Intermountain West Climate Summary

by The Western Water Assessment

Issued Sept 22, 2008
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September 2008 Climate Summary

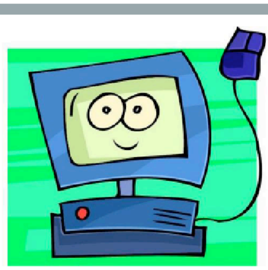
Hydrological Conditions — Drought persists in eastern Colorado, western and central Wyoming, and western Utah. The highest drought intensity continues to be in southeastern Colorado and southwest Wyoming; however, drought intensity has decreased in southeastern Colorado as of mid-July.

Temperature — Average temperatures in most of the region were above average in August, with areas in northwest Wyoming and southern Utah reaching 4ºF above average. However, average temperatures in parts of eastern Wyoming and Colorado were 4ºF below average.

Precipitation — Precipitation was near or above average across most of the Intermountain West in August. Parts of eastern Colorado, southwestern Wyoming, and northern Utah received over 150% of average precipitation.

ENSO — The equatorial Pacific returned to ENSO-neutral conditions during June 2008; this continued through August 2008. Models are largely in agreement regarding ENSO-neutral conditions throughout the forecast period (through July 2009).

Climate Forecasts — For the Oct–Dec and Nov–Jan seasons, there are increased chances of above average temperatures for most of the western U.S. There are equal chances of above, below, or near average precipitation.



WWA announces a new website!

Please visit our new and improved web site at the old address: http://wwa.colorado.edu and let us know what you think.

We are looking for your input on the Intermountain West Climate Summary (IWCS):

Keep an eye out for an invitation in your email next month to participate in an online survey about the IWCS. We hope you will help us evaluate this product so that we can improve it for you.

Upcoming Conferences:

Colorado Governor's Conference on Managing Drought and Climate Risk October 8–10, 2008 in Denver, CO. http://cwcb.state.co.us/

Wyoming Water Association Annual Meeting and Educational Seminar October 29–31, 2008 in Casper, WY. http://www.wyomingwater.org/registration.html

Utah Water Users Association: See http://www.utahwaterusers.com for their latest newsletter, and details the annual conference in December to be posted soon.

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

Contact Us - To receive an email when a new Summary is available, please email us at: **wwasummary@wwa.colorado.edu.**

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Assessing and Adapting to Climate Change
A Look at Two of the Climate Change Science Program's Latest Products

By Ava Dinges, University of Kansas student and WWA summer intern

The Climate Change Science Program (CCSP) recently released two Synthesis and Assessment Products, which compiled research from over 1000 publications to assess "The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States" (SAP 4.3), and SAP 4.4, which is a "Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources." This article highlights key points from SAP 4.3 and SAP 4.4, focusing on information that is important to water managers in the West.

Background

The Climate Change Science Program (CCSP) was created in 2002 to improve government-wide management of climate science and climate-related technology development. The CCSP integrates President Bush's Climate Change Research Initiative (CCRI) with the U.S. Global Change Research Program (USGCRP). The CCRI addresses issues related to uncertainty in global climate change science and the USGCRP supports research on the interactions of natural and human-induced changes in the global environment. The integration of these two organizations allows the CCSP to provide reliable climate information to policy makers so that they can make judgments and decisions about adapting to and mitigating climate change.

To support its mission, the CCSP coordinates and distributes Synthesis and Assessment Products (SAPs) specific to its five distinct goals (Table 1). Each SAP undergoes a peer review process as required by the Information Quality Act (IQA) for highly influential documents. So far, the CCSP has released eight final reports and plans to complete 13 more by September 2008, and more over time. The two most recent products, SAP 4.3 and SAP 4.4, support the CCSP's fourth goal of understanding the sensitivity and adaptability of ecosystems to climate change.

Synthesis and Assessment Products 4.3 and 4.4

Released in May 2008, SAP 4.3 assesses the potential impacts of climate change on U.S. land resources, water resources, agriculture, and biodiversity (hereafter referred to as the 'resources report.') The SAP 4.3 project was led and coordinated by the National Center for Atmospheric Research (NCAR) and sponsored by the U.S. Department of Agriculture (USDA). The report also examines whether current observed changes within these realms can be attributed in whole or part to climate change (4.3, p. vii). The CCSP released SAP 4.4 in June 2008 as a follow up to SAP 4.3 by presenting potential steps for adapting to climate change. SAP 4.4 (hereafter referred to as the "adaptation report,") provides information on adaptation options for climate sensitive ecosystems and resources such as national forests, national parks, and wild and scenic rivers, but is broadly applicable to many types of ecosystems (4.4, p. xviii). Because of limited information and understanding, the adaptation report does not include the cost and benefits of implementing adaptation options, yet works to assess the confidence and integrity behind each adaptation option (4.4, p. xix).

The authors of these synthesis products made an effort to use consistent terms when describing their confidence and conclusions throughout the reports (Figure 1a). The terms were agreed upon by the CCSP agencies and reflect the judgment of the reports' authors.

A Changing Climate, Especially in the West

According to the report on resources, "there is a robust scientific consensus that human-induced climate change is occurring" due to fossil fuel burning and deforestation (4.3, p.2). Over the last century, the global-average surface temperature has increased by about 0.6 °C and global precipitation over land increased about 2 percent (Figure 1b, 4.3, p.2). Temperature and precipitation records in the U.S. are consistent with these trends as the country, overall, became warmer and wetter during the 20th century (4.3, p.2). For most of the U.S., the increased precipitation helped minimize the impacts of the warming. However, the West experienced decreased precipitation, which together with increased temperatures, has strained the region's water supply.

A limited water supply makes the western region highly sensitive to changes in precipitation and temperature (4.3, 129). Recent studies of the West indicate both a decrease in the snow water equivalent of the snowpack from 1915–2003 and an earlier trend in spring snowmelt from 1948–2002 (Figure 1c, 4.3, p. 130) . Higher temperatures in the winter months are decreasing the mountain snowpack by causing more precipitation to fall as rain rather than snow. Warming has also led to earlier spring snowmelts as temperatures become warm enough for snow to melt much sooner in the year. These rising temperatures have exacerbated the effects of decreased precipitation by increasing evaporation, which in turn increases outdoor water demand.

Recent research also found that the variability of April–September streamflow has been increasing across the western U.S. since 1980 (4.3, p.130), which is a concern for water managers. Current methods for water management are based on the concept of statistical stationarity, meaning they assume that the probability distribution of observations does not change with time (4.3, p.121). However, "the reliance on past conditions as the foundation for current and future planning and practice will no longer be tenable as climate change

SAP Product #	Scheduled Completion Date	Topic
Goal 1: Improve knowledge of the Earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and change		
1.1	COMPLETED May-06	Temperature trends in the lower atmosphere: steps for understanding and reconciling differences
		http://www.climatescience.gov/Library/sap/sap1-1/finalreport/sap1-1-final-all.pdf
1.2	Sep-08	Past climate variability and change in the arctic and at high latitudes
1.3	Sep-08	Re-analyses of historical climate data for key atmospheric features, Implications for attribution of causes of observed change
Goal 2: Improve quantification of the forces bringing about changes in the Earth's climate and related systems		
2.1	COMPLETED Oct-07	Scenarios of greenhousegas emissions and atmospheric concentrations and review of integrated scenario development and application
		http://www.climatescience.gov/Library/sap/sap2-1/finalreport/sap2-1a-final-all.pdf
		http://www.climatescience.gov/Library/sap/sap2-1/finalreport/sap2-1b-final-all.pdf
2.2	COMPLETED Nov-07	North American carbon budget and implications for the global carbon cycle
		http://www.climatescience.gov/Library/sap/sap2-2/final-report/sap2-2-final-all.pdf
2.3	Oct-08	Aerosol properties and their impacts on climate
2.4	Aug-08	Trends in emissions of ozone-depleting substances, ozone layer recovery, and implications for ultraviolet radiation exposure
Goal 3: Reduce uncertainty in projections of how the Earth's climate and environmental systems may change in the future		
3.1	Jul-08	Climate change models: assessment of strengths and limitations
3.2	Jul-08	Climate projections for research and assessment based on emissions scenarios developed through the CCTP
3.3	COMPLETED Jun-08	Weather and climate extremes in a changing climate. Regions of focus: North America
		http://downloads.climatescience.gov/sap/sap3-3/sap3-3-final-all.pdf
3.4	Sep-08	Abrupt climate change

SAP Product #	Scheduled Completion Date	Topic
Goal 4: Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes		
4.1	Aug-08	Coastal elevation and sensitivity to sea level rise
4.2	Sep-08	Thresholds of change in ecosystems
4.3	COMPLETED May-08	The effects of climate change on agriculture, biodiversity, land, and water resources
		http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm
4.4	COMPLETED May-08	Preliminary review of adaptation options for climate-sensitive ecosystems and resources
		http://downloads.climatescience.gov/sap/sap4-4/sap4-4-final-report-all.pdf
4.5	COMPLETED Oct-07	Effects of climate change on energy production and use in the United States
		http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm
4.6	Jun-08	Analyses of the effects of global change on human health and welfare and human systems
4.7	COMPLETED Mar-08	Impacts of climate change and variability on transportation systems and infrastructure: Gulf Coast study
		http://www.climatescience.gov/Library/sap/sap4-7/final-report/sap4-7-final-all.pdf
Goal 5: Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change		
5.1	Jul-08	Uses and limitations of observations, data, forecasts, and other projections in decision support for selected sectors and regions
5.2	Sep-08	Best practice approaches for characterizing, communicating, and incorporating scientific uncertainty in decisionmaking

Table 1: A comprehensive list, taken from the CCSP website, of the CCSP's five goals and the Synthesis and Assessment Products (SAPs) pertaining to each goal.

