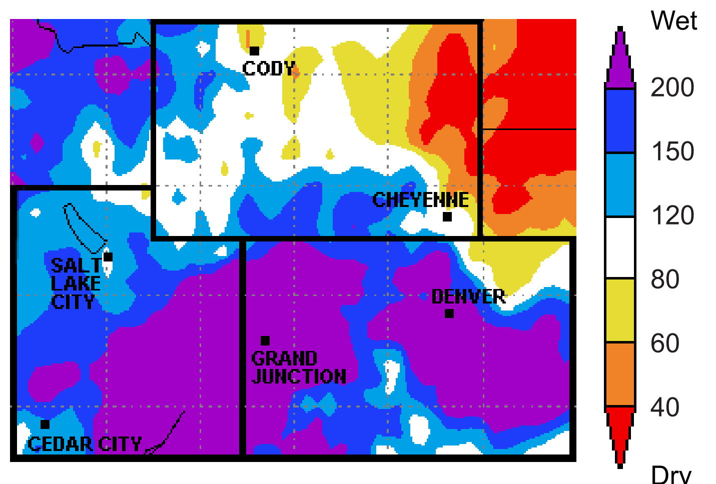


Figure 3b. Percent of average precipitation for the month of October 2006.

Notes

The water year runs from October 1 to September 30 of the following year. As of October 1, 2005, we are in the 2006 water year. The water year is more representative of climate and hydrological activity than the standard calendar year. It reflects the natural cycle of accumulation of snow in the winter and run-off and use of water in the spring and summer.

Average refers to the arithmetic mean of annual data from 1996-2005. This period of record is only ten years long because it includes SNOTEL data, which have a continuous record beginning in 1996. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

The data in Figs. 3a-c come from NOAA's Climate Prediction Center. The maps are created by NOAA's Earth System Research Laboratory and are updated daily (see website below). These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known data points to produce continuous categories.

On the Web

- For the most recent versions of these and maps of other climate variables including individual station data, visit: http://www.hprcc.unl.edu/products/current.html.
- For precipitation maps like these and those in the previous summaries, which are updated daily visit: http://www.cdc.noaa.gov/Drought/.
- For National Climatic Data Center monthly and weekly precipitation and drought reports for Colorado, Utah, Wyoming, and the whole U.S., visit: http://lwf.ncdc.noaa.gov/oa/climate/research/2002/perspectives.html.
- For a list of weather stations in Colorado, Utah, and Wyoming, visit: http://www.wrcc.dri.edu/summary.

U.S. Drought Monitor conditions as of 11/16/06

According to the National Drought Monitor on November 16, 2006, drought intensity status has decreased for much of **Colorado** and southeast **Utah** from the last IMW Climate Summary report on September 21, 2006. The drought category for western and southeast **Colorado** was lowered from D1-D2 to non-drought conditions, though the central and northeast sections are still in abnormally dry to moderate drought status. **Wyoming** status remains mostly unchanged with D3 (extreme) drought status over much of the northern and central counties and D0-D2 (abnormally dry to severe) over the west and southeast sections.

According to the U.S. Drought Monitor Impacts Reporter, all counties in **Wyoming** have been designated primary or contiguous natural disaster areas. This designation permits farmers and ranchers to apply for low-interest loans from the Farm Service Agency. The contiguous disaster counties include Crook, Fremont, Niobrara, Teton, Washakie and Weston. In other impacts reported for **Wyoming**, reduced quality and quantity of forage in Yellowstone National Park have impacting the health of bull elk and sheep farmers report that sustained drought conditions and corresponding lack of feed have driven them out of business. In northeast **Colorado**, problems continue from limited pumping from certain wells, ordered by the state water engineer. In some areas, the heat rendered herbicides ineffective, permitting weeds to grow and use what precious moisture the soil held. Farmers in Adams and Weld counties, who were thought to be using well water despite the order against it, may be fined for violation of the order.

Notes

The U.S. Drought Monitor (Figure 4) is released weekly (every Thursday) and represents data collected through the previous Tuesday. The inset (lower left) shows the western United States from the previous month's map.

The U.S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of the several agencies; the author of this monitor is Rich Tinker of the NOAA Climate Prediction Center.

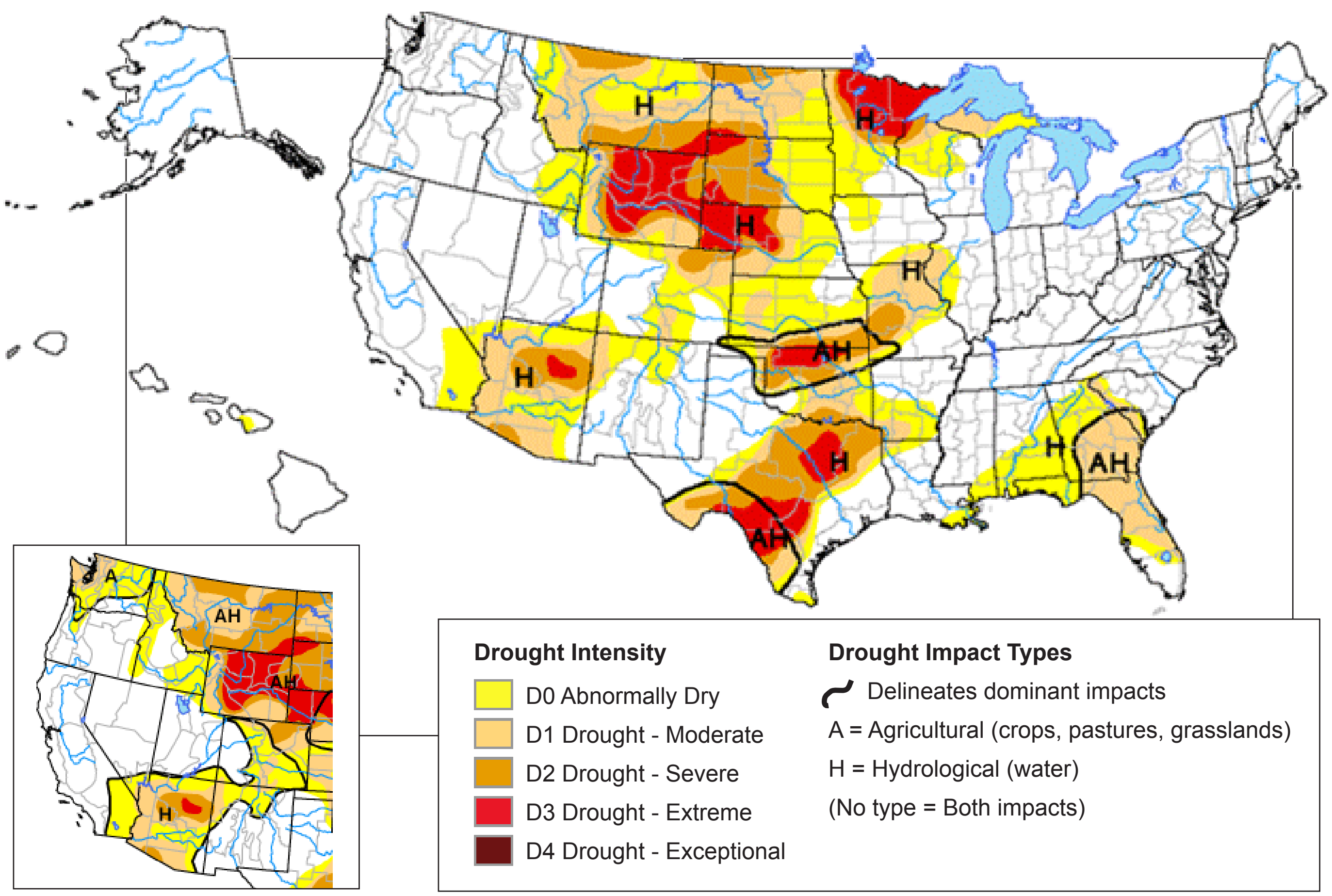


Figure 4. Drought Monitor released November 14, 2006 (full size) and last month October 17, 2006 (inset, lower left) for comparison.

On the Web

- For the most recent Drought Monitor, visit: http://www.drought.unl.edu/dm/monitor.html. This site also includes archives of past drought monitors
- Drought Impact Reporter (National Drought Mitigation Center): http://droughtreporter.unl.edu/

Reservoir Status

The first of October is the start of a new water year. With the majority of reservoir inflow occurring from snowmelt in April-July, reservoir levels generally peak by July, and then decrease due to water releases, delivery requirements, and other management objectives. The largest reservoirs, Lake Powell and Flaming Gorge Reservoir, are maintaining 52% and 84% capacity levels (Figure 5).

