Intermountain West Climate Summary

by The Western Water Assessment

Issued June 21, 2006

June 2006 Climate Summary

Hydrologic Conditions: Drought status has worsened in eastern Colorado and is likely to persist in eastern and southern Colorado and parts of Wyoming. Water supply forecasts for the season are lower than May 1st due to warm, dry conditions in most areas, although storage in many reservoirs is higher than average for this time of year due to early runoff.

Temperature: Temperatures were above average for much of the region for May, and contributed to early melting of snowpack.

Precipitation/Snowpack: Precipitation has been below average since May1 for most of the region. June is climatologically dry for much of the region, before summer rains associated with the monsoon begin. To see how to track progress of the monsoon, see the precipitation outlook page.

ENSO: ENSO-neutral conditions are favored to prevail throughout 2006 with an 80% chance of continuing through June-August; ENSO is not a significant factor in U.S. climate for the summer.

Climate Forecasts: CPC outlooks project above average temperatures for all or most of the Intermountain West region through September forecast periods, and equal chances of above, around normal, or below normal precipitation for all but a small area of the region.

Releases benefit endangered fish in the region

Reservoirs on two river systems made releases this spring to improve habitat downstream for endangered native fishes of the Colorado River, as part of the Upper Colorado River Basin Endangered Fish Recovery Program. The Colorado pikeminnow, humpback chub, razorback sucker and bonytail are all native to the Colorado River and once had abundant populations. According to a USBR news release on May 19, 2006 (http://www.usbr.gov/newsroom/newsrelease), five Upper Colorado River Basin reservoirs made releases in late May to augment the natural peak of the Colorado River near Cameo, Colorado. The participating reservoirs all "bypassed" surplus inflow on downstream, meaning that they did not store inflows during this period. Coordination is required to ensure that flows reach the river near Cameo in the same period to achieve the maximum effect. The Coordinated Reservoir Operations Team tracks snow pack and predicted runoff for the Colorado River basin to determine, each year, whether or not these releases can occur. Conditions have allowed for the program to operate only three times in the past ten years.

On the Green River near the border of Wyoming and Colorado, spring peak releases were made from Flaming Gorge Reservoir beginning on May 16th. Flows of the Yampa River were forecasted to peak above 12,000 cfs on May 22nd. The USBR began ramping up releases to full powerplant capacity in order to augment the natural peak, and to attempt to achieve 18,600 cfs in the Green River measured at Jensen, Utah for one day. As a result of releases at full capacity as well as bypass releases, Green River flows achieved 18,600 cfs for approximately 4 hours and peaked at 18,700 cfs. Green River flows peaked again the next day above 18,600 as a result of heavy precipitation in the Yampa River Basin late on May 22nd.

In This Issue

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New Streamflow Reconstructions for the Upper Colorado River Basin: Placing Recent Droughts into a Centuries-Long Context

By Connie A. Woodhouse[1], Eileen McKim[2], and Andrea Ray[3]

This article is a summary of a paper published in May 2006 in Water Resources Research, "Updated streamflow reconstructions for the Upper Colorado River Basin." The paper's authors are Connie Woodhouse of the NOAA/NCDC, who is a participant in the Western Water Assessment, Stephen Gray, formerly of USGS, now the Wyoming State Climatologist, and David Meko, of the University of Arizona and who is a participant in the Climate Assessment of the Southwest.

Over the past several decades, scientists have developed reconstructions of annual streamflow for centuries prior to the streamflow gage record using data from tree rings. These reconstructions are useful for assessing a broader range of hydrologic variability than contained in the gage records (Figure 1a). The Colorado River at Lees Ferry was the first tree-ring based quantitative reconstruction of streamflow (Stockton and Jacoby, 1976). Lees Ferry is the gage that reflects flows for the Upper Colorado River basin under the 1922 Colorado Compact. The Stockton and Jacoby reconstruction of the annual flows from 1520 to 1961 contained several important findings, including that the highest sustained flows in the entire record occurred in the first part of the 20th century, the period upon which the Colorado River Compact of 1922 was negotiated, while the most persistent and severe drought occurred in the late 16th century.

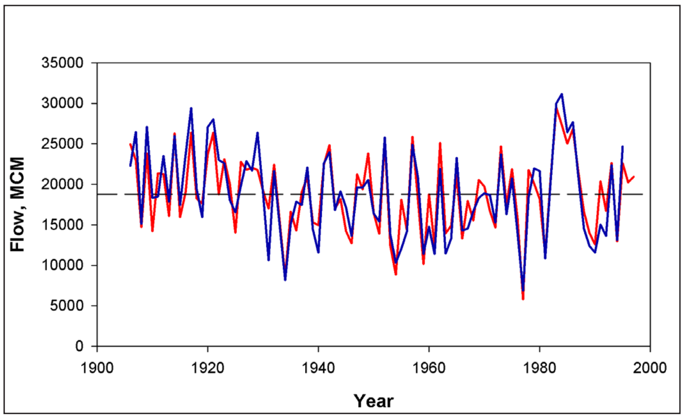


Figure 1a. Comparison of observed and reconstructed streamflow, Lees Ferry gauge (blue line) and Lees-A reconstruction (red line), 1906-1997 (gauge to 1995). Figures 1-3 are reproduced from WGM (2006), see the article for details.

In a paper published in May 2006, Woodhouse and co-authors (2006) updated the Stockton and Jacoby reconstruction at Lees Ferry using an expanded tree-ring network and a longer gage record for the calibration of the reconstruction. They also developed streamflow reconstructions for three key gages in the Upper Colorado River basin: the Green River at Green River, Utah; Colorado near Cisco, Utah; and San Juan near Bluff, Utah (Figure 1b). The reconstructions explain 72-81% of the variance in the gage records, and results are relatively stable across several reconstruction methodologies. The new reconstruction of Lees Ferry flows suggests a slightly higher long-term mean than Stockton and Jacoby's, but confirms the earlier findings that Colorado River allocations were based on one of the wettest periods in the past five centuries, while droughts more severe than any 20th-21st century event have occurred in the past. In addition, five-year droughts similar to the drought of 2000-2004 (in terms of average flow) appear to have occurred as many an eight times in the past five centuries. Analyses indicate similar patterns of runoff variations across the Green, Colorado main stem and San Juan sub-basins, indicating that drought tends to occur across the entire upper basin.

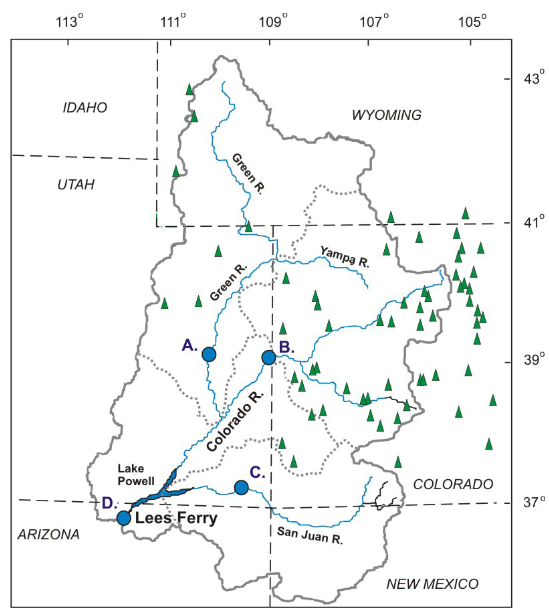


Figure 1b. Location of gages at Green River at Green River, Utah (A), Colorado River near Cisco, Utah (B), San Juan River near Bluff, Utah (C), and Lees Ferry, Arizona (D) (dots) and tree-ring chronologies (triangles). The upper Colorado River basin is outlined in a solid line, and the Green, Colorado with Yampa and Gunnison, and San Juan sub-basins are outlined by the dotted lines.

[1]NOAA/National Climatic Data Center (NCDC), [2]CIRES, [3]NOAA/ESRL, all in Boulder, CO

Updated Streamflow Reconstructions

Using an updated and expanded set of tree-ring chronologies which end in 1997 or later, the authors created high-quality streamflow reconstructions for four key gages in the Upper Colorado River basin (hereafter the "WGM" reconstructions) . The reconstructions were generated by calibrating the tree-ring chronologies with the most recent naturalized flows from the USBR, including data that were available as of summer 2004. The WGM reconstructions span the common years 1569 to 1997, with the Lees Ferry reconstructions extending to 1490 (available at: www.ncdc.noaa.gov/paleo/pubs/woodhouse2006/woodhouse2006.html.

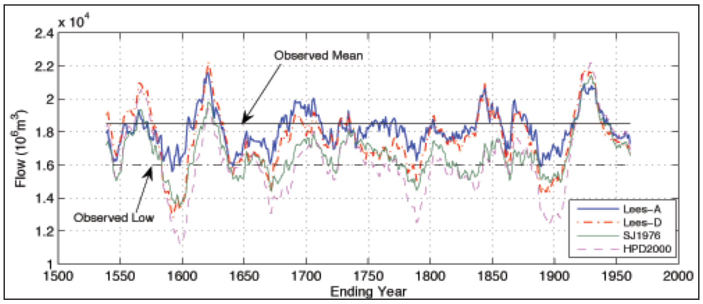


Figure 1c. Twenty-year running means of four alternative reconstructions of the annual flow of the Colorado River at Lees Ferry for common period 1520-1961. Lees-A and D are from WGM (2006), SJ1976 is the mean of two reconstructions from Stockton and Jacoby (1976), and HPD2000 is from Hidalgo et al. (2000). The horizontal lines are the 1906-2004 observed mean (solid) and the lowest observed 20-year running mean of the 1906-2004 period (dash-dot).

Because reconstructions can be sensitive to different modeling methods, two different models were tested for the Green, Colorado near Cisco, and the San Juan gages, and four different models were tested for Lees Ferry flows. The models vary in the pool of chronologies used and the statistical approaches used for handling the data. However, the authors found that different modeling methods had little significant impact on important features of the reconstructions, for example, the long-term annual mean, or the runs of drought years.

However, one factor that does have some impact on the magnitude of reconstructed high and low flows is how the persistence in year-to-year growth is treated in the tree-ring data. In the Lees Ferry reconstructions, the authors tested the effects of either retaining the year-to-year persistence in the tree growth in the chronologies, or removing this persistence The persistence-retained chronology models retain a degree of year-to-year persistence similar to that in the gage record, but overestimate the severity of multi-decadal droughts (20-year means) in the calibration period.