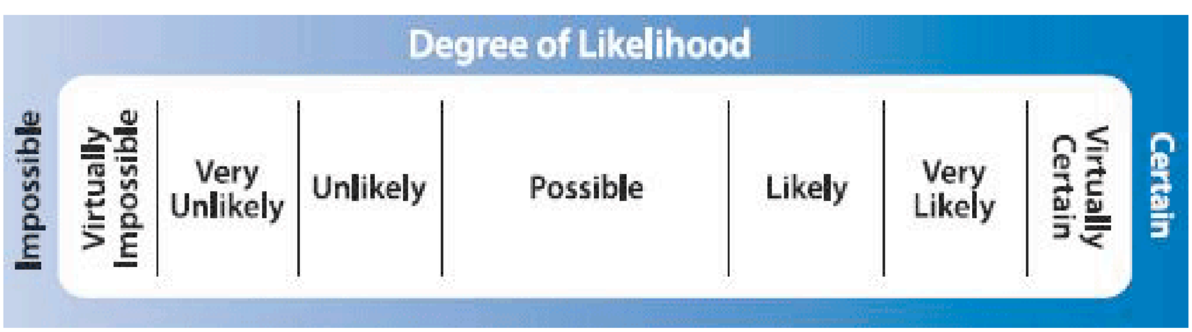


Figure 1a: Consistent language used to describe the confidence in findings and conclusions throughout the reports (4.3, p. 2).

and variability increasingly create conditions well outside of historical parameters and erode predictability" (4.3, p.8). Therefore, "management of western reservoir systems is very likely to become more challenging as runoff patterns continue to change" (4.3, p.192).

Future Projections

Trends toward reduced mountain snowpack and earlier spring snowmelt runoff peaks in the West are very likely to continue, as the Intergovernmental Panel on Climate Change (IPCC) projects the global average temperature will rise another 1.1 to 5.4°C by 2100 (4.3, p.2 and 149). Substantial decreases in annual runoff are expected for the Interior West, including the Colorado River Basin and the Great Basin (Figure 1d). "It is very likely that the magnitude and frequency of ecosystem changes will continue to increase" during the next 25 to 50 years, possibly accelerating in the future (4.3, p.3). These changes will have significant impacts

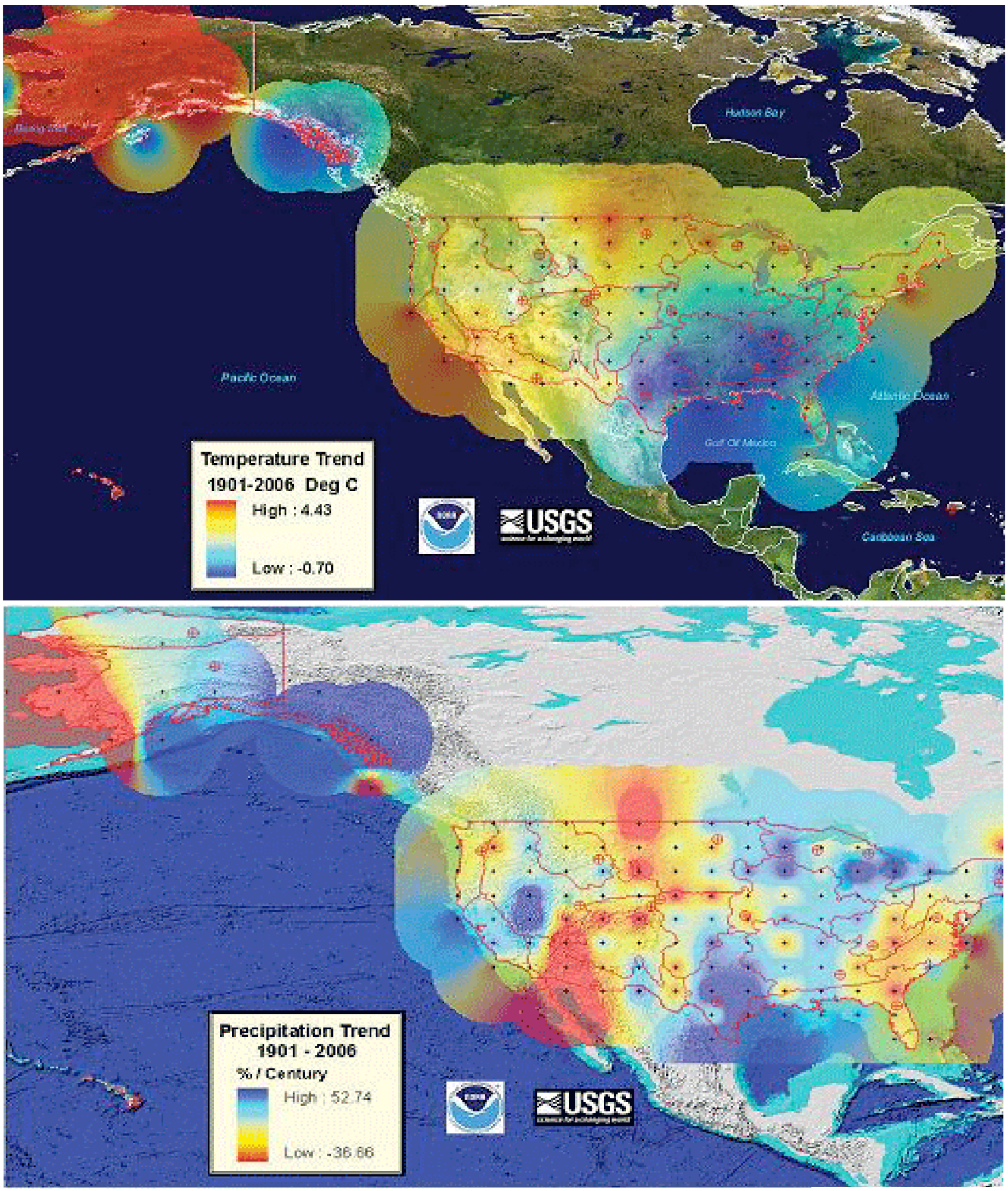


Figure 1b: U.S. temperature (upper) and precipitation (lower) trends from 1901–2006. Temperature data are averaged from weather stations across the country. Precipitation changes are shown as a percentage from the long-term average. Graphics courtesy of NOAA's National Climate Data Center and the U.S. Geological Survey (4.3, p. 16).