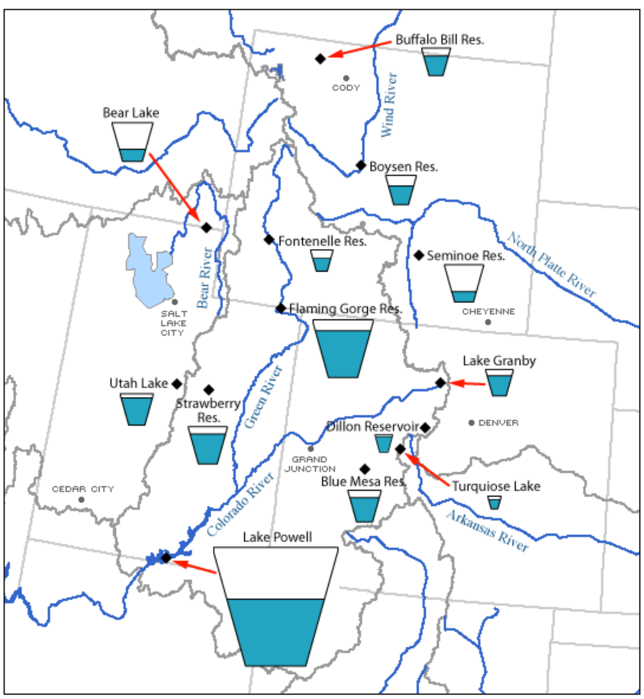
Colorado reservoirs in Figure 5 range from 98% to 107% of average storage for this time of year. Among major reservoirs in the state, Dillon and Blue Mesa filled in WY2006 and Turquoise Reservoir reached 92%. USBR reports that they made conservative releases from Blue Mesa, despite the optimistic January forecasts, to improve the chances of filling Blue Mesa. It filled in mid-June for the first time in 7 years; Blue Mesa has filled in 14 of the last 36 years. Lake Grandby topped out at 78% full at the end of the runoff period, and is now at 72%.

According to the NRCS, Utah Lake was the only large reservoir in **Utah** that filled this year. It topped out at about 888,000 acre-feet in early July, 102% of average for that time. Bear Lake only reached about 36% full. As of the end of October it remains at about 35% capacity, which is 54% of average for this time of year, however, that is significantly higher than the storage at the same time in WY2005. Strawberry Lake and Utah Lake are also above average for the end of October. USBR reports that unregulated inflow into Lake Powell for the 2006 water year was 73% of average in comparison to 105% of average inflows for WY2005, and forecasts Lake Powell inflows to remain between 80% to 90% of average for the remainder of the 2006 calendar year.

Buffalo Bill Reservoir in **Wyoming** filled in the beginning of July and Flaming Gorge reached 84% capacity, about 9 feet short of filling. April-July inflow into Fontenelle and Flaming Gorge Reservoirs was lower than inflows for the same period in WY2005. Peak inflow into Fontenelle Reservoir was above 7,000 cfs in comparison to last year's peak inflow figure of 8,500 cfs. According to a USBR Flaming Gorge operations report, the snowpack in 2006 was better than 2005, but the inflow was lower due to many factors including an early snowmelt. The early runoff forecast from the Green River basin was high, but as the season progressed and the forecast dropped to the low average range and by July dropped to moderately dry.

Notes

The size of each "tea-cup" in Figure 5 is proportional to the size of the reservoir, as is the amount the tea-cup is filled. The first percentage shown in the table is the current contents divided by the total capacity. The second percentage shown is the percent of average water in the reservoir for this time of year. Reservoir status is updated at different times for individual reservoirs, so see the websites below for the most recent information.



Reservoir	Current Water (KAF)	Total Capacity (KAF)	% Full	% of Average
Colorado				
Blue Mesa Res.	658.0	829.5	79%	104%
Dillon Res.	246.6	254.0	97%	107%
Lake Granby	389.2	539.7	72%	101%
Turquiose Lake	105.8	129.4	82%	98%
Utah				
Bear Lake	374.0	1,302.0	29%	54%
Lake Powell	12,529.0	24,322.0	52%	77%
Strawberry Res.	931.0	1,106.5	84%	146%
Utah Lake	788.0	870.9	90%	111%
Wyoming				
Boysen Res.	469.9	741.6	63%	85%
Buffalo Bill Res.	433.9	644.1	67%	139%
Flaming Gorge Res.	3,137.8	3,749.0	84%	99%
Fontenelle Res.	225.1	344.8	65%	91%
Seminoe Res.	275.5	1,017.3	27%	46%

KAF = Thousands of Acre Feet

Figure 5. Tea-cup diagram showing % full of several large reservoirs in the Intermountain West Region. Reservoir Storage calculated on November 2, 2006 .

On the Web

- Dillon Reservoir, operated by Denver Water: http://www.water.denver.co.gov/indexmain.html.
- Turquoise Lake, Boysen Reservoir, Seminoe Reservoir, and Buffalo Bill Reservoir operated by the U.S. Bureau of Reclamation (USBR) Great Plains Region: http://www.usbr.gov/gp/hydromet/teacup_form.cfm.
- Lake Granby is part of the Colorado-Big Thompson project, operated by Northern Colorado Water Conservancy District and the USBR Great Plains Region: http://www.ncwcd.org/datareports/data_reports/cbt_wir.pdf.
- Blue Mesa Reservoir, Lake Powell, Flaming Gorge Reservoir, and Fontenelle Reservoir operated by the USBR – Upper Colorado Region: http://www.usbr.gov/uc/wcao/water/basin/tc_cr.html.
- Strawberry Reservoir, operated by the Central Utah Water Conservancy District: http://www.cuwcd.com/operations/currentdata.htm.
- Utah Lake, operated by the Utah Division of Water Rights, and Bear Lake, operated by Utah Power: http://www.wcc.nrcs.usda.gov/cgibin/resv_rpt.pl?state=utah

Regional Standardized Precipitation Index data through 10/31/06

Source: Western Regional Climate Center, using data from NOAA National Climatic Data Center and NOAA Climate Prediction Center

The Standardized Precipitation Index (SPI) can be used to monitor conditions on a variety of time scales. 3- and 6-month SPIs are useful in short-term agricultural applications and longer-term SPIs (12-month and longer) are useful in hydrological applications. The 12-month SPI for the Intermountain West regions reflects precipitation patterns over the past 12 months (through the end of October 2006) compared to the average precipitation of the same 12 consecutive months during all the previous years of available data.

As of the end of October 2006, several climate divisions in **Wyoming** were downgraded by one to three categories drier from the classification at the end of August, 2006. The Yellowstone, Cody and Powder, Little Missouri, and Tongue climate divisions were downgraded by one category, while the Lower Platte division was downgraded by two categories drier. The Wind River division was downgraded by three categories drier from near average to extremely dry. In contrast, in **Colorado**, the Platte River division was upgraded by one category wetter, from very dry to moderately dry and in **Utah**, the Uinta, south central, southeast, and northern mountains climate divisions were upgraded by one category wetter from near average to moderately wet.

Notes

The Standardized Precipitation Index (SPI) is a simple statistic generated from accumulated precipitation totals for consecutive months compared to the historical data for that station. Near normal SPI means that the total precipitation for the past 12 months is near the long-term average for one year. An index value of –1 indicates moderate drought severity and means that only 15 out of 100 years would be expected to be drier. An index value of -2 means severe drought with only one year in 40 expected to be drier (courtesy of the Colorado Climate Center).