Comparison with Previous Lees Ferry Reconstructions

Hidalgo et al. (2000) generated reconstructions at Lees Ferry as well as Stockton and Jacoby (1976). Both of these reconstructions were calibrated on the years 1914-1961, using similar sets of tree-ring data but slightly different modeling approaches. Interannual variations in streamflow are similar across all of the reconstructions, and a comparison of these Lees Ferry reconstructions and that of WGM shows a relatively close match in variations of streamflow at decadal and longer time scales (Figure 1c). The WGM reconstructions differ from those of Stockton and Jacoby (1976) and Hidalgo et al. (2000) in suggesting a somewhat higher long-term mean for Upper Colorado River flows (Table 1, after Table 9 in WGM, 2006). The most conservative and most extreme Lees Ferry reconstructions generated by this study (called Lees A and Lees D) had long term (1520-1961) means that ranged from 14.3 to 14.7 maf, compared to Stockton and Jacoby's preferred Lees Ferry reconstruction, and the Hidalgo et al. reconstruction with means of 13.5 maf and 13.2 maf, respectively. The set of chronologies and gage records used for the reconstruction calibration may contribute to these differences, but the reconstruction methods used are likely also a factor. The causes of the differences are currently under investigation.

Table 1

Model	Calibration period	Long-term mean & 95% confidence interval
WGM- Lees Ferry-A	1906-1995	14.7 ± 0.2 MAF
WGM- Lees Ferry-B	1906-1995	14.3 ± 0.2 MAF
Stockton & Jacoby (1976)	1914-1961	13.5 *
Hidalgo et al. (2000)	1914-1961	13.2 ± 0.02 MAF

**no confidence interval calculated, not meaningful for the average of two reconstructions*

Highlights of the Reconstructed Streamflows

The recent 2000-2004 drought, as measured by 5-year running means of water-year total flow at Lees Ferry, is clearly a severe event when assessed in the context of the 500-year tree-ring reconstruction. It is highly unlikely (i.e., the probability is less than 10%) that any 5-year flows since 1850 has been as low (Figure 1d). But in considering the uncertainty in the reconstruction and evaluating the reconstruction probabilistically, flows for the period 1844-1848 were lower that 2000-2004, and there are eight periods between 1536 and 1850 that had at least a 10% probability of being as dry as 2000-2004. In addition, droughts longer than any in the gage record have occurred in the past. The Lees Ferry reconstruction includes up to eleven consecutive years with flows below the 1906-1995 average.

Severe multi-year, decadal, and multidecadal periods of

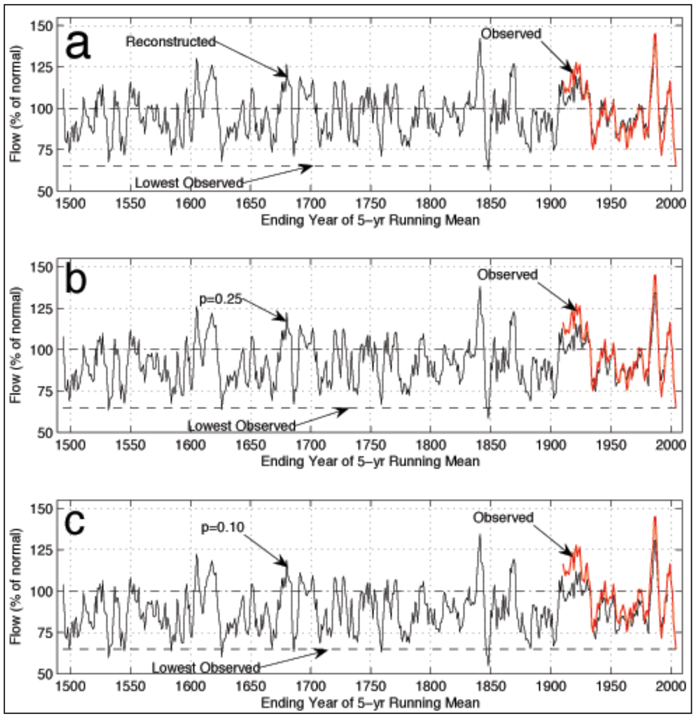


Figure 1d. Current drought in long-term context from Lees- A reconstruction five-year running means of natural flow at Lees Ferry, AZ. Observed flow and reconstructed flow with 0.10 non-exceedance probability. Flow plotted as percentage of 1906-95 mean of observed mean annual flow,15.232 MAF.

droughts in the Upper Colorado River basin have a tendency to be widespread, affecting the Green, San Juan, and Colorado mainstem basins. The most severe multi-year and multidecadal droughts at Lees Ferry are always reflected in the sub-basins, although there are some differences in the magnitude of droughts among the sub-basins. Most periods of low flow in one sub-basin coincide with low flows in the other sub-basins. Very occasionally, periods of low flow (10-year averages) in the Green River have coincided with higher flows in the San Juan basin that resulted in low flows at Lees Ferry flows (e.g. the 1930s). This suggests that drought in the Green River can have a dominant influence on Lees Ferry flows, even when high flows prevail on the San Juan.

The widespread nature of many single and multi-year droughts across the reconstructions suggests a common source of regional low-frequency hydroclimatic variability. Statistical associations have been demonstrated between North American drought and North Atlantic, North Pacific, and Indian Ocean variability (see WGM, 2006 for references), but more research is needed to understand how sea surface temperature variability is related to Upper Colorado River flows. The relationships between atmospheric and oceanic circulation and hydroclimatic variability in the Upper Colorado River basin likely involve complex processes.

Implications for Management

Reconstructions of streamflow for the Upper Colorado River basin confirm that severe, sustained droughts have been a major feature of the Upper Colorado River basin over the past five centuries. These reconstructions also indicate that streamflow varies over decadal and longer timescales, suggesting that short-term records are inadequate for long-term planning. These results suggest eventual conflicts between water demand and supply in the upper Colorado River basin as demands on the Colorado River now exceed average water availability. Predicted climatic changes, in particular, a shift in the ratio of snowfall to rainfall and earlier snowmelt and runoff (Cayan et al. 2001, Stewart et al. 2004), will likely increase the stress on Colorado River water resources. Reconstructions of past streamflow can aid in planning by providing insights into the range of long-term natural variability and extreme hydrologic events that are not observed in gage records. In concert with information on projected climate changes, reconstructions of long-term variability should guide planning for drought management and economic development in the basin in the future.

References Cited:

Cayan, D. R., S. A. Kammerdiener, M. D. Dettinger, J. M. Caprio, and D. H Peterson (2001), Changes in the onset of spring in the western United States, Bull. Am. Meteorol. Soc., 82, 399-415.

Hidalgo, H. G., T. C. Piechota, and J. A. Dracup (2000), Alternative principal components regression procedures for dendrohydrologic reconstructions, Water Resour. Res., 36, 3241-3249.

Stewart, I. T., D. R. Cayan, and M. D. Dettinger (2004), Changes in snowmelt runoff timing in western North America under a "business as usual" climate change scenario, Clim. Change, 62, 217-232.

Stockton, C. W., and G. C. Jacoby (1976), Long-term surface-water supply and streamflow trends in the Upper Colorado River Basin, Lake Powell Res. Proj. Bull. 18, Natl. Sci. Found., Arlington, Va.

Woodhouse, C. A., S. T. Gray, and D. M. Meko (2006), Updated streamflow reconstructions for the Upper Colorado River Basin, Water Resour. Res., 42, WO5415, doi:10,1029/2005WR004455.

On the Web

- For Lees Ferry reconstructions extending to 1490 visit: www.ncdc.noaa.gov/paleo/pubs/woodhouse2006/woodhouse2006.html.
- Tree-ring reconstructions of streamflow for Colorado: http://lwf.ncdc.noaa.gov/paleo/streamflow/

Temperature through 5/31/06 Source: High Plains Regional Climate Center

Temperatures for May 2006 for the entire Intermountain West region were above average by 0° to 8° F. Average temperatures were lowest in the mountains of western Wyoming and north central **Colorado** and highest in southeastern **Utah** and western and central **Colorado** (Figure 2 a-b). Temperatures in **Utah** had the highest departure from average, with some areas of northwest and southern **Utah** recording temperature of 6° to 8° F above average. Of the tri-state area, eastern **Wyoming** had temperatures closest to average (+/- 2F), but in the northwest temperatures were 2° to 4° F above average.

In comparison to May 2005 (Figure 2c) ,temperatures for 2006 were, on average, higher for the entire Intermountain West region, with the greatest difference from last year in northeast **Wyoming** and southern **Utah**.

According to the NWS, Salt Lake City, Utah recorded seventeen days in May, 2006 with above average temperatures, with records for high temperatures being tied or broken on four days. There were also five days in May when records were set for high minimum temperatures (nighttime). However, the last five days of May recorded below average lows, with a record low maximum temperature on May 28th of 54°, breaking an old record from 1935. The NWS, Denver, reports that the average temperature for Denver and northern Colorado was also on the warm side, with a monthly average for May 2006 of 3.2 degrees above normal.

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.

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.

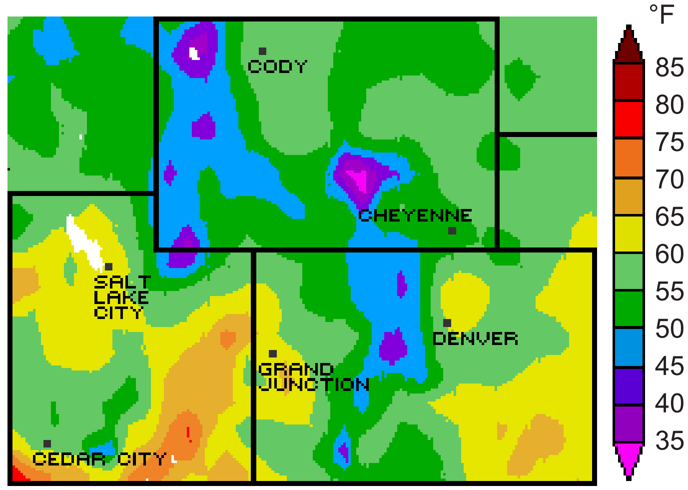


Figure 2a. Average temperature for the month of May 2006 in °F.