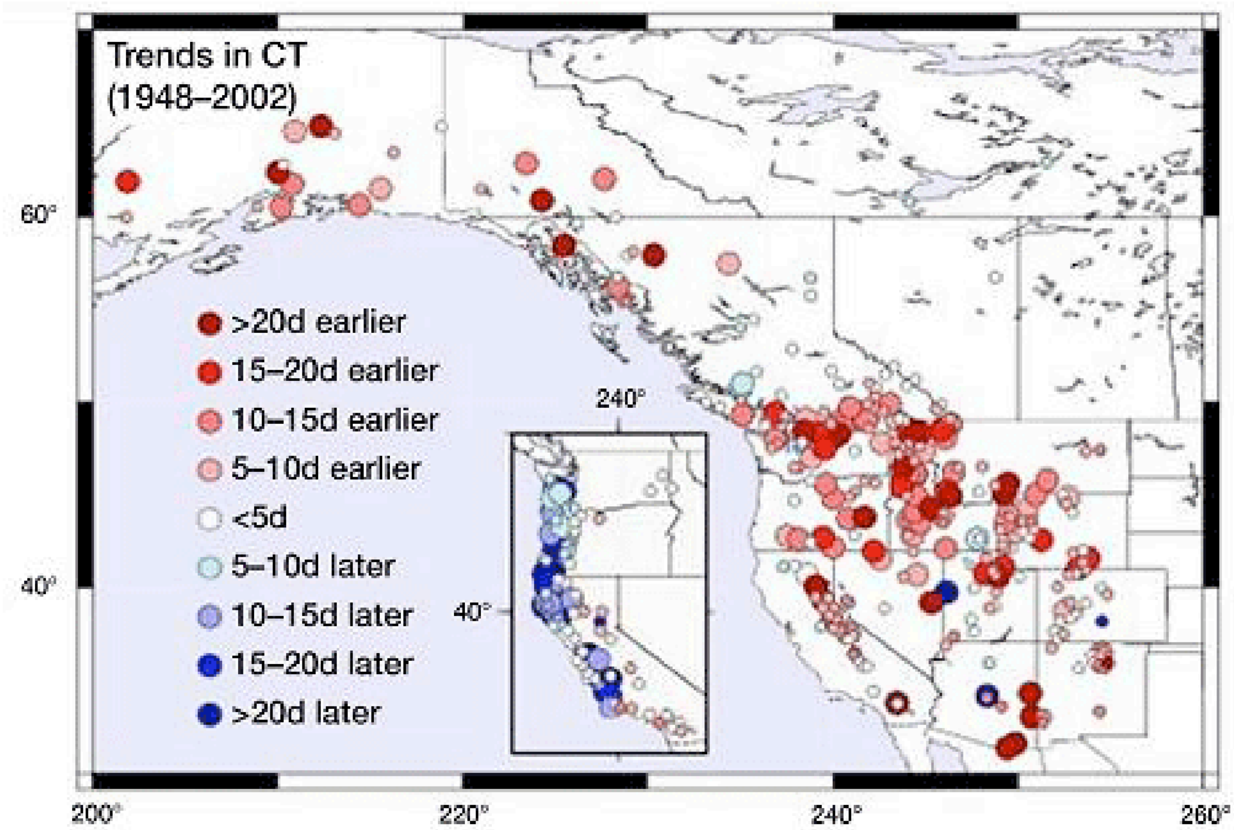


Figure 1c: Changes in western U.S. snowmelt runoff timing from 1948–2002. Source: Stewart et al. (2005) (4.3, p.131).

on U.S. hydrological systems.

A large-scale implication of projected climate change is the degradation of water quality throughout the U.S., as warmer temperatures reduce suitable habitats for cold-water and cool-water fish and enhance algal production in lakes (4.3, p.142). Climate change may also increase the intensity of storm events, implying an increase of nutrient runoff into lakes from storm-related erosion (4.3, p.142). Reduced streamflows in the West resulting from a warmer and drier climate will reduce the flushing rate, also increasing the concentration of nutrients within water sources (4.3, p.143).

The effects of climate change will extend beyond water resources as all ecosystems are sensitive to climate variations (4.3, p.121). Since 1985, there has been a decrease in growth of the semi-arid forests in the Southwest because of drought caused by warmer temperatures (4.3, p. 145). Earlier snowmelts, longer growing seasons and increased summer temperatures have been linked to an increase of wildfire activity in the western U.S. (4.3, p.146). Warmer temperatures also encourage the survival of insects, which promotes forest insect epidemics (4.3, p.146).

Where to Go From Here: Assessment and Adaptation

A key step in preparing for climate change is accurately assessing the situation – a task that may be difficult to do with our current hydrologic system. According to the resources report, "essentially no aspect of the current hydrologic observing system was designed to detect climate change or its effects on water resources" and "as a result, many of the data are fragmented, poorly integrated, and unable to meet the predictive challenges of a rapidly changing climate" (4.3, p.146). Improvements within those observing systems could increase the understanding of past hydroclimate changes and increase the ability to interpret the potential effects of future changes (4.3, p.146). Suggested improvements include an increase in the number of streamflow observation stations, continued improvements in the measurement of actual evaporation, and increased support for a core network of soil moisture monitoring stations (4.3, p. 146).

"While there will always be uncertainties associated with

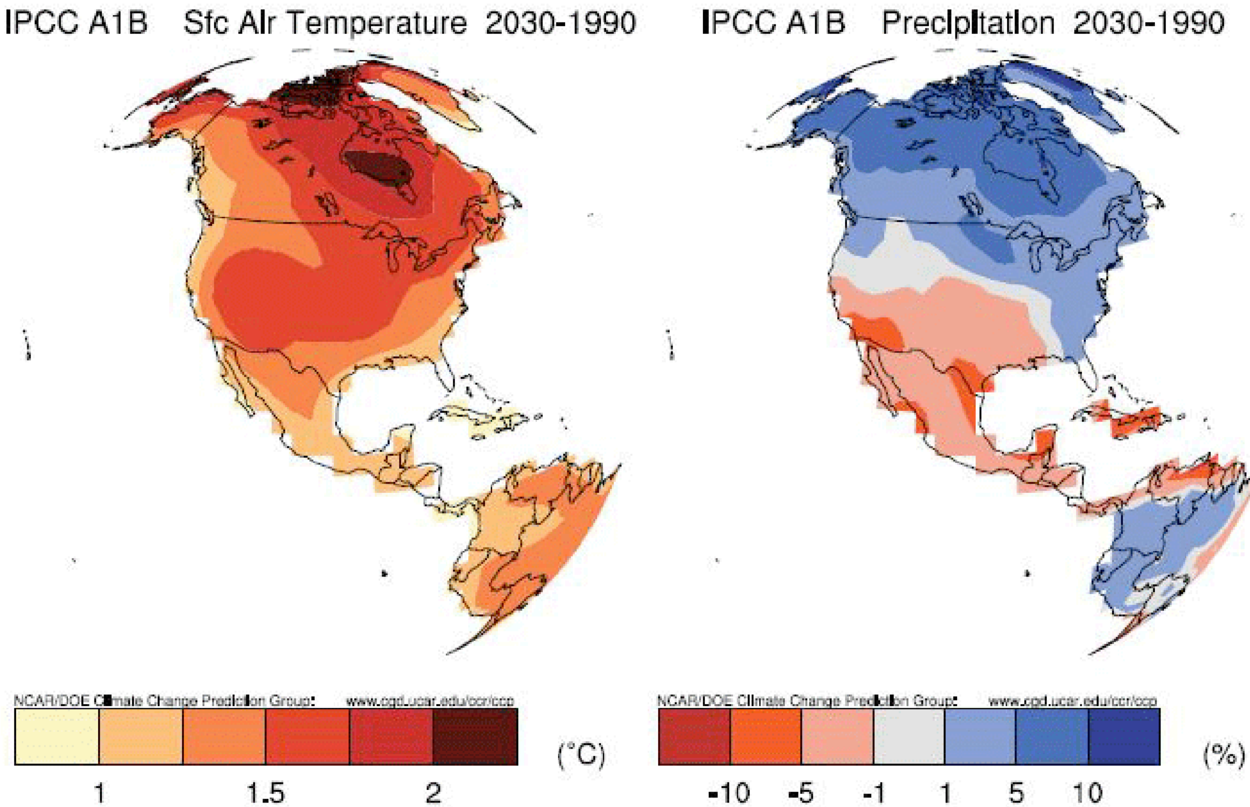


Figure 1d: Projected changes in U.S. temperature (left) and precipitation (right) by 2030 if atmospheric concentration of greenhouse gases increases to about 700 parts per million (roughly double the pre-industrial level). The changes are shown as the difference between two 20-year averages (2020–2040 minus 1980–1999). These results are based on simulations from nine different climate models from the IPCC AR4 multi-model ensemble. The simulations were created on supercomputers at research centers in France, Japan, Russia, and the United States (4.3, p.17).