The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median precipitation, and negative values indicate less than me-

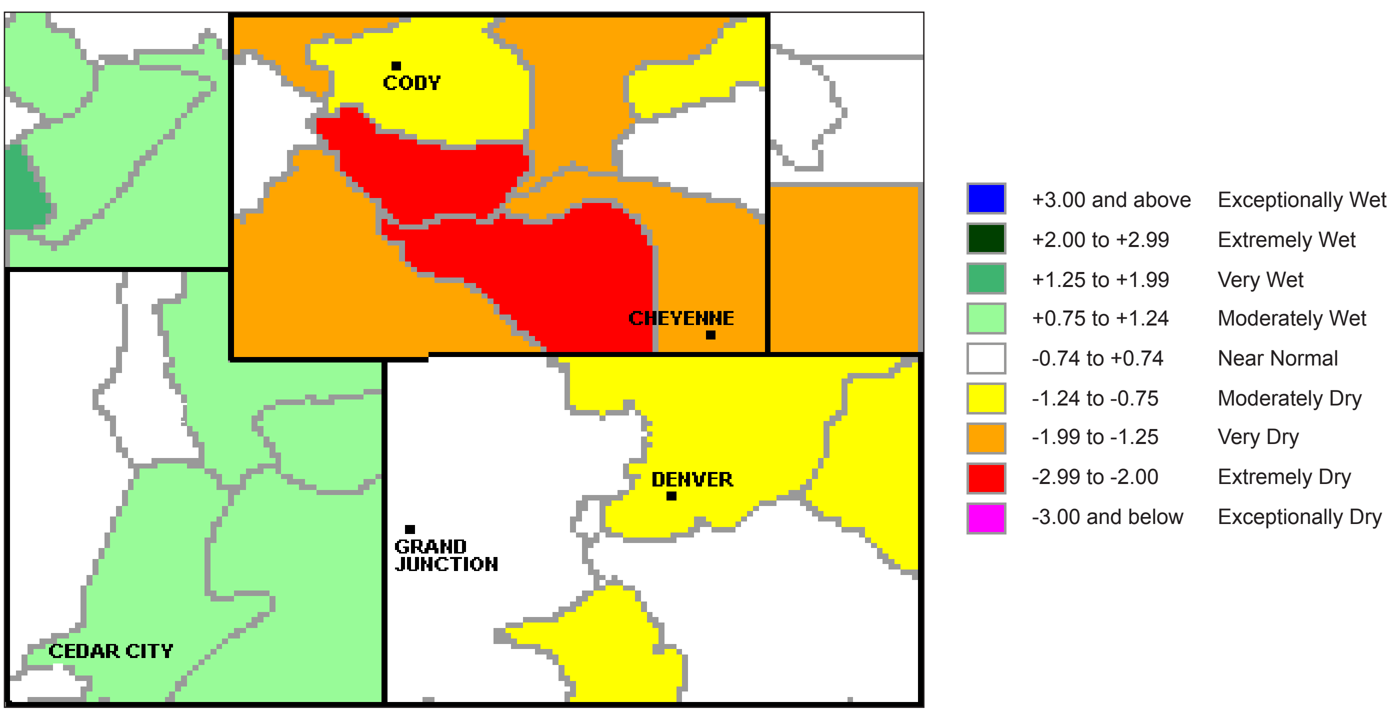


Figure 6. 12-month Intermountain West regional Standardized Precipitation Index. (data through 10/31/06)

On the Web

- For information on the SPI, how it is calculated, and other similar products for the entire country, visit http://www.wrcc.dri.edu/spi/spi.html.
- For information on past precipitation trends, visit: http://www.hprcc.unl.edu/products/current.html.

Colorado Water Availability

Source: Colorado Division of Water Resources, State Engineer; U.S. Geological Survey

Indicators of water supply in the state at this time of year include the Surface Water Supply Index (SWSI) and snowpack. SWSI values for October 2006 are based on snowpack, reservoir storage, and precipitation, and range from a high of 3.9 in the San Juan/Dolores Basin to a low of 1.4 in the Colorado Basin (Figure Xa). Precipitation in the western part of the state was above normal for the month, although in some areas most of that precipitation fell as rain, and is not reflected in snowpack.

Precipitation in the Colorado Basin for October was 150% of average and is reflected in the SWSI of 1.4 for October. Flows on the mainstem of the Colorado jumped from 4000 cfs to 15,000 cfs overnight at the Utah state line on October. A SWSI value of 3.4 for the Yampa and White River Basin is related to 166% of average snowpack at the end of October. Rio Grande Basin SWSI increased from 1.7 in September to 3.8 in October, also related to high precipitation. For example, precipitation in Alamosa was 1.59 inches, 0.92 inches above average.

The San Juan and Dolores River basins had the highest SWSI in the state (3.9). The Animas River peaked at 7070 cfs on October 7th and averaged 1600 cfs for the month, or 379% of average; the Dolores also averaged 401% for the month, or 538 cfs. However, most of the precipitation in the basins fell as rain and not snow, as snow water equivalent (SWE) in the Rio Grande and San Juan mountains is low, 40-80% of normal for this time of year, with the lowest SWE in Colorado in the San Juan Mountains.

SWE is highest in areas along the Northern Continental Divide, ranging from 100-160%. SWE throughout the state varies due to spatial variability in snowfall and temperature (Figure Xb). Therefore, use of individual SNOTEL site information is useful in pinpointing site-specific SWE conditions. Individual SNOTEL site information is collected by the NRCS, but is easily available from the Colorado River Basin Forecast Center (CRBFC) at http://www.cbrfc.noaa.gov/snow/snow.cgi.

Notes

The Surface Water Supply Index (SWSI), developed by the Colorado Office of the State Engineer and the USDA Natural Resources Conservation Service, is used as an indicator of mountain-based water supply conditions in the major river basins of the state. The Colorado SWSI is based on streamflow, reservoir storage, and precipitation for the summer period (May - October). This differs from winter calculations that use snowpack as well. During the summer period, streamflow is the primary component in all basins except the South Platte Basin, where reservoir storage is given the most weight. SWSI values in Figure 7a were computed for each of the seven major basins in Colorado on the first of each month, and reflect conditions through the end of the previous month.

Figure 7b shows the SWE as a percent of normal (average) for SNOTEL sites in Colorado.

Surface Water Supply Index for Colorado

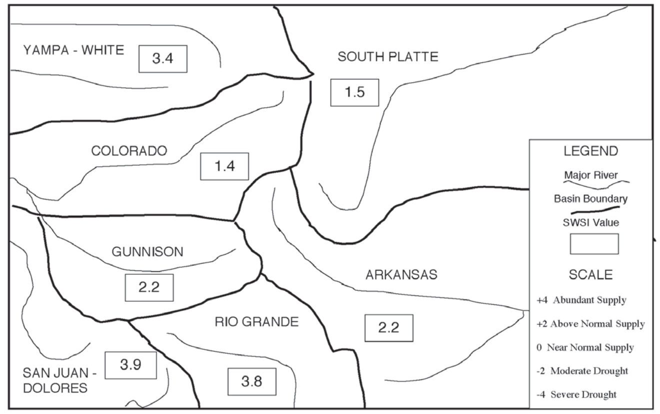


Figure 7a. Colorado Surface Water Supply Index. The map is an indicator of mountain-based water supply conditions in the major river basins of the state as of Nov. 1, 2006.

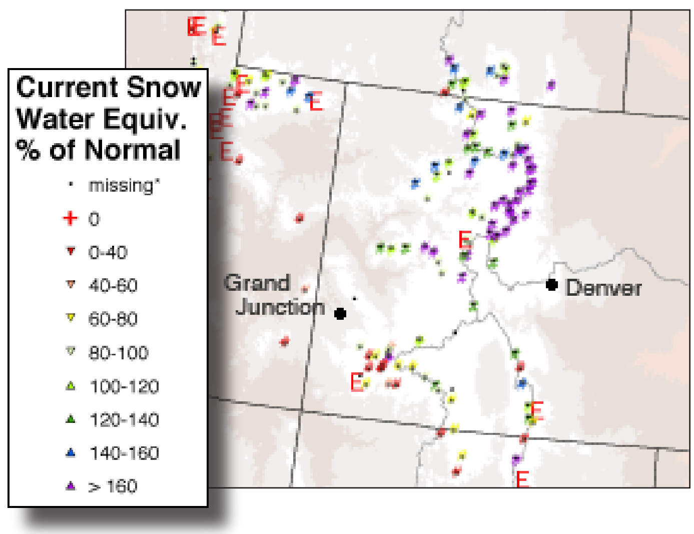


Figure 7b. Current snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Colorado as of November 6, 2006

On the Web

- For current streamflow information from USGS as in Figure 7b, visit: http://water.usgs.gov/waterwatch/.
- For the current SWSI map, go to: http://www.water.state.co.us/pubs/swsi.asp
- For monthly reports on water supply conditions & forecasts for major CO river basins, visit: http://www.co.nrcs.usda.gov/snow/snow/snow_all.html and click on "Basin Outlook Reports."
- The Colorado Water Availability Task Force's Aug meeting had not yet been scheduled at press time. Agendas & minutes of upcoming & previous meetings are available at: http://cwcb.state.co.us/Conservation/Drought/taskForceAgendaMinPres.htm.