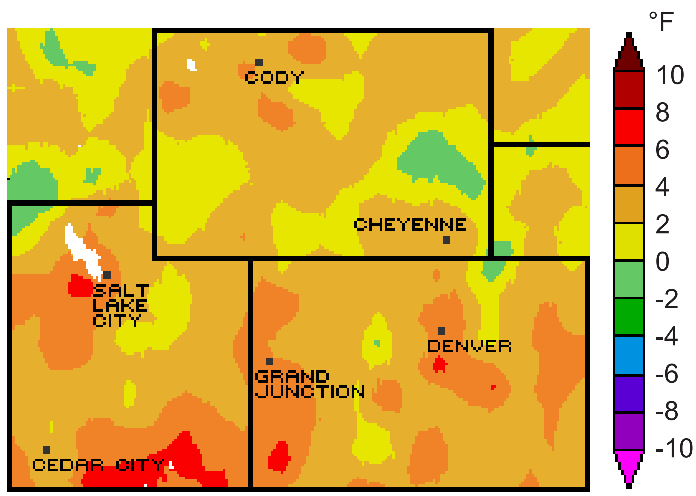


Figure 2b. Departure from average temperature for the month of May 2006 in °F.

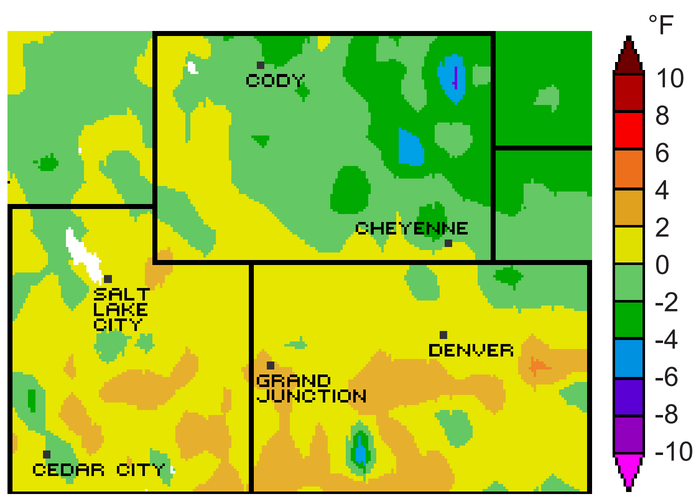


Figure 2c. Departure from average temperature in °F for last year, May 2005.

Precipitation through 5/31/06

Source: NOAA/ESRL/PSD Climate Diagnostics Branch, NOAA Climate Prediction Center

In May, precipitation totals in the Intermountain West region ranged in amounts from 0 to +3 inches (Figure 3a). Northeast and northwest **Wyoming**, and the north central mountains of **Colorado** received the largest amounts, and eastern **Colorado** received higher amounts of precipitation than in previous months, receiving 1 to 2 inches. All of the southern half of **Utah** is extremely dry, receiving from 0 to .50 inches total for the month of May.

Percent of average for the month of May (Figure 3b) is mostly below average. Some portions of northern central **Wyoming**, northern **Colorado** mountains and southeast **Colorado** is near average. The percent of average precipitation since the start of the water year (Figure 3c) reflects the high snowfall levels in northwest **Utah** and **Colorado** mountains and low snowfall levels in central **Wyoming** and southeast **Colorado**.

According to NWS, Grand Junction, warmer and drier than normal conditions across western **Colorado** and much of **Utah** have resulted in an earlier and prolonged snowmelt runoff season. Above average flows on rivers and streams were prevalent across northwest **Colorado** and northeast **Utah**, with some flooding experienced in Routt County on the Yampa and Elk Rivers. Below average peaks occurred in southwest **Colorado** and southeast **Utah** where the snowpack was much below normal this Winter. The early, rapid runoff has renewed drought concerns, especially for southwest **Colorado**. Moderate drought conditions have returned to that area, with little change expected throughout the summer (see page 16).

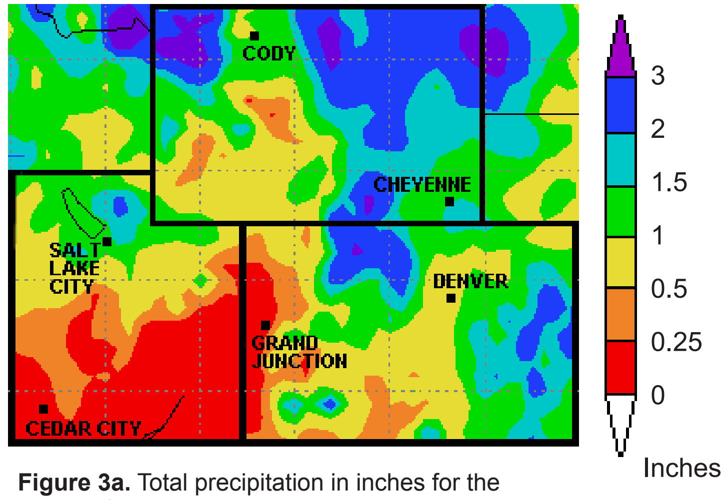


Figure 3a. Total precipitation in inches for the month of May 2006.

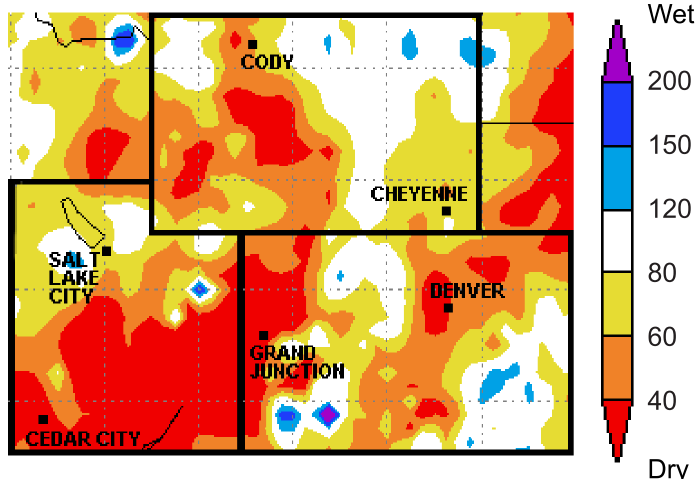


Figure 3b. Percent of average precipitation for the month of May 2006.

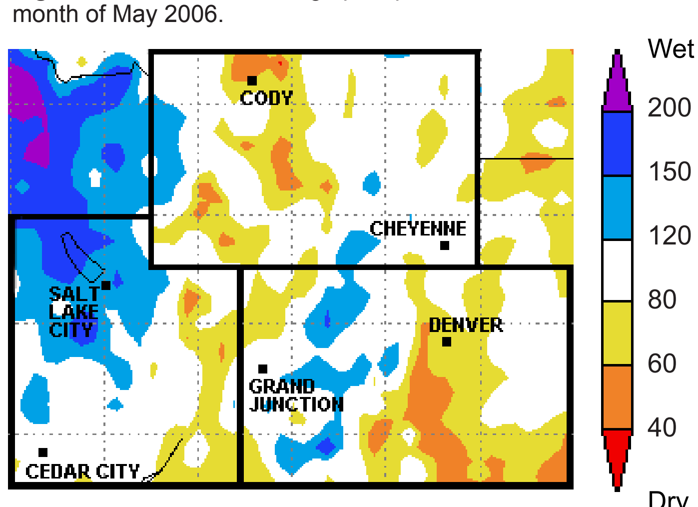


Figure 3c. Percent of average precipitation accumulated since the start of water year 2006. (Oct. 1 - May 30, 2006).

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 Climate Diagnostics Center, 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 6/13/06

Source: U.S. Department of Agriculture, National Drought Mitigation Center, National Oceanic and Atmospheric Administration

According to the National Drought Monitor Summary on June 13, 2006, areas of the Intermountain West designated as in drought status remain relatively unchanged for **Utah**, but now include all of **Colorado** and all but western **Wyoming**. The intensity of drought has increased in eastern **Colorado**, with southeastern **Colorado** moving from D2 Drought (severe) status to D3 (extreme). Drought categories were all shifted more to the west this week as water supply issues and agricultural concerns have become worse. Drought intensity has also increased for central and southern **Wyoming**, and for the central high plains, including western Nebraska and Kansas. April through June is normally the wettest time of the year for the central High Plains, and non-irrigated crops and pastures depend upon this precipitation.

North central **Colorado** had the most drought impact reports in the Intermountain West region, especially in Weld County. According to the National Drought Monitor Summary, irrigation wells were being shut off in parts of **Colorado** to ensure flows into the South Platte River basin. The lack of irrigation could result in millions of acres of croplands drying out and left to die if rains don't occur. In the southwest portions of **Colorado** near Durango, D2 conditions were expanded north from New Mexico due to melting of remaining snowpack tracking 2 to 4 weeks earlier than normal and several fire restrictions in place. Peak flows have already occurred in many of the rivers and streams in this region because of the earlier-than-normal influx of water into these watersheds.