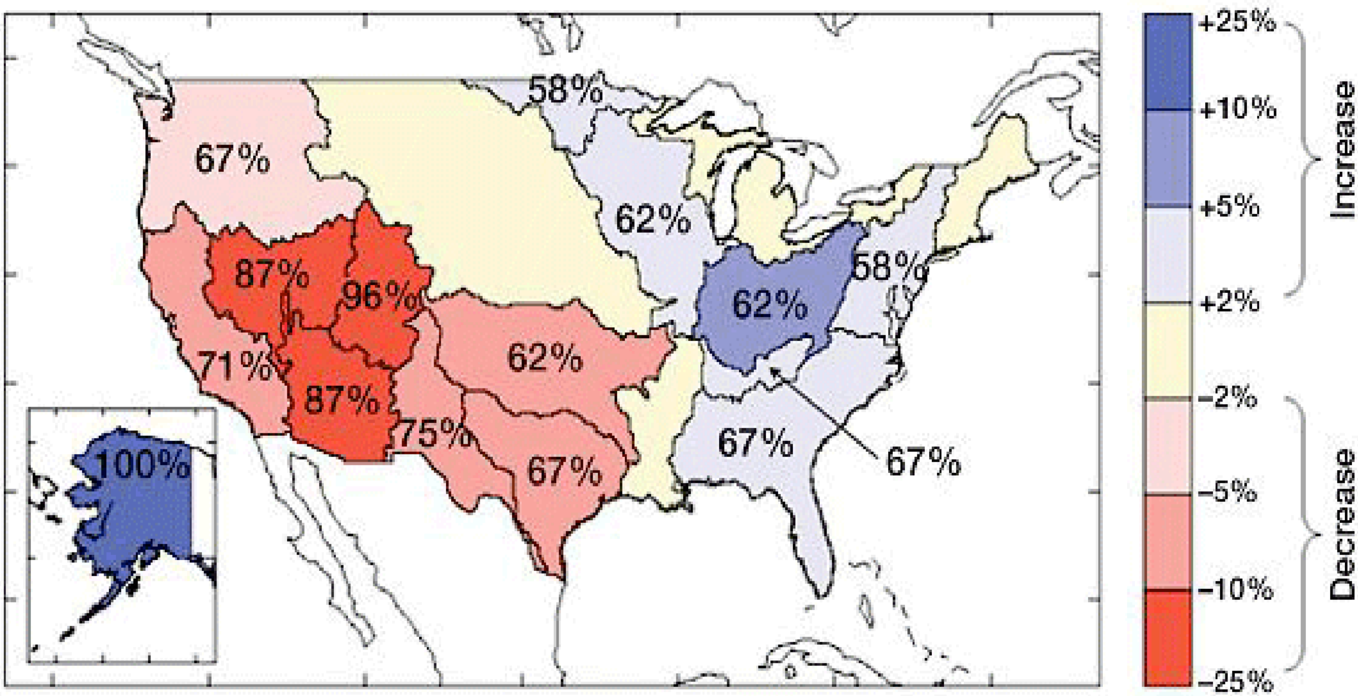


Figure 1e. Projected changes in median runoff interpolated to U.S. Geological Survey (USGS) water resources regions from 24 pairs of global climate model (GCM) simulations for 2041–2060 relative to 1901–1970. Percentages are fraction of 24 runs for which differences had same sign as the 24-run median. Results replotted from Milly et al. (2005) (4.3, p. 138).

the future path of climate change the response of ecosystems to climate impacts, and the effects of management, it is both possible and essential for adaptation to proceed using the best available science" (4.4, p. 1–2). While the adaptation report did not offer suggestions exclusive to the West, their proposals were widely applicable to many different ecosystems.

Increasing ecosystem resilience is an existing water management approach that can be adapted to mitigate longer-term climate change (4.4, p. 1–3). Such approaches include protecting key ecosystem features, restoring lost or compromised ecosystems, and using areas less affected by climate change as refuge for climate-sensitive migrants (4.4, p. 1–3). SAP 4.4 suggests that approaches should be based on considerations such as: "the ecosystem management goals, type and degree of climate effects, type and magnitude of ecosystem responses, spatial and temporal scales of ecological and management responses, and social and economic factors" (4.4, p. 1–3).

Reducing anthropogenic stresses is another option that is a widely accepted response to climate change (4.4, p. B–8). Land use change, increased pollution and invasive species are among the many stresses disturbing the natural ecosystem, exacerbating the affects of climate change (4.3, p.3). Human stressors such as deforestation, dam building, urbanization, and agriculture not only harm resources and ecosystems, but also hinder their ability to cope with climate change. The adaptation report suggests "there is very strong scientific data to show that when human stresses are reduced, the systems recover" (4.4, p. B–8).

Conclusion

The latest CCSP synthesis product on resources (SAP 4.3) indicates a trend toward increased temperatures and decreased precipitation across the western U.S., with drought-like conditions likely to continue and worsen. Water management in the West is likely to become more challenging as water becomes more scarce and variable. The report suggests that the first step preparing for and mitigating future changes is assessing the current situation and identifying where improvements within current hydrologic observing systems are needed. They find that "trends toward increased water use efficiency are likely to continue in the coming decades" and suggests that "declining per capita water consumption will help mitigate the impacts of climate change on water resources." A second recent synthesis product, the adaptation report (SAP 4.4), presents subsequent steps including the increase of ecosystem resilience and the decrease of anthropogenic stresses. As the understanding of climate change increases, so will the ability of humans to prevent, mitigate and adapt to future changes.

References

CCSP, 2007. *About the US Climate Change Science Program*. Accessible at: http://www.climatescience.gov/about/default.htm.

CCSP, 2007. *CCSP Info Sheets*. Accessible at: http://www.climatescience.gov/infosheets/factsheet5/default.htm.

CCSP, 2008: *Preliminary review of adaptation options for climate-sensitive ecosystems and resources. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research.* [Julius, S.H., J.M. West (eds.), J.S. Baron, B Griffith, L.A. Joyce]. U.S. Environmental Protection Agency, Washington, DC, USA, 873 pp.

CCSP, 2008: *The effects of climate change on agriculture,land resources, water resources, and biodiversity. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research.* P. Backlund, A. Janetos, D. Schimel. U.S. Environmental Protection Agency, Washington, DC, USA, 362 pp.

On the Web

- Full copies of SAP 4.3 and SAP 4.4, as well as other final CCSP products, can be found at: http://www.gcrio.org/library/sap-final-reports.htm.
- For more information about the CCSP, visit: http://www.climatescience.gov.

Temperature 08/01/08 – 08/30/08

Monthly average temperatures for August 2008 were highly variable throughout the Intermountain West, ranging between about 50 and 80°F (Figure 2a). Temperatures were generally at or above average throughout **Utah**, with the largest anomalies (>4°F) in the central and southern regions of the state (Figure 2b). Average monthly temperatures exceeded 3°F above average in northwestern **Wyoming** and in the far southwest corner of **Colorado**. Temperatures were slightly below average (-1°F) in the eastern parts of both **Wyoming** and **Colorado**, with significant departures (-3°F) in the northeastern portion of **Colorado**.

Several records were broken for high temperature, heat wave duration, high minimum temperatures and low maximum temperatures according to NWS. Throughout the Intermountain West, the highest average temperatures occurred earlier in the month. In Salt Lake City, **Utah**, 19 consecutive days exceeded 90°F, bringing the total number of summer days exceeding 90°F to 61. Salt Lake City also recorded its hottest day of the year (103°F on August 1). Record high temperatures were also set in Grand Junction, **CO**; Denver, **CO**; Casper, **WY**; Lander, **WY** and many other locations throughout the Intermountain West during the month. Record high minimum temperatures were also recorded throughout **Utah** during the first week of August.

This pattern abruptly changed in the middle of the month, with record low maximum temperatures. For example, on August 15, the high recorded at **Denver** International Airport was 59°F. The previous record for that date was 68°F set 128 years ago (1880). Locations in **Utah** and **Wyoming** also set records for lowest high temperatures. In Utah temperatures increased again beginning on the 22nd, setting record high and record high minimum temperatures throughout the state.

Compared with the pattern of average temperatures from August 2007 (Figure 2c), the average temperatures for 2008 (Figure 2b) are more variable across the Intermountain West. Last year, patterns were similar throughout the region with temperatures approximately 1°F greater than average. For 2008, the range of anomalies was much larger (-4°F and 4°F).

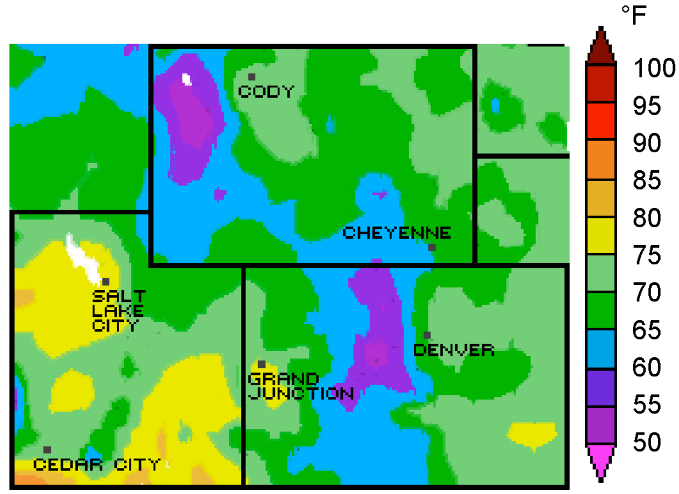


Figure 2a. Average temperature for the month of August 2008 in °F.