Wyoming Water Availability October 2006

Source: Wyoming Water Resources Data System and USDA Natural Resources Conservation Service

The Wyoming drought status indicates the status of drought throughout the state through October, 2006 (Figure 8a). It is has not changed from the assessment of the last IMW Climate Summary in September 2006. Western Wyoming is in drought watch and most of the rest of the state is in a warning status. Fremont County remains in extreme drought conditions. See more on the drought impact reports in Wyoming in the Drought Monitor, page 6.

El Niño conditions have recently developed in the tropical Pacific and that these conditions should persist through early spring 2007. According to the Wyoming State Climatologist, Wyoming lies in a transition zone between the dominant responses to El Niño /La Niña variability. Research suggests that both the strength of the sea surface temperature anomalies in the tropical Pacific and the seasonal timing of the start/end of an El Niño or La Niña episode govern its effects on Wyoming. The stronger the event, the more likely Wyoming will see an impact of El Niño/La Niña. Moreover, regional topography may mediate the impacts of El Niño/La Niña within Wyoming.

During a weak to moderate El Niño, for example, the very highest elevations of the North Platte and Upper Green River basins will likely experience some increase in winter snowpack, while surrounding areas at low to middle elevations, may show the opposite response (i.e. drier than average) or no response at all. In effect this high elevation vs. low elevation contrast can negate any potential changes in spring runoff produced by an El Niño/La Niña event. Because of this contrast, an El Niño is not likely to cause dramatic state-wide changes in drought status. Instead, based on historic data from past El Niño events, this event brings slightly higher-than-average chances of a dry winter to the far northwest (especially in the Yellowstone drainage), and slightly higher-than-average chances for a wet winter to the southern mountains. Other areas such as the Bighorn Mountains and Black Hills have roughly a 50-50 chance for a wetter-than-average or drier-than-average winter.

Many of the streamflow sites on the USGS "7-day average streamflow map" (Figure 8b) increased from the below average category (10th – 24th percentile) in the September IMW Climate Summary to the average category (25th -75th percentile) as of November 9, 2006. However, several sites in north central and southeast Wyoming are still running in the below average category and a few sites, especially in the eastern half of the state, are still in the lowest category (<10th percentile).

Notes

The Drought Status (Figure 8a) is calculated by the Wyoming state climatologist, based on snow water equivalent and other data.

The "7-day average streamflow" map (Figure 8b) shows the average streamflow conditions for the past 7 days compared to the same period in past years. By averaging over the past 7 days, the values on the map are more indicative of longer-term streamflow conditions than either the "Real-time streamflow" or the "Daily streamflow" maps. If a station is categorized in "near normal" or 25th – 75th percentile class, it means that the streamflows are in the same range as 25-75% of past years. Note that this "normal" category represents a wide range of flows. Only stations having at least 30 years of record are used. Areas containing no dots indicate locations where flow data for the current day are temporarily unavailable. The data used to produce this map are provisional and have not been reviewed or edited. They may be subject to significant change.

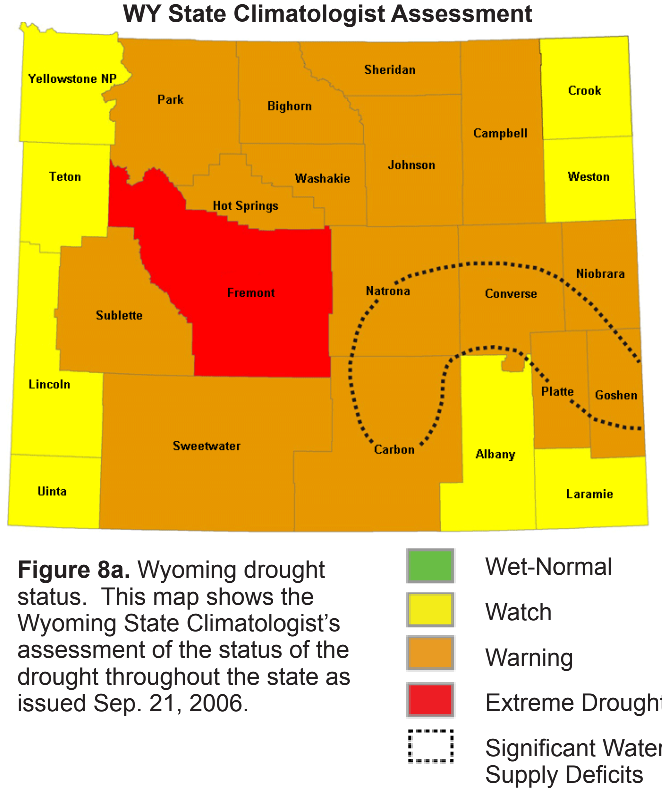


Figure 8a. Wyoming drought status. This map shows the Wyoming State Climatologist's assessment of the status of the drought throughout the state as issued Sep. 21, 2006.

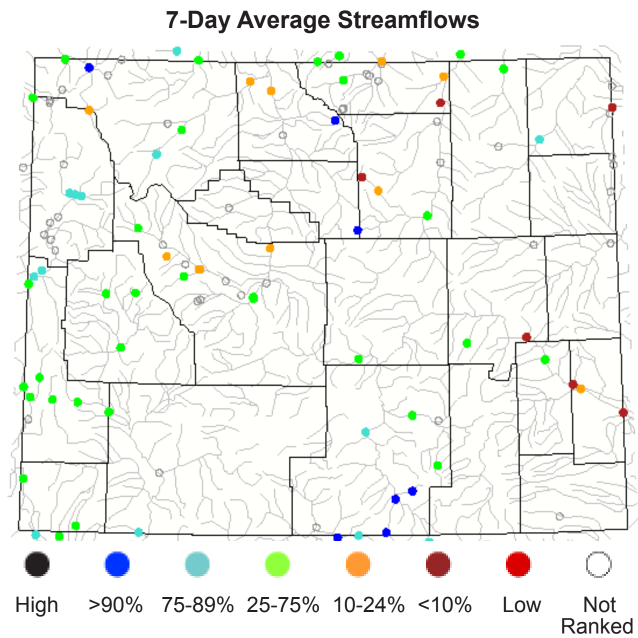


Figure 8b. Seven-day average streamflow conditions for points in Wyoming as of November 9, 2006, computed at USGS gauging stations. The colors represent 7-day average streamflow compared to percentiles of 7-day average streamflow for 11/9/06.

On the Web

- Information on current Wyoming snowpack, SWE, and SWSI, along with more data about current water supply status for the state, can be found at: http://www.wrds.uwyo.edu/wrds/nrcs/nrcs.html.
- The Palmer Drought Index is found on NOAA's drought page: www.drought.noaa.gov.
- For current streamflow information from USGS, visit: http://water.usgs.gov/waterwatch/
- For current maps of SWE as a percent of normal like in Figure 8a, go to: http://www.wcc.nrcs.usda.gov/gis/snow.html.

Utah Water Availability

Source: USDA Natural Resources Conservation Service and the Colorado Basin River Forecast Center

As of November 9th, 2006 a majority of streamflow sights on the USGS "7-day average streamflow map" (Figure 9a) had flow values in the average category (25th – 75th percentile), and several in central and eastern Utah running above average (75th to >90 percentile). However, several sites in northeast and central Utah recorded below-average flows within the (10th – 24th percentile).

Utah and the "Four Corners" region experienced extraordinary precipitation and high streamflows in October. Record-breaking daily flows were observed on the San Juan, Dolores, San Rafael, Fremont/Dirty Devil, Escalante, and Paria Rivers in the first half of October. The most exceptional of these high flows were the flood flows on the Fremont/Dirty Devil on October 6 and 7, 2006. The stage (level of the river) of the Dirty Devil above Poison Springs Wash near Hanksville, Utah (USGS surface water discharge station #09333500) increased by more than 15 feet during the event; the USGS is surveying highwater marks and collecting other data, and has calculated a provisional/preliminary peak streamflow of 42,000 cfs (Figure 9b). This event caused many problems across Utah, including many roads washed out and several rivers overflowed, and flash flooding occurred in Wayne and Kane counties. Precipitation events were particularly intense in the vicinity of Lake Powell. According to USBR, arroyos and drainages that are typically dry flowed, and literally hundreds of waterfalls were observed in the sandstone cliffs of Lake Powell during and after these storm events. Another storm system on the 14th again produced widespread heavy rainfall, many places receiving well over 1" of rain. Flash flooding occurred along the Paria River, where the gage rose 3 feet in 5 hours.