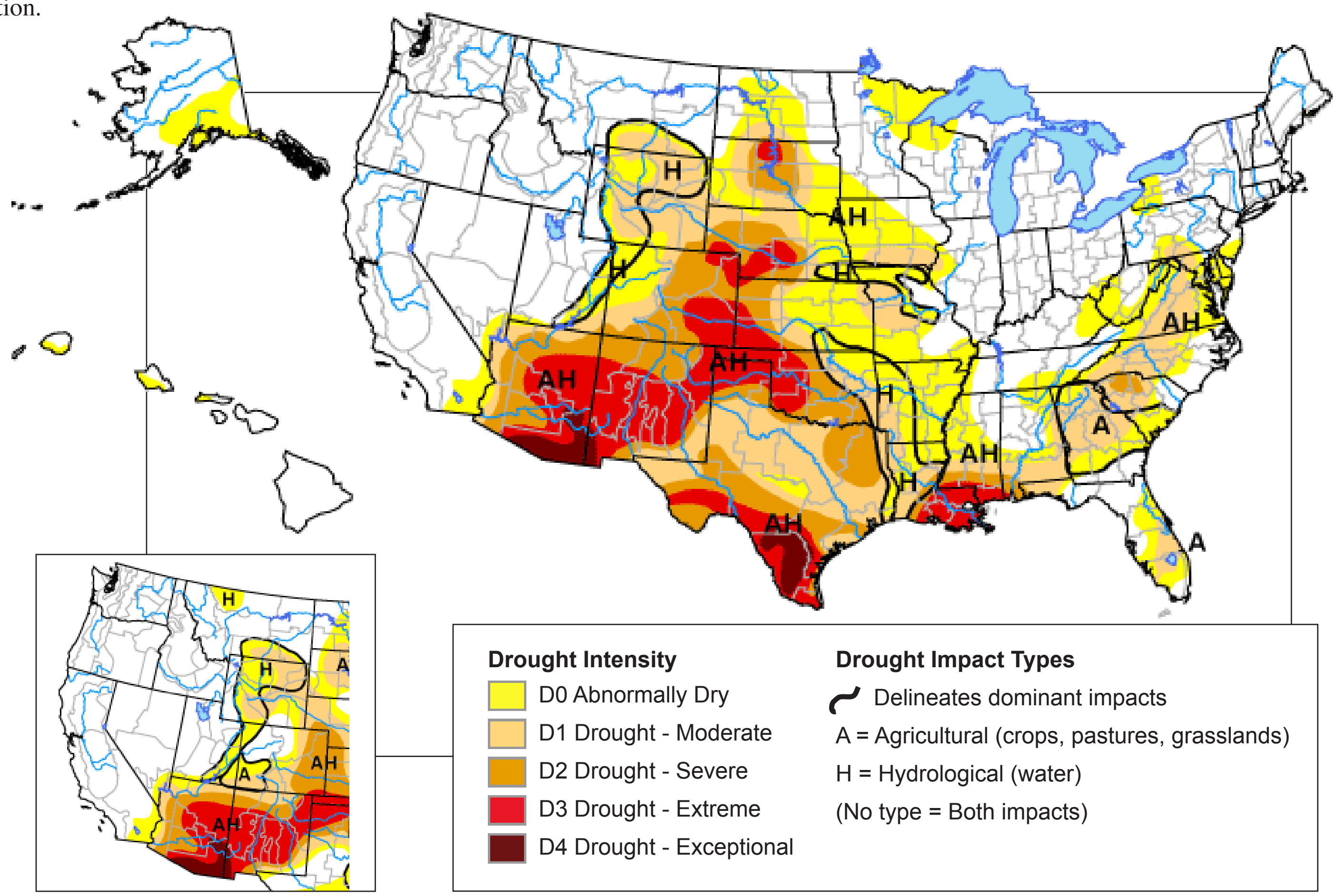


Figure 4. Drought Monitor released June 15, 2006 (full size) and last month May 16, 2006 (inset, lower left) for comparison.

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.

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

Source: Denver Water, U. S. Bureau of Reclamation, Northern Colorado Water Conservancy District, Natural Resources Conservation Service, and Central Utah Water Conservancy District

This month we have made a change in the way that the average storage is calculated: Storage as a percent of average is now compared to the 1971-2000 average storage for Lake Powell, Blue Mesa, Fontenelle, and Flaming Gorge, as calculated by the NRCS (http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html), instead of computing averages based on the longer period of record of the reservoir.

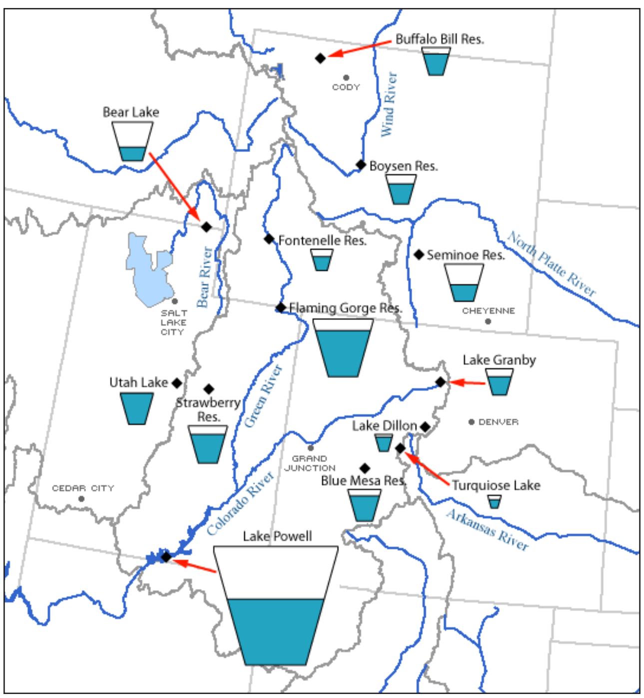
In June, reservoirs are usually filling, and the storage compared to average represents a balance of inflows for the season forecasted by the NOAA River Forecast Centers and the NRCS, the goal of filling the reservoir, and the need to preserve space for flood control in case of rapid inflows from warming or spring storms. For example, According to the USBR in Grand Junction, in April 2006, Blue Mesa reservoir, part of the Aspinall Unit on the Gunnison River in Colorado, was predicted to fill, although inflow forecasts had dropped over the spring. But in early June, the Gunnison River was producing slightly higher than average runoff. On June 12th, with 160,000 AF of inflows still forecast and the reservoir within two feet of filling, USBR managers increased releases from the Aspinall Unit in order to preserve capacity in the reservoirs for flood control if needed.

According to the USBR in Salt Lake City, inflow projections to Lake Powell have been reduced in response to warm and dry spring conditions in the Colorado River Basin, and it is now almost a certainty that inflow to Lake Powell will be below average in 2006.

The inflow forecast, issued June 5th by the NWS/Colorado Basin River Forecast Center, projects April through July unregulated inflow to Lake Powell to be 5.9 million acre-feet, 74% of average. Inflow forecasts earlier in the year were significantly higher (the April inflow forecast projected Lake Powell is 97% of average). Lake Powell storage was 51% percent of capacity in early June, an effect of multiple years of low inflow.

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.	755.1	829.5	91%	146%
Lake Dillon	250.8	254.0	99%	110%
Lake Granby	393.0	539.7	73%	115%
Turquiose Lake	100.1	129.4	77%	124%
Utah				
Bear Lake	467.5	1,302.0	36%	57%
Lake Powell	12,297.4	24,322.0	51%	63%
Strawberry Res.	921.0	1,106.5	83%	131%
Utah Lake	950.8	870.9	109%	105%
Wyoming				
Boysen Res.	548.7	741.6	74%	108%
Buffalo Bill Res.	559.0	644.1	87%	167%
Flaming Gorge Res.	3,009.7	3,749.0	80%	99%
Fontenelle Res.	260.7	344.8	76%	143%
Seminoe Res.	460.8	1,017.3	45%	76%

KAF = Thousands of Acre Feet

Figure 5. Tea-cup diagram of several large reservoirs in the Intermountain West Region. All reservoir content data is from between April 30 and May 4, 2006.

On the Web

- Lake Dillon, 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 5/31/06

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

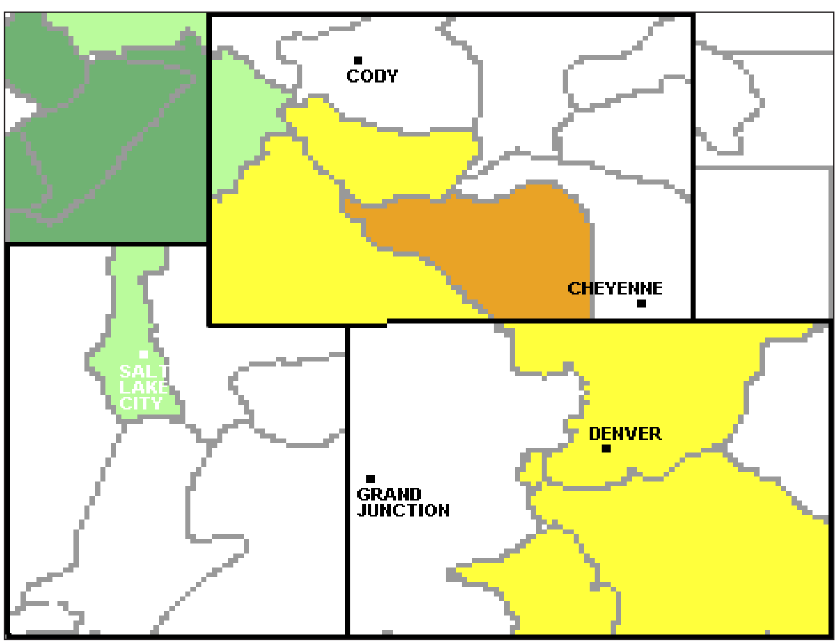
The Standardized Precipitation Index (SPI) can be used to monitor conditions on a variety of time scales. 3- and 6-month SPIs are useful in short-term agricultural applications and longer-term SPIs (12 months and longer) are useful in hydrological applications. The 12-month SPI for the Intermountain West region reflects precipitation patterns over the past 12 months (through the end of May 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 May 2006, the SPI around the Intermountain West region ranges from moderately wet in small portions of northwest **Utah** and northwest **Wyoming** to very dry in south central **Wyoming** (Figure 6). As opposed to April 2006, when several climate divisions in western **Utah** and northern **Wyoming** were in wet categories, several divisions have moved into average to drier conditions. The following divisions moved into one-drier category in May: the Arkansas climate division in **Colorado**; the Green and Bear, Snake, Wind River, Cheyenne & Niobrara, Upper Platte, Big Horn and Yellowstone divisions in **Wyoming**; the Powder, Little Missouri and Tongue division in **Wyoming** moved into a two-drier category from very wet to average, and the south central, western, north central divisions in **Utah** moved into a one-drier category.

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 median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way. The SPI is valuable in monitoring both wet and dry periods.