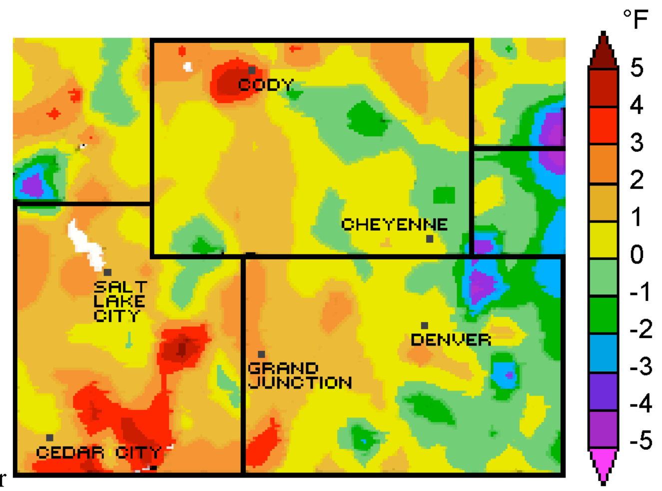


Figure 2b. Departure from average temperature for the month of August 2008 in °F.

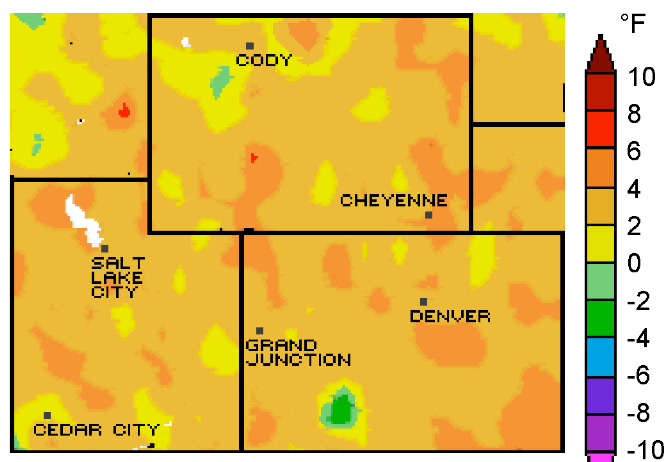


Figure 2c. Departure from average temperature in °F for last year, August 2007.

Notes

Figures 2a–c are experimental products from the High Plains Regional Climate Center. These data are considered experimental because they utilize the most recent data available, which have been subject to minimal quality control. 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 incorrect values in data-sparse regions. For maps with individual station data, please see web sites listed below. *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.

On the Web

- For maps like Figures 2a–c and maps of other climate variables including individual station data, visit: http://www.hprcc.unl.edu/maps/current/.
- 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.
- For current discussions about the El Niño Southern Oscillation (ENSO), visit: http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory/.
- For current Southwest Forecast discussions, visit: http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html.

Precipitation 08/01/08 – 08/30/08

Monthly total precipitation ranged between 0.25 and >3 inches throughout the Intermountain West (Figure 3a). The largest totals were in the eastern half **Colorado**, where precipitation exceeded 3 inches. Throughout **Colorado**, totals exceeded 1 inch, with only few exceptions. Moving eastward through the Intermountain West, precipitation totals declined. In **Wyoming,** totals were typically 1–2 inches, with pockets of precipitation greater and less than this amount. Western **Utah** saw total precipitation measurements of 0.5 inches.

Throughout the region, precipitation fell predominantly in the second half of the month, according to the NWS. During the last week of August, a monsoonal storm front generated record daily maximum rainfall accumulations in **Wyoming** (Lander, 0.56 inches), **Utah** (Hanksville, 0.70 inches), and in several locations in eastern **Colorado**. Consequently, the percent of average monthly precipitation was between 120 and 200% for eastern **Colorado**, the southeast and southwest corners of **Wyoming**, and northeast and central **Utah** (Figure 3b). Precipitation totals were below average in the northeastern part of **Wyoming**, and in small pockets in **Colorado** and **Utah**.

Despite the precipitation in eastern **Colorado**, the area is still below average for the water year (Figure 3c). The far southeast corner of **Colorado** has had 50–70% of average precipitation during the water year. This is an increase over the status as of June 30, where parts of the area were at 50% of average for the water year. This is reflected by changes in the drought severity in the region (see Drought Monitor Page 11). Throughout **Utah** and **Wyoming**, conditions remained relatively unchanged from June, with most areas in these states at or above average for the water year; only the far western area of **Utah** and the southwest corner of **Wyoming** are below average for the water year.

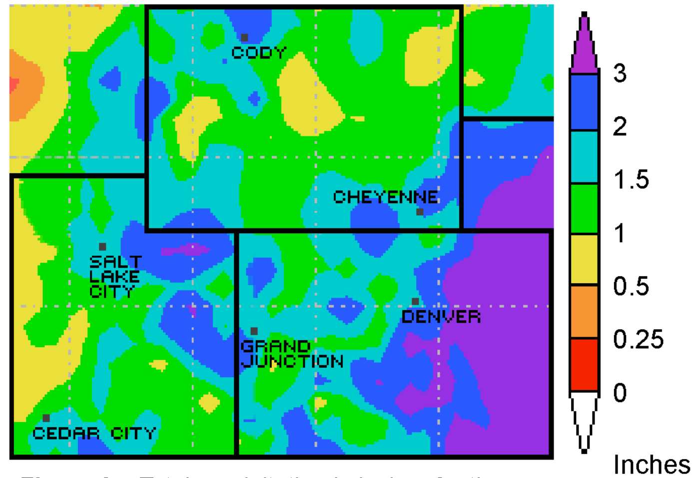


Figure 3a. Total precipitation in inches for the month of August 2008.

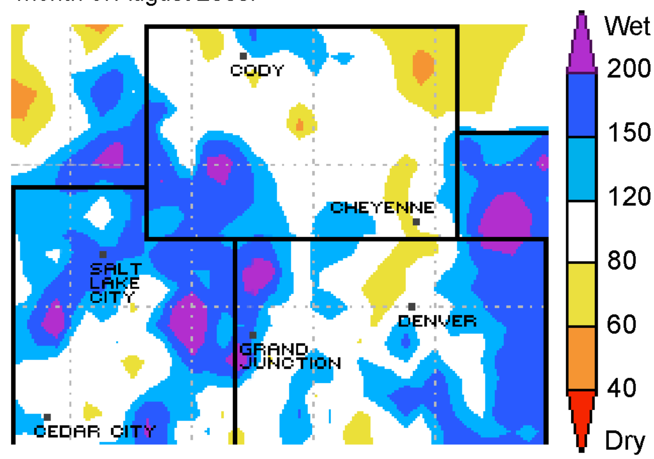


Figure 3b. Percent of average precipitation for the month of August 2008.

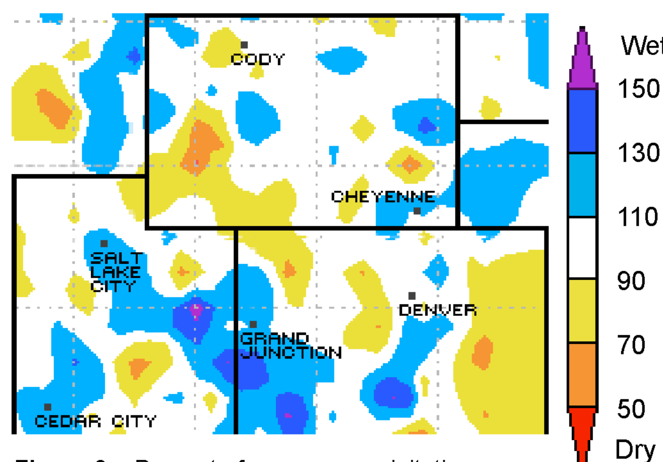


Figure 3c. Percent of average precipitation accumulation since the start of the water year 2008 (Oct. 1, 2007–August 30, 2008).