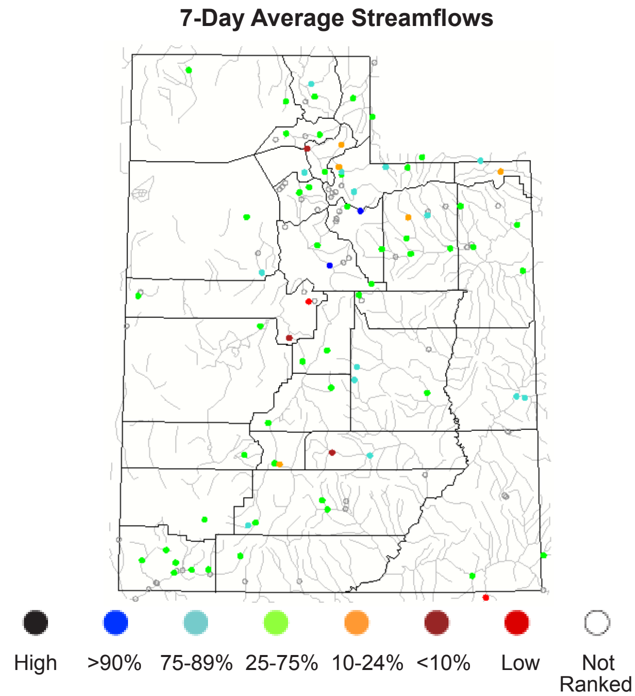


Figure 9a. Seven-day average streamflow conditions for points in Wyoming as of November 9, 2006, computed at USGS gauging stations. The colors represent 7-day average streamflow compared to percentiles of 7-day average streamflow for November 9th.

Figure 9b. The Dirty Devil River in south-central Utah. Highwater marks were found more than 25 feet above the low water stage and cross sections averaged about 300 feet across. Note the ATV barely visible in the center of the photo for scale. Photo courtesy Cory Angeroth, USGS.

Notes

The "7-day average streamflow" map (Figure 9a) shows the average streamflow conditions for the past 7 days compared to the same period in past years. By averaging over the past 7 days, the values on the map are more indicative of longer-term streamflow conditions than either the "Real-time streamflow" or the "Daily streamflow" maps. If a station is categorized in "near normal" or 25th – 75th percentile class, it means that the streamflows are in the same range as 25-75% of past years. Note that this "normal" category represents a wide range of flows. Only stations having at least 30 years of record are used. Areas containing no dots indicate locations where flow data for the current day are temporarily unavailable. The data used to produce this map are provisional and have not been reviewed or edited. They may be subject to significant change.

On the Web

- The Utah SWSI, along with more data about current water supply status for the state, can be found at: http://www.ut.nrcs.usda.gov/snow/watersupply/.
- The Palmer Drought Index is found on NOAA's drought page: www.drought.noaa.gov
- For current streamflow information from USGS, visit: http://water.usgs.gov/waterwatch/
- Utah NRCS Soil Moisture plots can be found at: http://www.ut.nrcs.usda.gov/snow/climate/

Temperature Outlook December 2006 - April 2007

According to the NOAA/CPC, the ongoing El Niño event is expected to strengthen and may reach moderate strength during the upcoming cold season with maximum impacts on U.S. climate expected in the December-April period. The NOAA/CPC monthly and seasonal forecasts issued November 16th are based on models and temperature composites from weak and moderate El Niño events.

The CPC temperature forecasts for December 2007 and later seasonal forecast periods have changed significantly since last month in that there is not as large an area in the Western U.S. with an increased risk of above average temperatures, which has been the forecast for many months based on temperature trends. In this month's forecast for upcoming months, "EC" is predicted over the Southwest and Great Basin, for Dec2006-Feb2007 through Feb-April 2007 due to potential effects from El Niño, which include anticipated cooling effects of enhanced rainfall in those regions. This influence affects **Colorado**, **Utah**, and in some months, **Wyoming**. "EC" refers to equal chances of above, below, or around average temperatures. The impacts of the El Niño event are expected to diminish in the spring, and the effects of the increasing temperature trend return to dominate the forecast for the Intermountain West by summer of 2007.

The temperature forecast for December 2006 will be updated on November 30th. This forecast is available on the same CPC webpages as the regular mid-month forecasts. Updated monthly forecast maps tend to feature more confident details than the regular mid-month forecast maps.

Notes

The seasonal temperature outlooks in Figures 10a-d predict the likelihood (chance) of *above-average, near-average,* and *below-average* temperature, but not the magnitude of such variation. The numbers on the maps refer to the percent chance that temperatures will be in one of these three categories, they do not refer to actual temperature values.

The NOAA-CPC outlooks are a 3-category forecast based largely on the status of El Niño and recent trends. As a starting point, the 1971-2000 climate record for each particular 1 or 3 month period is divided into 3 categories or terciles, each with a 33.3 % chance of occurring. The middle tercile is considered the *near-average* (or normal) temperature range. The forecast indicates the likelihood of the temperature being in one of the warmer or cooler terciles--*above-average* (A) or *below-average* (B)--with a corresponding adjustment to the opposite category; the near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high. For a detailed description of how this works, see notes on the following page.

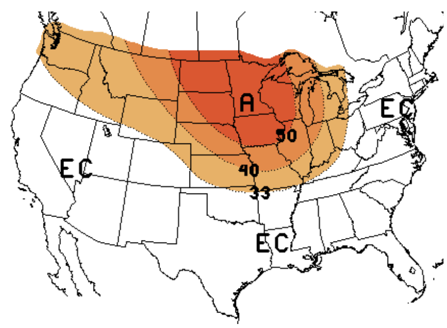


Figure 10a. Long-lead national temperature forecast for October 2006. (released Sep. 21, 2006)

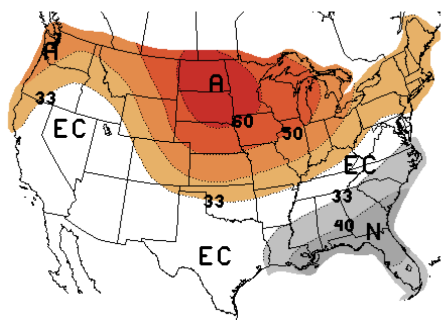


Figure 10b. Long-lead national temperature forecast for Oct. - Dec. 2006. (released Sep. 21, 2006)

A = Above
- 60.0–69.9%
- 50.0–59.9%
- 40.0–49.9%
- 33.3–39.9%

B = Below
- 40.0–49.9%
- 33.3–39.9%

EC = Equal Chances

N = Normal

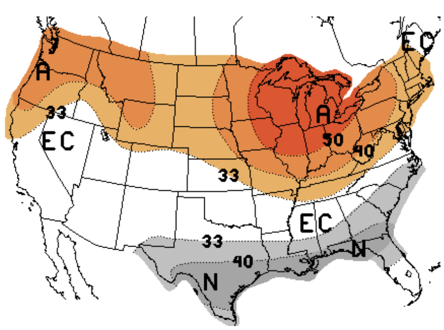


Figure 10c. Long-lead national temperature forecast for Nov. 2006 - Jan. 2007. (released Sep. 21, 2006)

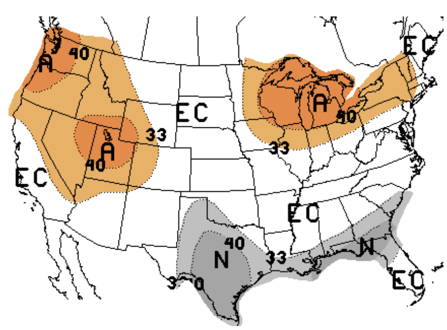


Figure 10d. Long-lead national temperature forecast for Dec. 2006 - Feb. 2007. (released Sep. 21, 2006)

On the Web

- For more information and the most recent forecast images, visit: http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html. Please note that this website has many graphics and may load slowly on your computer.
- The CPC "discussion for non-technical users" is at: http://www.cpc.noaa.gov/products/predictions/90day/fxus05.html
- For IRI forecasts, visit: http://iri.columbia.edu/climate/forecast/net_asmt/.
- More information about temperature distributions at specific stations in Colorado, Utah, Wyoming, and across the West can be found at the Western Regional Climate Center, http://www.wrcc.dri.edu/CLIMATEDATA.html.