	+3.00 and above	Exceptionally Wet
	+2.00 to +2.99	Extremely Wet
	+1.25 to +1.99	Very Wet
	+0.75 to +1.24	Moderately Wet
	-0.74 to +0.74	Near Normal
	-1.24 to -0.75	Moderately Dry
	-1.99 to -1.25	Very Dry
	-2.99 to -2.00	Extremely Dry
	-3.00 and below	Exceptionally Dry

Figure 6. 12-month Intermountain West regional Standardized Precipitation Index. (data through 5/31/06)

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 June 2006

Source: USDA Natural Resources Conservation Service

According to the NRCS Colorado State Basin Outlook Report, May was the second consecutive month of warm and dry conditions across Colorado, resulting in a worsening of the state's water supply outlook. Statewide June 1 snowpack was down to 26% of average with basinwide totals ranging from 6% of average in the San Juan, Animas, Dolores, and San Miguel basins to 51% of average in the Arkansas Basin. Snow water equivalent (SWE) as a percent of normal as of June 13 was either 0% or between 0 and 40% at most sites (Figure 7a). Only a handful of sites were at or above average.

The state's Water Availability Task Force (WATF) reported after its May 16 meeting that drought conditions existed in the South Platte, Arkansas, and Rio Grande River Basins and parts of the southwest. Although high elevation snowpack in May helped delay the start of drier conditions, early melt, low streamflow and lack of precipitation is raising significant concerns, particularly about agricultural impacts and wildfire. Those impacts are already being felt. State officials shut down 440 wells in Weld, Morgan and Adams counties under a state law requiring that wells be turned off in dry years to satisfy higher priority rights, leading to upwards of millions of dollars of losses. Numerous small wildland fires have been reported up and down the Front Range.

USGS 7-day average streamflow observations compared to historical streamflow graph (Figure 7b), most of Colorado's rivers are running in the normal category (25th – 75th percentile) for this time of year. Some stations on the White River in the northwest part of the state and on the Dolores, Animas, and San Juan Rivers in the southwest are below normal. Flows are extremely low (5% or less of average) on the Arkansas River at Cherry Creek and Fountain Creek, as well as at the Nebraska and Kansas state lines.

June Surface Water Supply Index (SWSI) figures were not yet available as of press time.

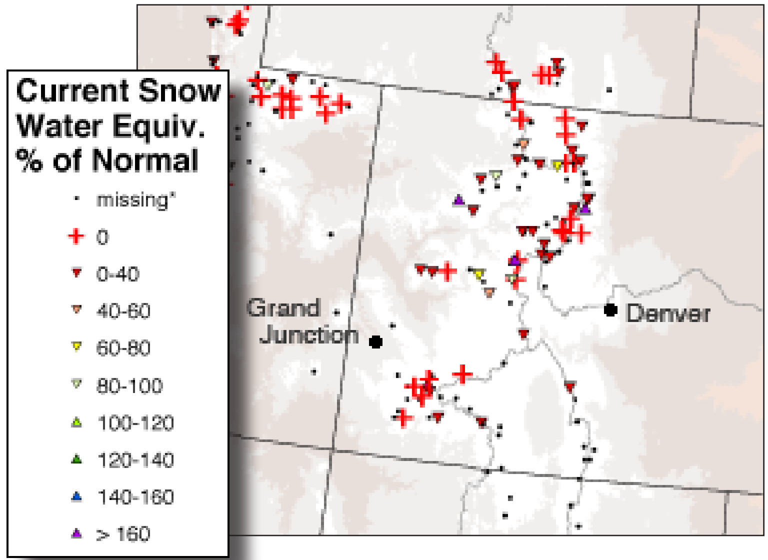


Figure 7a. Currrent snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Colorado as of June 13, 2006. **This is provisional data**. For current SNOTEL data and plots of specific sites, see http://www.cbrfc.noaa.gov/snow/snow.cgi or http://www.wcc.nrcs.usda.gov/snow/.

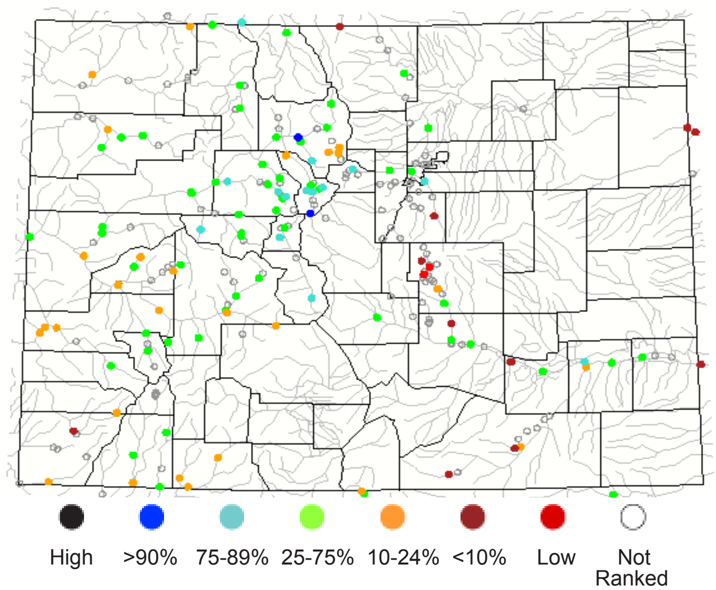


Figure 7b. Seven-day average streamflow conditions for points in Colorado as of 6/11/06.

Notes

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

The "7-day average streamflow" map (Figure 7b) 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

- For current maps of SWE, visit: http://www.wcc.nrcs.usda.gov/gis/snow.html.
- For current streamflow information from USGS, visit: http://water.usgs.gov/waterwatch/.
- For the current SWSI map, go to: http://www.co.nrcs.usda.gov/snow/fcst/state/current/monthly/maps_graphs/index.html.
- For monthly NRCS 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 next meeting is scheduled for Thursday, June 22, 2006, 10:00am-Noon, Colorado Division of Wildlife Headquarters, Big Horn Room, 6060 Broadway, Denver, CO. Agendas and minutes of this and previous meetings are available at: http://cwcb.state.co.us/Conservation/Drought/taskForceAgendaMinPres.htm.

Wyoming Water Availability June 2006

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

USGS reports that most steamflow gauges (Figure 8a) for western and south central Wyoming are mostly in the normal category (25th to 75th percentile), with some areas of high flow in the Shoshone and Upper Green Rivers. Low flows are recorded in the northern part of Wyoming on the Snake, Powder and Wind Rivers and in the southeast on the Upper and Lower Platte Rivers.

The Surface Water Supply Index (SWSI) values (Figure 8b) are similar to streamflow: in the near normal category in western and south-central Wyoming and lower in other areas. The SWSI indices decreased for nearly all basins during May. The driest basins are the Wind, Powder and Big Horn River basins; they are in moderate to severe drought categories. The Lower North Platte, Laramie and Upper North Platte in the southeast section of Wyoming are also below zero, in a mild to moderate drought category. There was a slight increase in SWSI values from April, 2006 for the Shoshone and Powder River Basins. According to the NWS, Riverton, the Lander/Riverton area received only 3% of normal precipitation in May 2006, making it the driest May on record since 1892.

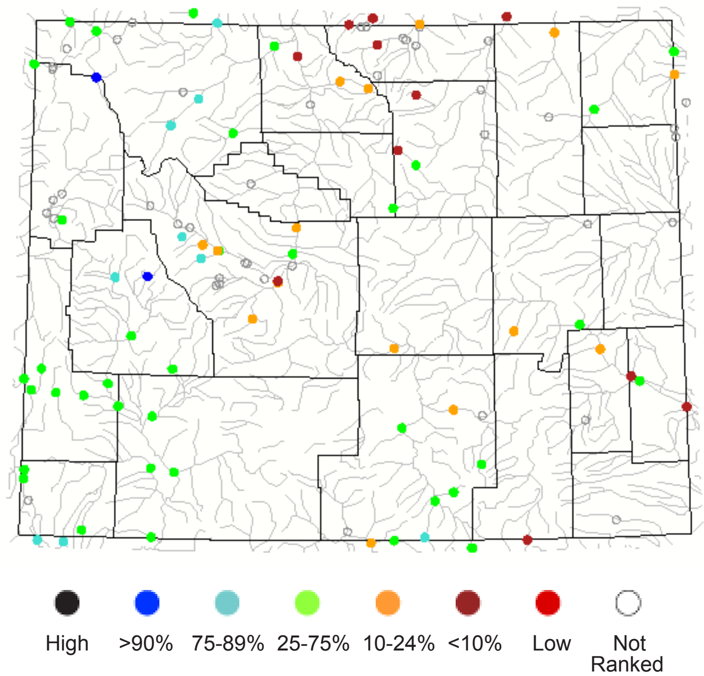


Figure 8a. Wyoming Percentile Streamflow Conditions (updated 6/11/06).

Notes

The "7-day average streamflow" map (Figure 8a) 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. The Surface Water Supply Index (SWSI-Figure 8b) is computed using only surface water supplies for the drainage. The computation includes reservoir storage, if applicable, plus the forecast runoff. The index is purposely created to resemble the Palmer Drought Index, with normal conditions centered near zero. Adequate and excessive supply has a positive number and deficit water supply has a negative value. Soil moisture and forecast precipitation are not considered as such, but the forecast runoff may consider these values.

Legend

> 4.0	Extremely Wet
3.0	Very Wet
2.0	Moderately Wet
1.0	Slightly Wet
0.5	Incipient Wet Spell
0.0	Near Normal
- 0.5	Incipient Dry Spell
- 1.0	Mild Drought
- 2.0	Moderate Drought
- 3.0	Severe Drought
< - 4.0	Extreme Drought

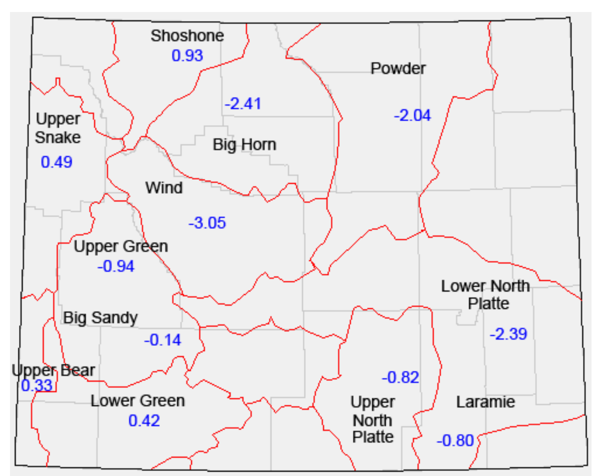


Figure 8b. Wyoming Surface Water Supply Index (data through 6/1/06)

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 June 2006

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

As of June 13, 2006 (Figure 9a) snow water equivalent (SWE) as a percent of average in Utah was as low as 0% to 80% at southern stations, and 40% to 80% of average at northern stations. One station in the northern mountains reported 100 to 120% of average SWE.