Notes

The data in Figs. 3 a–c come from the High Plains Regional Climate Center. These data are considered experimental because they utilize the most recent data available, which have been subject to minimal quality control. 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 incorrect values in data- sparse regions. For maps with individual station data, please see web sites listed below. The water year runs from October 1 to September 30 of the following year. The 2008 water year began October 1, 2007 (Figure 3c). The water year better reflects the natural cycle of accumulation of snow in the winter and run-off and use of water in the spring and summer. It is a better period of analysis for presenting climate and hydrologic conditions. Average refers to the arithmetic mean of annual data from 1971–2000. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

On the Web

- For precipitation maps like Figures 3a–c, which are updated daily visit: http://www.cdc.noaa.gov/Drought/.
- For other precipitation maps including individual station data, visit: http://www.hprcc.unl.edu/maps/current/.
- 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/monitoring.html.
- For a list of weather stations in Colorado, Utah, and Wyoming, visit: http://www.wrcc.dri.edu/index.html.

Regional Standardized Precipitation Index data through 08/30/08

The Standardized Precipitation Index (SPI) is used to monitor drought conditions based only on precipitation. The distinguishing traits of this index are that it identifies emerging droughts months sooner than the Palmer Index and that it is computed on various time scales. Three- and 6-month SPIs are useful in short-term agricultural applications. Longer-term SPIs (12 months and longer) are useful in hydrological applications. Although the 3-month SPI shows predominantly dry conditions throughout the Intermountain West (Figure 4a), the 36-month record indicates conditions are average in most areas (Figure 4b).

The above average precipitation in the eastern half of **Colorado** in August contributed to an increase in the 3-month SPI relative to conditions shown in the July IWCS for April–June, particularly in the far eastern climate division where very wet conditions (+1.25 to +1.99) prevail (Figure 4a). The opposite situation applies to western half of the state, where high temperatures and near average precipitation resulted in drier conditions (-1.99 to -1.25). Conditions in **Wyoming** show a decrease in the 3-month SPI compared with the April–June period. The southern half of **Wyoming** is categorized as dry, and the northern climate divisions have changed from moderately/extremely wet to average. Conditions in **Utah** did not change relative to the April–June period, likely because extremely warm temperatures offset high precipitation totals.

The 36-month SPI shows persistent dryness (-1.99 to -1.25) in far western **Utah**, and near normal conditions elsewhere. Precipitation in late August caused a dramatic change in the **Wyoming** 36-month SPI compared with the July 2005–June 2008 period, with wet conditions (+0.75 to +1.24) in the northern regions and near average settings in the rest of the state. For **Wyoming**, the change in the 36-month SPI is consistent with the change in the 3-month index. Throughout **Colorado** conditions continue to be near average.

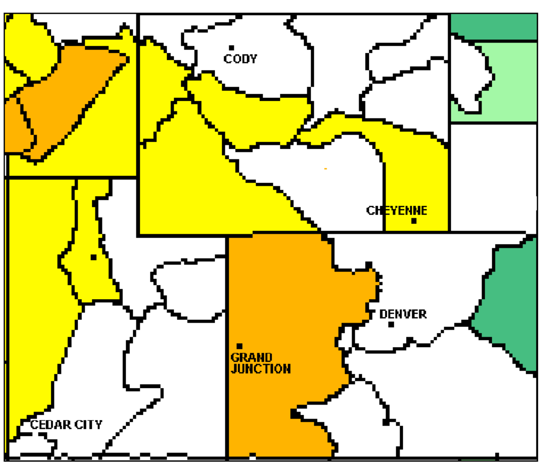


Figure 4a. 3-month Intermountain West regional Standardized Precipitation Index (data from 06/1/08–08/30/08).

Notes

The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed by the NOAA National Climatic Data Center (NCDC) for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought. The Colorado Climate Center describes the SPI as valuable in monitoring both wet and dry periods, and it can be applied to other types of data (e.g. streamflow, reservoir levels, etc.). 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% would be expected to be drier. An index value of -2 means severe drought with only 2.5% of years expected to be drier.

The 3-month SPI uses data for the last three months and represents short-term precipitation patterns (Figure 4a). The 36-month SPI (Figure 4b) compares precipitation patterns for 36 consecutive months with the same 36 consecutive months during all the previous years of available data. The SPI at these time scales reflect long-term precipitation patterns. Figures 4a and b come from the Western Regional Climate Center, which uses data from the NCDC and the NOAA Climate Prediction Center.

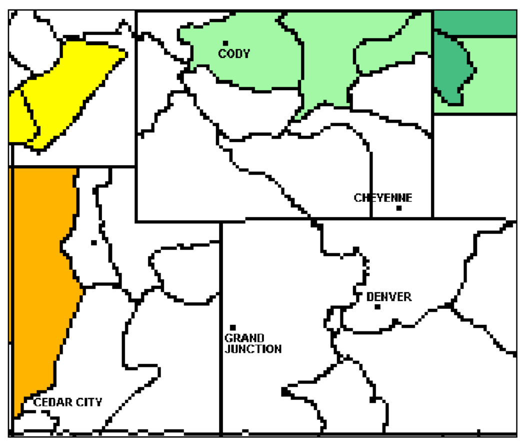


Figure 4b. 36-month Intermountain West regional Standardized Precipitation Index (data from 09/01/05–08/30/08).

	+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

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.
- For SPI products directly form the NCDC, visit: http://lwf.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html. These maps use the same data as Figures 4a and b, but the categories are defined slightly differently.

U.S. Drought Monitor conditions as of 9/16/08

The U.S. Drought Monitor shows that the pattern of drought severity in the IMW has changed in parts of the region since the last Intermountain West Climate Summary in July (Figure 5; see inset). While drought intensity decreased in southeastern Colorado, it increased in northwest Wyoming and western Utah.

August brought above average precipitation to eastern Colorado, which helped the southeastern region move out of any exceptional or extreme drought categories (D4 or D3). Now most of eastern Colorado is in the abnormally dry category (D0), with a small area in the southeastern corner in the moderate to severe drought categories (D2 to D3).

Below average precipitation in August and during the first two weeks of September contributed to an increase in the drought intensity in northwestern Wyoming and parts of western Utah. The northwest corner of Wyoming went from no drought to the abnormally dry category (D0). Likewise, drought intensity expanded in western Utah, moving the region from the abnormally dry to the moderate drought category (D1). Despite these changes, the Drought Monitor discussion states that the dry conditions in the western U.S. are near average for this time of year.

Drought is negatively affecting the agricultural communities in eastern Colorado and western Utah, according to the Drought Impact Reporter. In Colorado, 22 counties in the eastern half of the state were declared national disaster areas on September 16, 2008. This declaration permits affected farmers, ranchers, and other agricultural producers in the disaster-affected counties and in the 18 bordering counties to apply for low-interest emergency loans from the Farm Service Agency (this effectively covers the entire eastern half of the state). Agricultural producers in several counties in western Utah are reporting that they have not received adequate rain all summer and they expect large financial losses due to under production of livestock and feed crops. No impacts were reported in Wyoming.

Notes

The U. S. Drought Monitor (Figure 5) 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 summary's map.

The U. S. Drought Monitor and drought monitor discussion 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 several agencies.