Precipitation Outlook December 2006 - February 2007

According to the NOAA/CPC, the ongoing El Niño event is expected to strengthen and may reach moderate strength during the upcoming cold season with maximum impacts on U.S. climate expected in the December-April period. The NOAA/CPC monthly and seasonal forecasts issued November 16th, t, are based on models and precipitation composites from weak and moderate El Niño events. In December 2007, there is an increased chance of above average precipitation in southern **Colorado** and **Utah** as well as the southwestern and south-central U.S. for December 2006. This pattern of above average precipitation in the southwest and southern U.S. is a typical El Niño impact, and continues in the seasonal forecasts through the March-April-May (MAM) 2007 forecast period, although **Colorado** and **Utah** are not included in the area of above average precipitation in all forecast periods Precipitation in western **Wyoming** is more closely related to the Pacific northwest, which has an opposite signal during El Niño: this area has a slightly increased chance for lower than average precipitation in December 2006 and forecast periods through Feb-April 2007.

The precipitation forecast for Decemer 2006 will be updated on November 30th. This forecast is available on the same CPC webpages as the regular mid-month forecasts. Updated monthly forecast maps tend to feature more confident details than the regular mid-month forecast maps.

Notes

The seasonal precipitation outlook in Figures 11a-b predicts the likelihood (chance) of above-average, near-average, and below-average precipitation, but not the magnitude of such variation. The numbers on the maps refer to the percent chance that precipitation will be in one of these three categories, they do not refer to inches of precipitation.

The NOAA-CPC outlooks are a 3-category forecast based largely on the status of El Niño and recent trends. As a starting point, the 1971-2000 climate record for each particular 1 or 3 month period is divided into 3 categories or terciles, each with a 33.3% chance of occurring. The middle tercile is considered the near-average (or normal) precipitation range. The forecast indicates the likelihood of the precipitation being in one of the wetter or cooler terciles--above-average (A) or below-average (B)--with a corresponding adjustment to the opposite category; the near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high.

Thus, using the NOAA-CPC temperature outlook, areas with light brown shading display a 33.3-39.9% chance of above-average, a 33.3% chance of near-average, and a 26.7-33.3% chance of below-average temperature. A shade darker brown indicates a 40.0-50.0% chance of above-average, a 33.3% chance of near-average, and a 16.7-26.6% chance of below-average temperature, and so on.

Equal Chances (EC) indicates areas for which the models cannot predict the temperature with any confidence. EC is used as a “default option” representing equal chances or a 33.3% probability for each tercile indicating areas where the reliability (i.e., ‘skill’) of the forecast is poor.

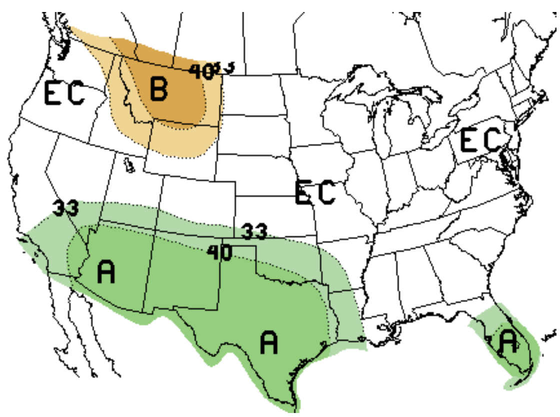


Figure 11a. Long-lead national precipitation forecast for December 2006. (released Nov. 16, 2006)

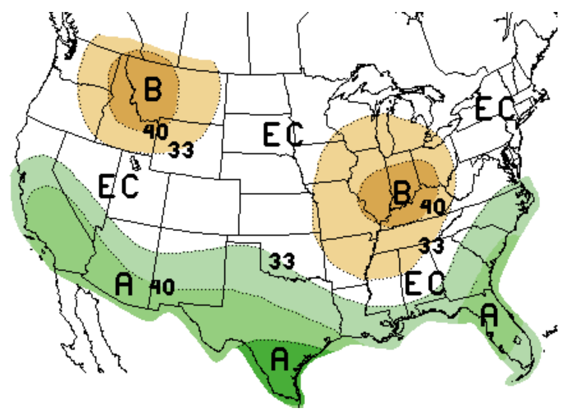


Figure 11b. Long-lead national precipitation forecast for Dec. 2006 - Feb. 2007. (released Nov. 16, 2006)

A = Above	B = Below	EC = Equal Chances
40.0–49.9%	40.0–49.9%	
33.3–39.9%	33.3–39.9%	

On the Web

- For more information and the most recent CPC forecast images, visit: http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html. Please note that this website has many graphics and may load slowly on your computer.
- The CPC “discussion for non-technical users” is at: http://www.cpc.noaa.gov/products/predictions/90day/fxus05.html
- For IRI forecasts, visit: http://iri.columbia.edu/climate/forecast/net_asmt/.
- More information about temperature distributions at specific stations in Colorado, Utah, Wyoming, and across the West can be found at the Western Regional Climate Center, http://www.wrcc.dri.edu/CLIMATEDATA.html.

Seasonal Drought Outlook through February 2007 Source: NOAA Climate Prediction Center

The latest U.S. Seasonal Drought Outlook through February 2007, released November 16th by NOAA/CPC, reports that the ongoing El Niño should contribute to improving drought conditions in the Southwest and parts of the Plains including Nebraska, although many locations, including western **Wyoming** will see persisting or worsening drought conditions. CPC sees indications that further improvement will take place over many remaining drought areas in the Great Plains, including parts of Nebraska, eastern **Wyoming**, and northern **Colorado**. (Note that the conditions described above are not reflected in the map below.) Due to El Niño, it is more likely that the upcoming snow season will be above average in the Southwest, including parts of southern **Utah** and **Colorado**. The Pacific Northwest is the only area of the country where drought development is likely.

The next Seasonal Drought Outlook will be issued in December.

Notes

The delineated areas in the Seasonal Drought Outlook (Figure 12) are defined subjectively and are based on expert assessment of numerous indicators, including outputs of short- and long-term forecasting models. "Ongoing" drought areas are schematically approximated from the Drought Monitor (D1 to D4). For weekly drought updates, see the latest Drought Monitor text on the website: http://www.drought.unl.edu/dm/monitor.html. NOTE: The green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