Nearly all streamflow sites on the USGS map (Figure 9b) are in the near normal category (25th to 75th percentile) for this time of year, with a few streamflow sites in north central Utah running above average (76th to > 90th percentile). However, a few sites in central and eastern Utah are running below average (10th to 24th percentile).

According to the Utah Center for Climate and Weather, (NCDC) the state's average temperature in May was 59.3° F, 3.8° F warmer than the 1901-2000 (20th century) average, the 10th warmest May in 112 years. The state's average precipitation, 0.40 inches in May 2006, the 14th driest May on record.

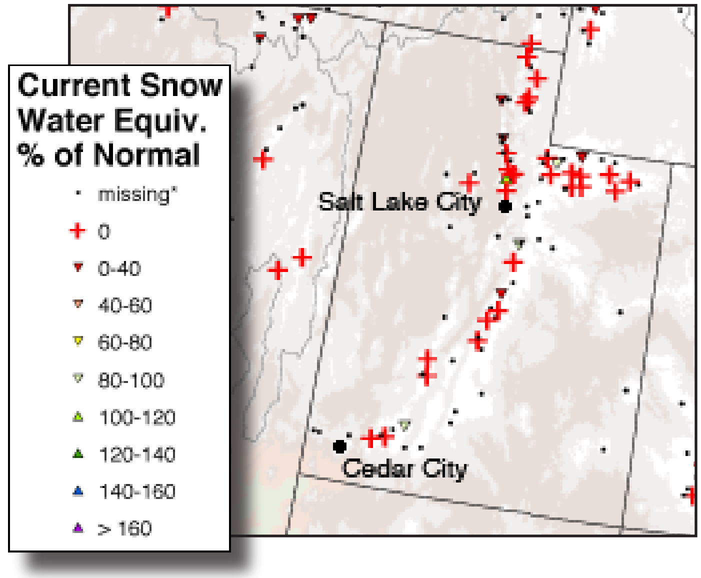


Figure 9a. Currrent snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Utah as of June 13, 2006. **This is provisional data**. For current SNOTEL data and plots of specific sites, see http://www.cbrfc.noaa.gov/snow/snow.cgi or http://www.wcc.nrcs.usda.gov/snow/

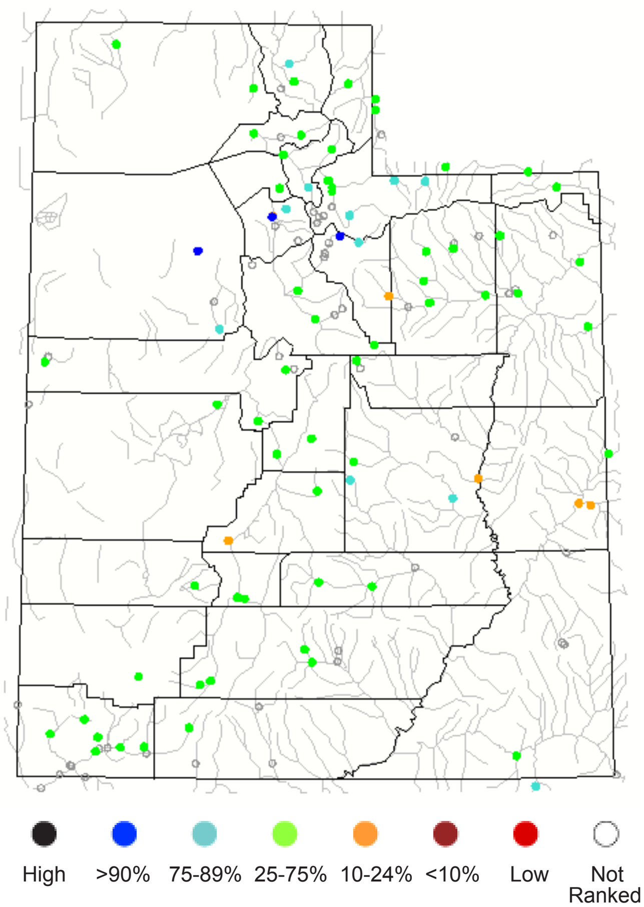


Figure 9b. Utah Percentile Streamflow Conditions (updated June 11, 2006).

Notes

Figure 9a shows the SWE as a percent of normal (average) for SNOTEL sites in Utah. The "7-day average streamflow" map (Figure 9b) 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

- For current maps of SWE as a percent of normal like in Figure 9a, go to: http://www.wcc.nrcs.usda.gov/gis/snow.html.
- 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/

Temperature Outlook **July - November 2006** Source: NOAA Climate Prediction Center

According to the NOAA/CPC monthly and seasonal forecasts issued June 15th, above median temperatures are predicted across much of the southern tier of the U.S. for July 2006 (Figure 10a), and including especially the south-central region. Many forecast tools support this forecast, including tools based solely on antecedent soil moisture for which there are large deficits over a very large area of the central U.S.

The seasonal (three-month) temperature outlook continues to indicate increased risk for above average temperatures through the September-October-November (SON) forecast period. A large area of the southern and western U.S., including Utah, most of Colorado, and southern Wyoming, has a 50% or more increased risk of above average temperatures in July-September (JAS) 2006 (Figure 10b), and above average temperatures are likely throughout the summer for all or most of the Intermountain west (Figure 10b-d). The high odds for a warm summer in Colorado are anchored by a fairly pronounced warming trend (in addition to the soil moisture impacts).

The forecast for July 2006 will be updated on June 30th. Last year, CPC began updating its forecast for the next month on the last day of the previous month. This "zero-lead" forecast often can take advantage of long-lead weather forecasts and typically has increased skill over the forecast made mid month because of the shorter lead time. This forecast is available on the same CPC webpages as the regular mid-month forecasts.

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.

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.

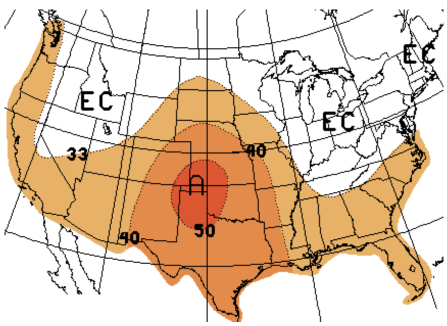


Figure 10a. Long-lead national temperature forecast for July 2006. (released June 15, 2006)

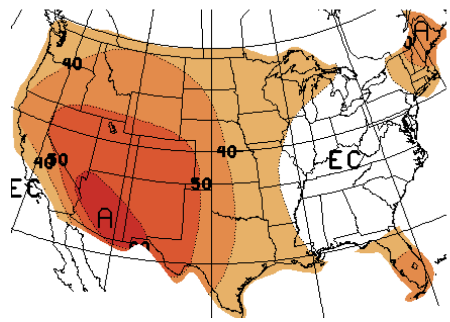


Figure 10b. Long-lead national temperature forecast for Jul. - Sep. 2006. (released June 15, 2006)

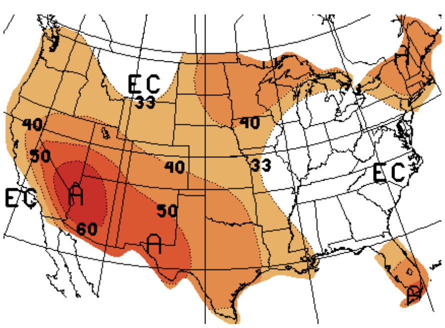


Figure 10c. Long-lead national temperature forecast for Aug. - Oct. 2006. (released June 15, 2006)

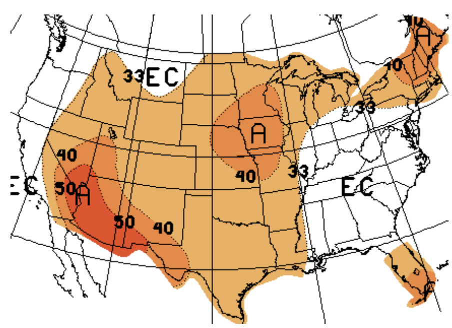


Figure 10d. Long-lead national temperature forecast for Sep. - Nov. 2006. (released June 15, 2006)

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

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 July - September 2006 Source: NOAA Climate Prediction Center

Summer seasonal precipitation forecasts, issued June 15th by the NOAA Climate Prediction Center (CPC), have changed little since the May forecast. The Intermountain West has "equal chances" of above-average, near-normal or below-average precipitation for the June 2006 and June-August forecasts period (Figure 11a and 11b). According to CPC, there are no significant skillful indications for June precipitation anomalies from the forecast tools.

The monsoon is one of the features that affects summer precipitation in parts of the Intermountain West. According to the NWS Weather Forecast Office in Grand Junction, the monsoon generally begins around the second week of July for western Colorado and eastern Utah. A high pressure area usually "breaks away" from the main Pacific ridge and settles in over the Great Basin by June, bringing hot temperatures during June and early July. As this high pressure center moves eastward across the Continental Divide and into the Central Plains, a slightly cooler but much more moist environment will prevail in the southwest flow behind the high. In most years, the monsoon is over by the end of August, but can last as late as October. Many areas in southwest Colorado and southeast Utah experience a secondary precipitation maximum in October due to late-season tropical storm moisture carried northward by the monsoonal flow. Monsoon start date is determined when the average daily dewpoint in Tucson, AZ is 54° F or greater for "3" consecutive days. Statistics on monsoon starts are: latest start, July 25, 1987; earliest start, June 17, 2000; average start: July 3rd. Last year's start was relatively late, July 18, 2005. To track the monsoon see the NWS/Weather Forecast Office in Tucson's monsoon page: http://www.wrh.noaa.gov/twc/monsoon/dewpoint_tracker.php.

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.