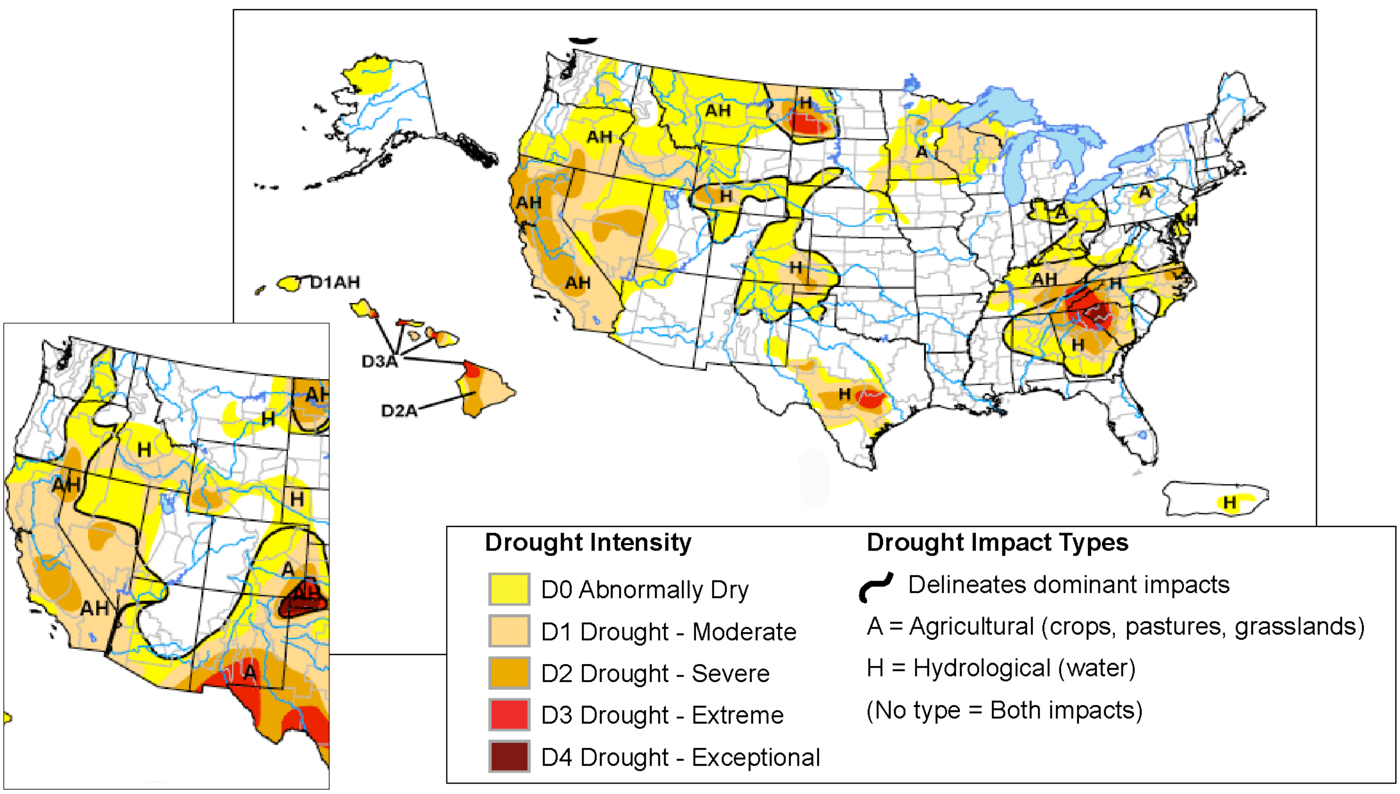


Figure 5. Drought Monitor from September 16, 2008 (full size) and July 15, 2008 (inset, lower left) for comparison.

On the Web

- For the most recent Drought Monitor, released every Thursday, 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/.
- NIDIS Drought Portal: http://www.drought.gov.

Reservoir Supply Conditions

Storage in most reservoirs shown in Figure 6 decreased during August because inflows slowed while releases increased. The only exception was Turquoise Lake in **Colorado**, which was 77% full on July 6 and 81% full on August 30. A decrease in storage during this time of year is typical, and nine of the 14 reservoirs featured in Figure 6 increased their percent of average capacity since early July. Most of these increases were about two percentage points, but Buffalo Bill Reservoir in **Wyoming** increased by 15 percentage points.

The Upper Colorado Region of the Bureau of Reclamation (Reclamation) provides some interesting information about several of the large reservoirs that are featured in Figure 6. **Fontenelle** and **Flaming Gorge** were two of the reservoirs that decreased their percent of average storage. The total April–July inflows to these reservoirs were 68% and 61% of average. Despite below average inflows, **Fontenelle** still filled and released bypass flows for 11 days. Bypass flows are common for **Fontenelle**, because the annual flows significantly exceed storage capacity. The end-of-year storage in **Flaming Gorge** is projected to be 80% of average.

The April–July inflows to **Lake Powell** were 111% of average, and the reservoir is at 61% of capacity. Reclamation anticipates steady releases from Lake Powell during September and October, which falls under the Equalization Tier of the Interim Guidelines. Their goal is to maintain Lake Mead at its current level, 11.99 maf (46% of capacity).

Blue Mesa Reservoir had 140% of average inflows for April–July. Because above average inflows have been projected since at least April, Reclamation was able to plan for an early, above average peak storage and release. The high storage occurred on July 31 and stood only 4.5 feet below full pool elevation. The storage is currently 87% of capacity and decreasing, as inflows are about 710 cfs and the release rate is 2100 cfs.

Reservoir	Current Storage (KAF)	Total Capacity (KAF)	% Full	% of Average
Colorado				
Dillon Reservoir	253.5	254.0	100%	111%
Turquiose Lake	105.4	129.4	81%	91%
Lake Granby	434.8	539.7	81%	107%
Blue Mesa Res.	725.7	829.5	87%	107%
Pueblo	186.9	354.0	53%	139%
Utah				
Strawberry Res.	935	1,106.5	85%	138%
Utah Lake	686	870.9	79%	95%
Bear Lake	373.8	1302.0	29%	43%
Lake Powell	14803.6	24322.0	61%	74%
Wyoming				
Fontenelle Res.	383.9	344.8	82%	104%
Flaming Gorge Res.	3054.8	3749.0	81%	93%
Seminoe Res.	562.4	1017.2	55%	90%
Boysen Res.	663.6	741.6	85%	112%
Buffalo Bill Res.	661.5	644.1	97%	142%

KAF = Thousands of Acre Feet

Notes

The size of each "tea-cup" is proportional to the size of the reservoir, as is the amount the tea-cup is filled (Figure 6). The first percentage shown in the table is the current contents divided by the total capacity. The second percentage shown is the current contents divided by the average storage for this time of year (not shown). Reservoir status is updated at different times for individual reservoirs.

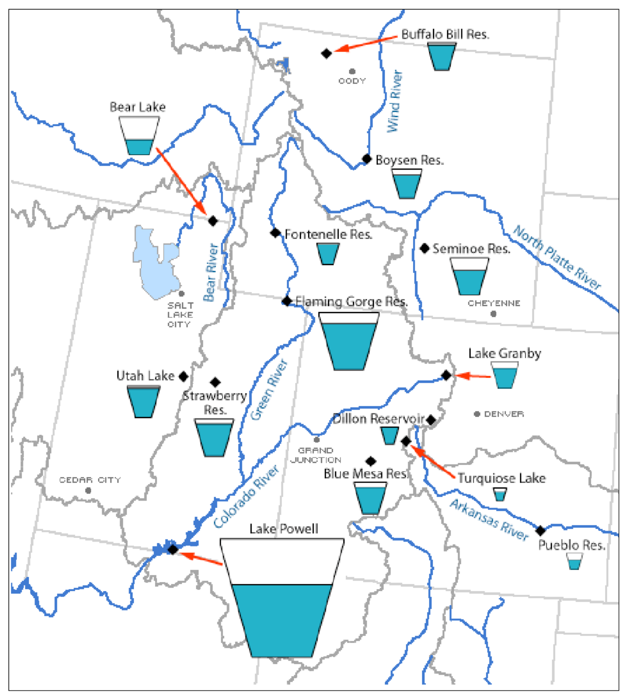


Figure 6. Tea-cup diagram and table of several large reservoirs in the Intermountain West Region. All reservoir content data is from August 30, 2008.

On the Web

- For individual reservoir information including management agency, operations, and storage content, visit the WWA website at: http://wwa.colorado.edu/products/forecasts_and_outlooks/intermountain_west_climate_summary/links.html, and click on individual links. The NOAA/NWS Seasonal Runoff Volume Forecast website is: http://www.cbrfc.noaa.gov/westernwater.
  - For individual site-specific streamflow forecasting information, click on desired region and drag mouse over square box.
  - For individual forecast point plot graphs click on the desired square box.
- For monthly reports from NRCS on water supply conditions & forecasts for major CO river basins, visit: http://www.wcc.nrcs.usda.gov/cgibin/bor.pl.
- For water Supply Outlook for the Upper Colorado River Basin, produced by the CBRFC at: http://www.cbrfc.noaa.gov/wsup/wsup.cgi.

Colorado Water Availability

As of September 3, 2008, streamflows were near to above average throughout most of Colorado. The majority of the USGS streamflow sites in western Colorado had flows in the average (25–75th percentile) to the above average (75–90th percentile) categories (Figure 7a). Some of the highest streamflows were reported in the northwest, where the Little Snake River near Lily, had streamflows in the 96th percentile, and in the southeast where Purgatoire River near Thatcher had streamflows in the 97th percentile. Flows in the Animas River Basin in the southwest were also in the above average category (75–89th percentile). The lowest streamflow reported (15th percentile) was at the southwest in the Uncompahgre River near Ridgeway.

This month two new graphics of current soil moisture conditions are presented. Both are near-real time daily analysis of hydrologic conditions from the VIC hydrologic model at the University of Washington (Figures 7b and c; see Notes). As of September 1, 2008, most of Colorado had above average soil moisture (>70th percentile, Figure 7b), most likely due to above average precipitation during August, particularly during the last week of the month. The highest soil moisture (95–99th percentile) calculated was in south-central Colorado and the lowest soil moisture was in the near average category (30–70th percentile) in central Colorado.