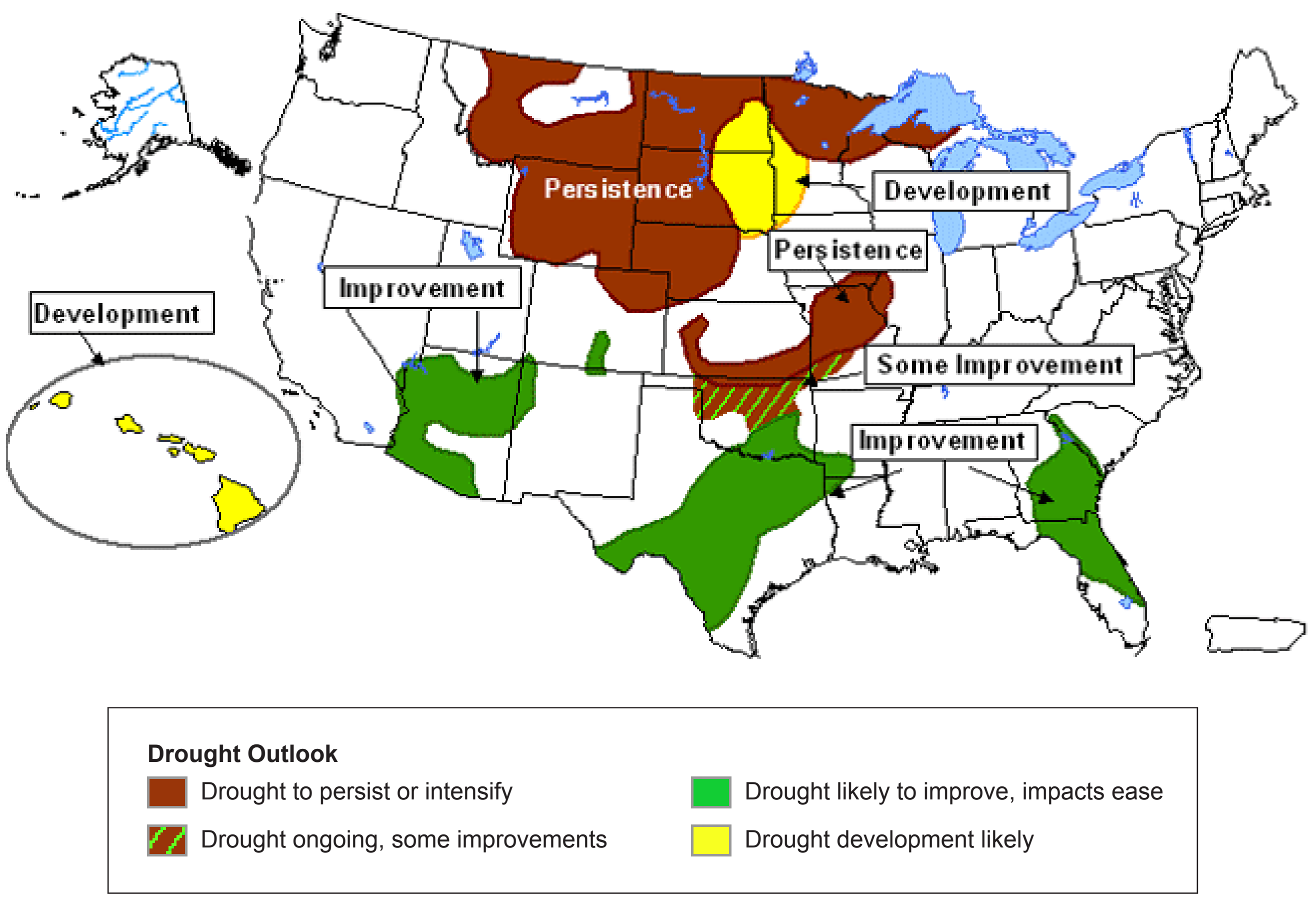


Figure 12. Seasonal Drought Outlook through February 2007 (release date November 16, 2006).

On the Web

- For more information, visit: http://www.drought.noaa.gov/.
- Drought termination probabilities: http://www.ncdc.noaa.gov/oa/climate/research/drought/current.html

El Niño Status and Forecast

Source: NOAA Climate Prediction Center, International Research Institute For Climate and Society

As of mid-November, sea surface temperature (SST) anomalies greater than 0.5ºC are present across the tropical Pacific, and both the NOAA Climate Prediction Center (CPC) and the NOAA-funded International Research Institute for Climate and Society (IRI) consider that an El Niño is underway and likely to persist through early 2007. According to CPC, the strength of this El Niño event must still be regarded as being on the border between weak and moderate

The potential impacts of this event on U.S. climate have not yet fully developed, because the coupling of the unusually warm SSTs near the date line (180ºE/W in the mid-Pacific) with the atmosphere in the tropical Pacific has not yet become fully established. This coupling is expected to occur during the next month or so. However, a variety of SST forecasts predict anomalies in the "Nino 3.4" region of 0.9ºC to 1.5ºC. The NOAA consolidated forecast is for anomalies in the 0.5-0.7ºC range -- which has already been exceeded - indicating that the SST forecast is likely too conservative. Therefore this episode is expected to strengthen and may reach moderate strength during the upcoming cold season, with maximum impact on the climate expected during Dec-Feb through Feb-April 2007 forecast seasons. However, there is still some uncertainty in the expected intensity of the event and its impacts due to event-to-event variability among the relatively small number of observed moderate El Niño cases,

El Niño events typically develop in late spring or early summer, so this year's event started late. Most El Niño events last between six and twelve months, but have been known to persist through two winters (such as 1986-87 and 87-88). With respect to El Niño impacts over North America, CPC notes that these effects include warmer-than-average temperatures over the western and northern U.S. as well as western and central Canada. Wetter-than-average conditions are likely over portions of the U.S. Southwest as well as the Gulf Coast and Florida, while drier-than-average conditions can be expected in the Ohio Valley, the Pacific Northwest. The next IRI ENSO Update should be available the week of 20 November, and the next CPC ENSO Diagnostic Discussion will be issued 14 December.

Notes

Two graphics in Figure 13a produced by NOAA show the observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. This data is from the TOGA/TAO Array of 70 moored buoys spread out over the Pacific Ocean, centered on the equator. These buoys measure temperature, currents and winds in the Pacific equatorial band and transmit data in real-time. NOAA uses these observations to predict short-term (a few months to one year) climate variations.

Figure 13b shows multiple forecasts for SST in the Niño 3.4 region for nine overlapping 3-month periods from September 2005 to July 2006. "Niño 3.4" refers to the region of the equatorial Pacific from 120ºW to 170ºW and 5ºN to 5ºS, which is one basis for defining ENSO sea surface temperature anomalies. Initials at the bottom of the graph represent groups of three months (e.g. SON = Sept-Nov). The expected skills of the models, based on historical performance, are not equal to one another. The skills also generally decrease as the lead-time increases. Forecasts made at some times of the year generally have higher skill than forecasts made at other times of the year. They are better when made between June and December than between February and May. Differences among the forecasts of the models reflect both differences in model design and actual uncertainty in the forecast of the possible future SST scenario.

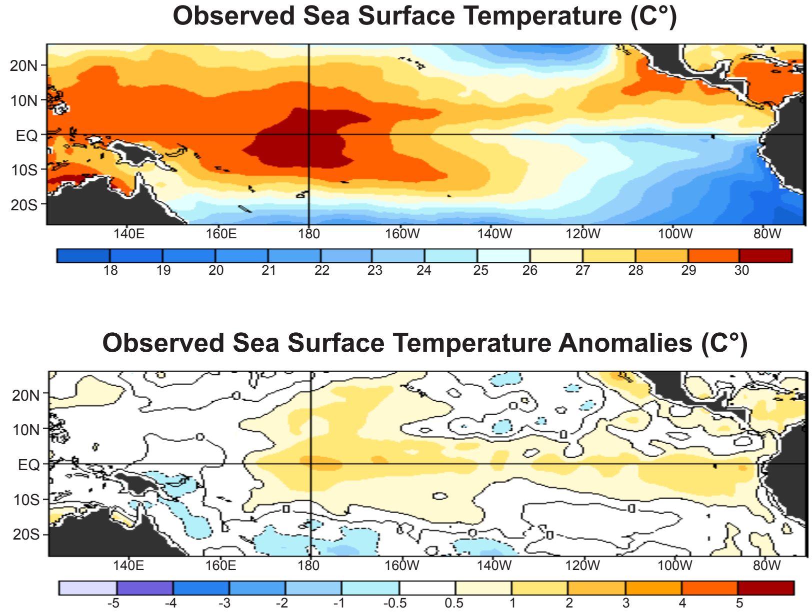


Figure 13a. Two graphics showing the observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. The Niño 3.4 region encompasses the area between 120ºW-170ºW and 5ºN-5ºS. The graphics represent the 7-day average centered on September 20, 2006.

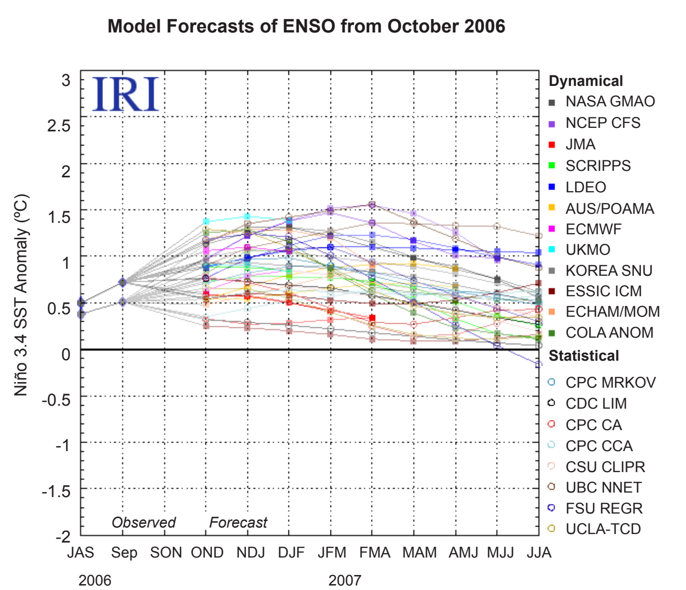


Figure 13b. Forecasts made by dynamical and statistical models for sea surface temperatures (SST) in the Niño 3.4 region for nine overlapping 3-month periods from September 2006 through July 2007 (released Sep. 20, 2006). Forecasts are courtesy of the International Research Institute (IRI) for Climate and Society.

On the Web

- For a technical discussion of current El Nino conditions, visit: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/.
- For updated graphics of SST and SST anomalies, visit this site and click on "Weekly SST Anomalies": http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml#current.
- For more information about El Nino, including the most recent forecasts, visit: http://iri.columbia.edu/climate/ENSO/.

Climate Workshops in Wyoming and Colorado

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The WWA recently co-sponsored two meetings on climate issues in the Intermountain West. The first was “Water, Drought and Wyoming’s Climate,” on October 5th in Laramie, WY, and then a week later, WWA cosponsored a conference on “Climate Change and Variability in the San Juan Mountains” in Durango, CO. Below are summaries of the two workshops.