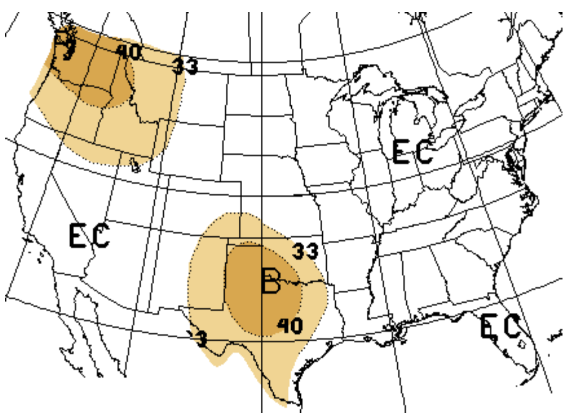


Figure 11a. Long-lead national precipitation forecast for June 2006. (released May 18, 2006)

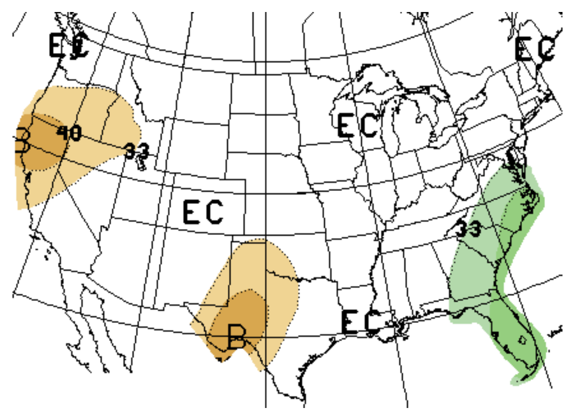


Figure 11b. Long-lead national precipitation forecast for Jun. - Aug. 2006. (released May 18, 2006)

A = Above
40.0–49.9%
33.3–39.9%

B = Below
40.0–49.9%
33.3–39.9%

EC = Equal Chances

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.

Precipitation Outlook continued

The experimental guidance for the Southwest for July-September 2006 (Figure 11c) indicates monsoon has the potential to be above-average from southwestern New Mexico into eastern Colorado. This product incorporates factors influencing southewest climate that are used only a limited way in the official CPC forecast.

Notes

The experimental guidance for seasonal future precipitation in Figure 11c shows most recent forecast of shifts in tercile probabilities for July - September 2006. In order to be shown on this map, a forecast tilt in the odds has to reach at least 3% either towards wet (above-average), dry (below-average), or near-normal (average). Shifts towards the wettest (driest) tercile are indicated in green (red), and are contoured in 5% increments, while near-normal tilts of at least 3% are indicated by the letter “N”. Shifts over 10% considered significant. Positive (negative) shifts between three and five percent are indicated by a green (red) plus (minus) sign, while minor shifts of one or two percent are left blank in this display.

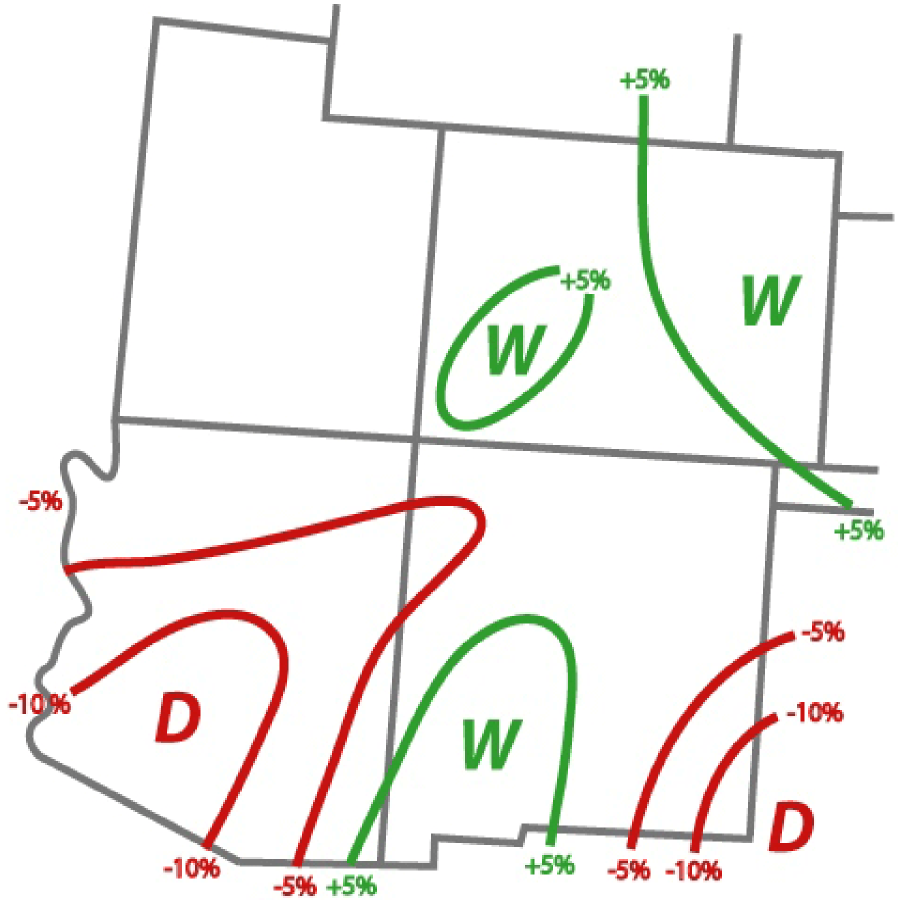


Figure 11c. Experimental guidance for seasonal precipitation in the southwest for July - September (issued June 14, 2006).

On the Web

- The CDC experimental guidance product, including a discussion and executive summary, is available on the web at: http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html

Seasonal Drought Outlook through September 2006 Source: NOAA Climate Prediction Center

According to the Drought Outlook issued June 15th by the NOAA Climate Prediction Center, drought status in the Intermountain West is likely to persist in eastern and southern **Colorado**, central and northeastern **Wyoming** and western Nebraska and Kansas. Improvements are anticipated in parts of central Nebraska and Kansas, and areas of the Southwest that are influenced by the rains from the upcoming monsoon season. This Outlook has not changed appreciably since the May 2006 Outlook. The monsoon typically begins in July over Arizona and New Mexico, but also may bring rain to **Colorado**. The greatest impact of the rains will likely be the reduction of fire danger in July and August.

The Seasonal Drought Outlook is based on the CPC long-lead precipitation outlook for the upcoming season in this case June-August (p. 14), drought termination and amelioration probabilities from the NOAA/National Climatic Data Center (see URL below), and various medium and short-range forecasts and models such as the 6-10 day and 8-14 day forecasts, and the soil moisture tools.

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.

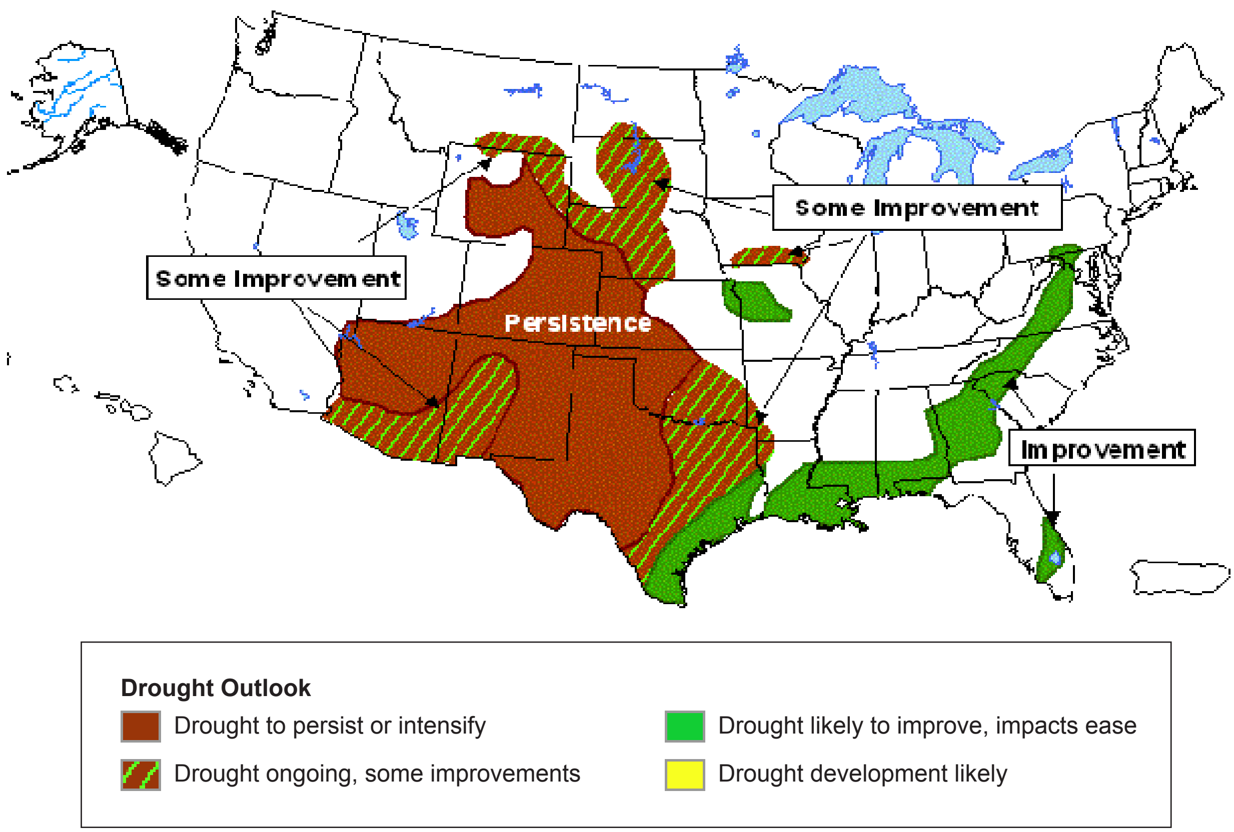


Figure 12. Seasonal Drought Outlook through September 2006 (release date June 15, 2006).

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

According to both the NOAA/CPC sea surface temperatures (SSTs) in the Nino 3.4 region, a critical indicator for the ENSO state, are currently in the average range, about 0.3° C. Low level and upper level winds in the tropical Pacific also averaged close to normal in the last month or so. These indicators suggest that ENSO is in a neutral phase.

According to both the NOAA/CPC and the International Research Institute for Climate and Society (IRI), ENSO-neutral conditions are expected to prevail through the rest of 2006. IRI's "ENSO Update" issued June 13th says that the western and central equatorial Pacific have warmed to about 0.5 deg C above average since mid-May 2006, but the surface and sub-surface temperature anomalies that currently exist in the tropical Pacific are not particularly large or well structured to indicate an imminent El Niño event. The observations and models suggest that neutral conditions will be in place at least through mid-2006. Most of a large set of dynamical and statistical forecast models predict neutral conditions continuing throughout 2006. IRI projects the probability of a La Niña or El Niño conditions for June-July-August (JJA) is less than the climatologically expected odds of 25%, and neutral conditions are favored throughout 2006 starting with a 80% likelihood for JJA. Historically, El Niño and La Niña events tend to develop in the April-June period, and they reach their maximum strength in December-February.

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.

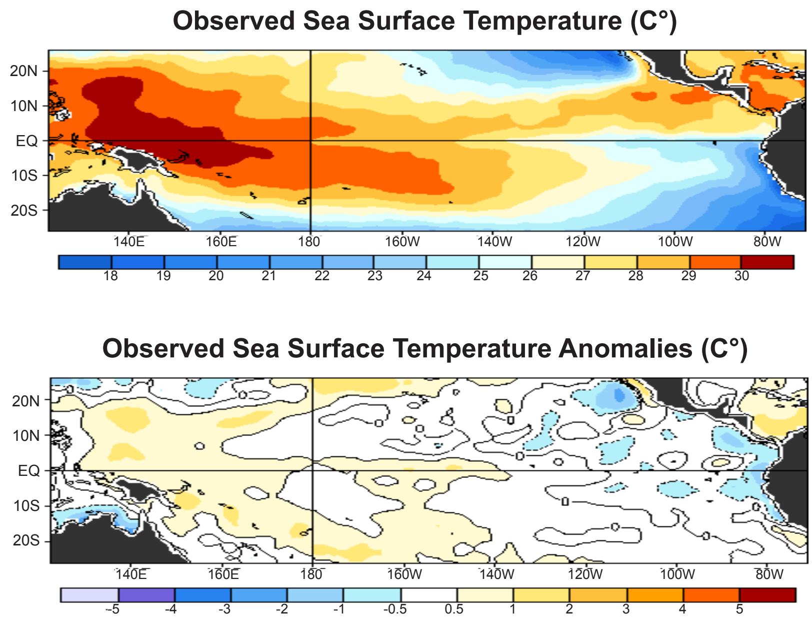


Figure 13a. Two graphics showing the observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. The Niño 3.4 region encompasses the area between 120ºW-170ºW and 5ºN-5ºS. The graphics represent the 7-day average centered on June 7, 2006.

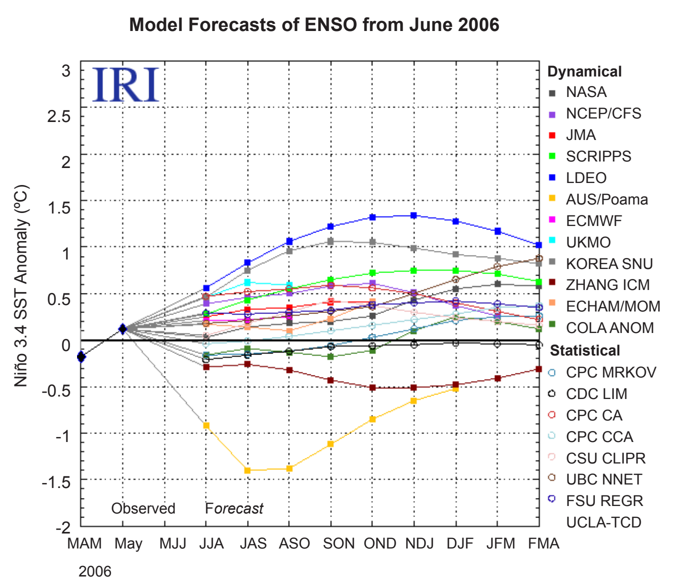


Figure 13b. Forecasts made by dynamical and statistical models for sea surface temperatures (SST) in the Niño 3.4 region for nine overlapping 3-month periods from June 2006 through April 2007 (released June, 13 2006). Forecasts are courtesy of the International Research Institute (IRI) for Climate and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

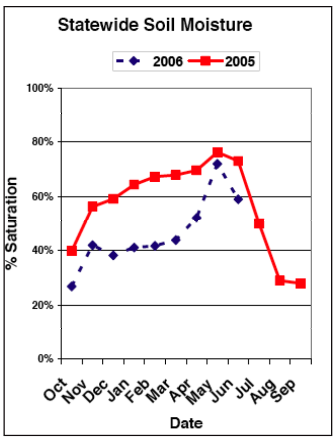
On the Web

- 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/.

Advances in Soil Moisture Science: New in situ soil moisture measurements from NRCS

By Christina Alvord, Western Water Assessment

There is a new technology in the world of soil moisture monitoring and research, the Stevens Hydroprobe sensor, which measures soil moisture and soil temperatures. This technology is being used by the Natural Resources Conservation Service (NRCS) to better measure impacts of dry or wet soils on seasonal run-off. The study and management of soils is one component of the NRCS mission, which includes the conservation of soil, water, air, plants, and animals -- the “SWAPA” resources. Climate and hydrology serve as a common thread, linking all of the various resources, and detailed quality data are key to better understanding. In particular, data from these new soil moisture and temperature sensors are useful for improving seasonal water supply outlooks and on-the-ground irrigation decisions but also have a broader range of scientific applications, including drought monitoring and climate change.



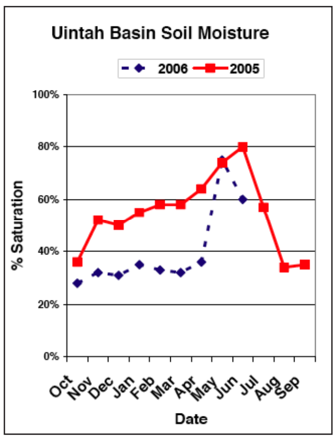


Figure 14a: (Left) Using new sensors, soil moisture chart for the state of Utah for 2005 and 2006 is generated by compiling monthly averages of soil moisture from various watershed basins around the state.

Figure 14b: (Right) Soil moisture chart for Uintah Basin in 2005 and 2006 plotted using monthly averages of soil moisture collected from10-16 different sites.

As of 2005, the agency has installed over 1000 of these sensors, according to Dr. Thomas Pagano, water supply forecaster of the NRCS National Water and Climate Center (NWCC) in Portland, Oregon. Many of these sensors are in the mountains of the Western US, coupled with the SNOTEL network, while many are also part of the Soil Climate Analysis Network (SCAN) in regions including Hawaii, Puerto Rico, the Eastern US, and even Antarctica. In the Western US, Utah has developed excellent geographic coverage of sensors and has acquired a long enough period of record to generate realtime graphical products for users. These include soil moisture time series charts (Figures 14a and 14b) and a state Soil Moisture Update Report, available on the web (see URLs below). These complement the basic suite of tabular products available at the NWCC webpage.

The primary objective is to measure soil moisture and temperature, although other data such as capacitance and conductance are also available from the sensors. The sensors are typically placed at 2, 8, and 20 inch depths in the soil to measure these parameters at 10-16 sites within each large basin. Sensor readings are weighted in proportion to corresponding depths (Figure 14c). The 2 inch depth sensor represents the first 6 inches of soil starting at the soil surface, the 8 inch sensor represents the next consecutive 9 inches of soil and the 20 inch sensor measures the following consecutive 12 inches with a total measurement of 26 inches of soil. Each month, NRCS generates graphs of the data (Figures 14a and 14b) which display the average percentage of ground saturation for each watershed basin and region being measured.

Already these data are being used to improve the water supply outlooks; Randall Julander, Snow Survey Supervisor for the Utah NRCS, says that based on preliminary results on a small Utah watershed, Centerville Creek, the data recorded using these sensors saw “substantial improvement in predictive capability over using snow data alone.” By knowing the soil moisture deficit, one can better estimate the anticipated seasonal runoff efficiency; are the soils full and will the snowmelt directly feed the streams? Or will the soils capture most of the moisture? “These data should also give us a better handle on significant sublimation events” indicated Dr. Pagano. “Before, if the snow was disappearing, it would be hard to know if it was going into the soils or disappearing into the sky. Now we can track that as it happens and adjust accordingly.”

Julander’s experience has been that these sensors are a low maintenance, reliable technology that provides a consistent, unified method of measuring soil moisture. Based on initial successes, NRCS plans to implement these sensors at all SNOTEL sites in Utah, Nevada, and the Sierras. At this pace, it should not be long until this investment matures into quantitative improvements in water supply forecasts and management practices. In time, this data stream may also become an indispensable part of the national and global climate monitoring network.

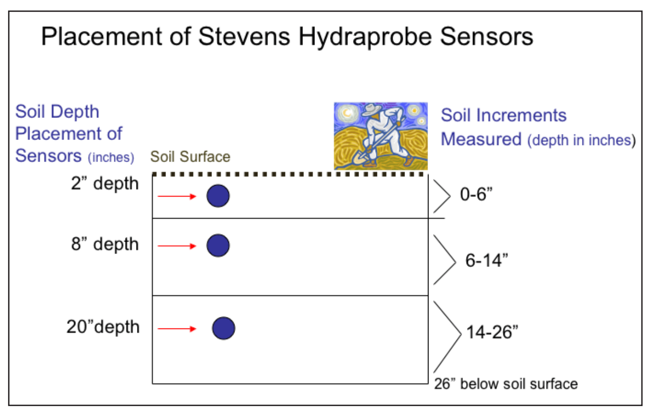


Figure 14c: Descriptive graph of sensor placement within soil where 3 sensors are used at every site within each watershed basin.

On the Web

- NRCS: Climate Information, including soil moisture charts and the Utah Soil Moisture Update Report: http://www.ut.nrcs.usda.gov/snow/climate/
- NRCS: Field Office Guide to Climatic Data: http://www.wcc.nrcs.usda.gov/climate/foguide.html