Water, Drought and Wyoming’s Climate

On October 5, 2006, the University of Wyoming (UW) hosted an all day workshop in Laramie, dedicated to understanding how climate variability and change impacts Wyoming’s water resources. A followup to a WWA sponsored workshop in December 2005, this event included 75 participants representing a range of expertise and interests including the Wyoming Governor’s and State Engineer’s Offices, NOAA, the Family Farm Alliance, and the Laramie County Conservation District. The purpose of this workshop was to facilitate discussion between water managers, water users, and researchers to discuss current understanding of climate change as it relates to Wyoming’s water, and to discuss areas of further research and future water management needs. Split into a morning and afternoon session, the workshop was set-up to maximize participation by attendees through morning and afternoon break-out discussion groups.

The workshop began with opening remarks by Dr. Harold Bergman, Director of the UW Haub School and Ruckelshaus Institute, and Dr. Mike Besson, Director of the Wyoming Water Development Commission. Then, Dr. Steven Gray, Wyoming State Climatologist and Director of the Water Resources Data System addressed why Wyoming’s water resources are vulnerable to climate change, emphasizing that even the most conservative warming scenarios could constitute major impacts on Wyoming water. Dr. Gray identified two questions for the workshop participants to consider: first, how do current management practices and policies make us more or less vulnerable to climate change? And second, how will changing land use, land cover, and climate interact to impact regional hydrology? Gray commented that we need a better understanding of current and potential future uses of water to better understand the future role of water as it relates to agriculture uses.

Figure 14a. Diana Hulme, Assistant Director of the Ruckelshaus Institute leads a break-out discussion at the WY Water and Climate Workshop.

A four-member panel discussion included Kirk Miller from the USGS Chief Hydrologic Studies, Clint Bassett of the City of Cheyenne Board of Public Utilities, Pat O’Toole, Rancher and President of the Family Farm Alliance, and Harry LaBonde of the State Engineer’s Office. Such needs identified by the panel presentations included additional long-term statewide monitoring of streamflows and groundwater levels, assessment of consumptive and unconsumptive water uses for Wyoming, additional water retention for agriculture and food production purposes, and the need for real-time data for use by the State Engineer’s Office. Following presentations, participants were divided into six facilitated break-out groups that focused discussion on climate/water-related issues and concerns that were addressed in the morning’s presentations. Mimicking many of the concerns of the morning speakers, the break-out groups additionally stated the need to link surface and groundwater law and policy, cited the need for a drought and water conservation public awareness campaign, and emphasized the need for increased monitoring of snowpack, water availability, and soil moisture parameters.

The afternoon session included a presentation on available climate products and resources and how they can be utilized was presented by Dr. Andrea Ray, a Research Scientist with WWA and NOAA. She described climate and water resource products including the Intermountain West Climate Summary, NOAA National Integrated Drought Information System, and the U.S. Drought Monitor. The break-out discussion groups reconvened in order to refine goals presented in the morning session into a list of immediate and long-term objectives and recommendations. Short-term and long-term priorities highlighted by the participants include assessment of current monitoring tools in terms of what is working and what isn’t, baseline assessment of water consumption, linking of interagency information, i.e. Governor’s Drought Task Force, NWS/NOAA, and Water Conservation Districts, public educational campaigns concerning climate and drought, and involvement by the public in data collection.

This workshop provided a forum for many fields of expertise to come together and identify common goals and gaps in current research with the intent of recognizing and mitigating the effects of climate change on Wyoming’s water resources. Organizers and participants see a potential to address these concerns with follow-up meetings that focus on some of the topics identified. The Ruckelshaus Institute, in conjunction with federal, state, and local agencies is interested in playing a role in providing an information clearinghouse for climate, water, and drought related topics. For more information on the workshop, contact Dr. J.J. Shinker, UW Dept. of Geography, jshinker@uwyo.edu, or see the conference webpage at: http://www.uwyo.edu/enr/Wyoming-Water.asp. A report of the workshop is available online, as well as the workshop agenda and presentations.

Figure 14b. Participants in the San Juan workshop, (left-right) Rob Davis of Forest Energy Corporation, Congressman John Salazar, and Ellen Stein of MSI, one of the conference organizers.

Climate Change and Variability in the San Juan Mountains

On October 11th and 12th at Fort Lewis College in Durango, about 70 scientists from academia, government research institutions, and natural resource management agencies met to share research and initiate planning of the SJM Climate Initiative. The purpose of the conference was to facilitate information-sharing and interaction between scientists and local stakeholders regarding the implications and potential impacts of climate variability and change in the San Juan Mountain region. A second goal was to begin development of a San Juan Mountain (SJM) Climate Initiative, a stakeholder and scientist driven climate research and outreach program.

Topics on Oct 11th included measurements of global and local climate change, and associated impacts to hydrology, biodiversity, forests, and agriculture. After the presentations, scientists were asked to discuss what we don't know but really should about climate change in the San Juans. This discussion produced a list of "information gaps" and potential research topics that will help shape the SJM Climate Initiative. The evening keynote address by Dr. Jonathan Overpeck of the University of Arizona drew nearly 250 people including conference-goers, concerned community members, and FLC students. Overpeck discussed "Global Climate Change, the West, and What We Can Do about It." He reported that average temperatures in the West are anticipated to increase 4 or 5 degrees Fahrenheit by mid-century. These rising temperatures will have major implications for timing and length of snowmelt, stream flow levels throughout the summer season, evaporation from reservoirs, and water loss from vegetation and soils, among other concerns. Overpeck not only discussed climate change implications but also energy conservation strategies and alternative energy production, such as clean-coal technology.

The second day brought together scientists with natural resource managers, elected officials, community planners, energy industry representatives, conservationists, farmers and ranchers, recreation and tourism professionals, community leaders, concerned citizens, students, and others. Attendees heard presentations from stakeholders and scientists on the climate of the past present and future, and how climate affects water supply, snow, air quality, forest health, wildfire, recreation, tourism, agriculture, ranching, energy, biodiversity and more. After lunch, participants split into focus groups (i.e., water and community planning, agriculture and ranching, forestry, recreation and tourism, ecosystems and biodiversity, and energy) to identify how climate affects their interests and what information or tools would be most useful in mitigating and preparing for the future impacts climate change may bring. The dialogue provided a unique opportunity to collectively identify information and research needs in the region. MSI staff are currently synthesizing the reports from these focus groups along with the scientist "information gaps" to produce a draft SJM Climate Initiative Action Plan.

The final day of the conference took place at MSI facilities in Silverton. About 20 people attended a morning field tour to Swamp Angel Study Area in Senator Beck Basin. This instrumented watershed is managed by the Center for Snow and Avalanche Studies, a partner organization of MSI also based in Silverton. After lunch and a tour of MSI headquarters, there was a Renewable Energy Discussion and Public Reception, also attended by Congressman John Salazar and Joe Colgan, candidate for State Representative, and representatives from the Forest Service, BLM, and local wood products industry.

The three days of collaborative and progressive discussion included not only the implications of climate change, but also alternatives and potential projects to help adapt to and curb the documented trends. Coincidentally, less than a week later, the Durango City Council voted to sign the U.S. Mayors Climate Protection Agreement, agreeing to "strive to meet or exceed Kyoto Protocol targets for reducing global warming pollution." Over 320 U.S. cities have signed the agreement to date; including Aspen, Basalt, Boulder, Denver, Durango, Gunnison, Frisco, and Telluride. A proceedings and synthesis of identified research and information gaps are being incorporated into the SJM Climate Initiative Action Plan. Initial project ideas resulting from the conference include:

1) Producing paleoclimactic (tree-ring) reconstructions of river flows in the San Juans for use in water management. These products are available for other locations in Colorado and have helped water managers understand flow variability for a time period extending beyond the instrumented record. This project would include training of water managers to use the data products.

2) Applying the Watershed Analysis Risk Management Framework (WARMF) developed for the San Juan Basin. WARMF can be used to model water quantity and quality and to develop and test management options. Potential applications could include water management strategies for climate change, growth, and diversions.

3) Producing accessible outreach materials for SJM climate stakeholders, including a website and a booklet.

For more information on the workshop, Ellen R. Stein, Executive Director, Mountain Studies Institute, estein@mountainstudies.org, or see the conference webpage at: www.mountainstudies.org. A report of the workshop is will be available soon online.