The second new graphic shows changes in soil moisture by percentiles. During the week of August 28 to September 4, soil moisture decreased (-5 to -25 in percentiles, depending on the area) i.e., dried somewhat, in central and northeastern Colorado (Figure 7c). In contrast, soil moisture increased during the same time period in small areas in western and southern Colorado (+5 to +35 change in percentiles).

Notes

The average streamflow conditions for 7 consecutive days are compared to streamflows during the same time period in past years (Figure 7a). The “near normal” or 25–75th percentile range indicates 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. These data are provisional and may be subject to significant change.

The estimates of soil moisture and the change in soil moisture conditions (Figures 7b and 7c) are calculations from University of Washington’s VIC hydrologic model. VIC is a macroscale hydrologic model that solves full water and energy balances. It is driven by observed daily precipitation and temperature maxima and minima from approximately 2130 stations, selected for reporting reliably in real-time and for having records of longer than 45 years (and various other criteria). The model output provides a near real-time daily analysis of hydrologic conditions throughout the continental U.S.

The soil moisture map (Figure 7b) shows conditions on the day indicated (e.g. Sept 1st) based on observed temperature and precipitation compared to 1915–2003 climatology. The 30–70th percentile range is considered near average (white areas), and indicates that soil moisture is in the same range as 30–70% of past years. Green shading indicates wet soil moisture >70th; orange is drier than average, <30th percentile. The change in soil moisture map (Figure 7c) shows the change in percentiles between two dates, one week apart. A change from -5 to +5 is considered insignificant (white areas), whereas an increase in more than +5 indicates wetter conditions (blues) and a decrease in more than -5 indicates drier conditions (browns).

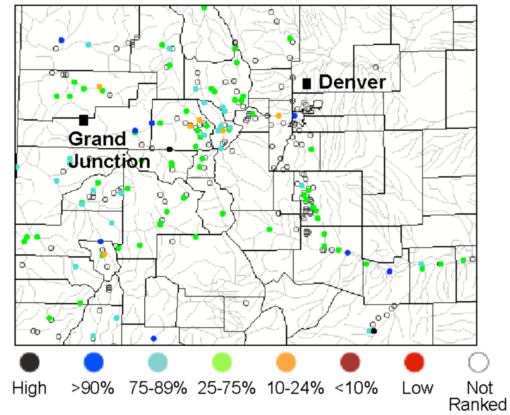


Figure 7a. 7-day average streamflow conditions for points in Colorado as of September 3, 2008 recorded at USGS gauging stations.

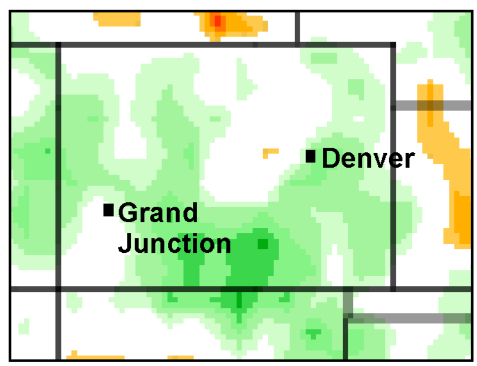
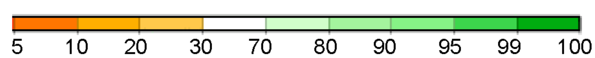


Figure 7b. Calculated daily soil moisture for Colorado as of September 1, 2008, in percentiles relative to the climatological period 1915-2003.



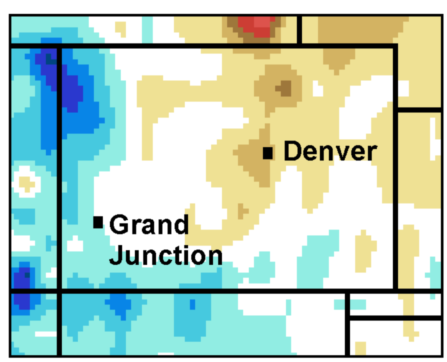
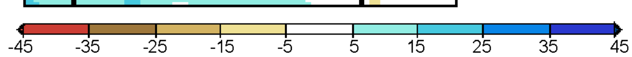


Figure 7c. Change in soil moisture percentiles for the week of August 28, 2008 to September 4, 2008.



On the Web

- See Utah or Wyoming water availability pages for links to graphics on this page.
- The Colorado SWSI along with more data about current water supply conditions for the state can be found at: http://www.co.nrcs.usda.gov/snow/fcst/watershed/current/monthly/maps_graphs/index.html.
- The Colorado Water Availability Task Force information, including agenda & minutes of meetings is available at: http://cwcb.state.co.us/Conservation/DroughtPlanning/WaterAvailabilityTaskForce/MeetingAgendasPresentations/

Wyoming Water Availability

As of September 3, 2008, streamflows were closer to average than they were in the last IWCS in beginning of July. The majority of the USGS streamflow sites in Wyoming were near to above average (25th – 89th percentile; Figure 8a). Some sites scattered across the state reported below average conditions (10th – 24th percentile). The highest streamflow reported (90th percentile) was in the Encampment River, in the south-central North Platte River Basin . The lowest streamflow reported (13th percentile) was at Pine Creek in central Wyoming.

This month two new graphics of current soil moisture conditions are presented. Both are near-real time daily analysis of hydrologic conditions from the VIC hydrologic model at the University of Washington (Figures 8b and c; see Notes). As of September 1, 2008, soil moisture was below average to near average (<70th percentile) across the state (Figure 8b). Some areas in eastern and southeast Wyoming had extremely dry conditions, with soil moistures in the 1st–5th percentiles.

The second new graphic shows changes in soil moisture by percentiles. These same areas showed a large decrease in soil moisture percentiles (>35 percentile decrease) during the week of August 28 to September 4, 2008 (Figure 8c). Other areas in the state did not have as large of changes in soil moisture percentiles, although northern and western Wyoming did show increases in soil moisture as high as 15–25 percentiles.

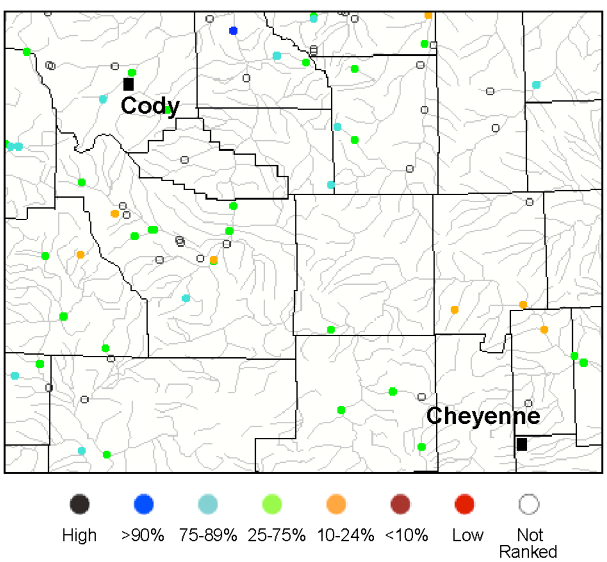


Figure 8a. 7-day average streamflow conditions for points in Wyoming as of September 3, 2008 recorded at USGS gauging stations.

Notes

The average streamflow conditions for 7 consecutive days are compared to streamflows during the same time period in past years (Figure 9a). The "near normal" or 25–75th percentile range indicates 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. These data are provisional and may be subject to significant change.

The estimates of soil moisture and the change in soil moisture conditions (Figures 9b and 9c) are calculations from University of Washington's VIC hydrologic model. VIC is a macroscale hydrologic model that solves full water and energy balances. It is driven by observed daily precipitation and temperature maxima and minima from approximately 2130 stations, selected for reporting reliably in real-time and for having records of longer than 45 years (and various other criteria). The model output provides a near real-time daily analysis of hydrologic conditions throughout the continental U.S.

See Colorado water availability page for a more detailed description of figures 8b and c.

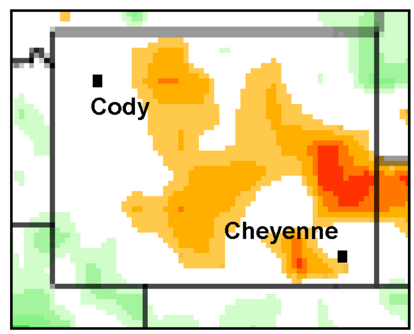
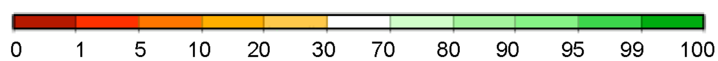


Figure 8b. Moisture Calculated daily soil moisture for Wyoming as of September 1, 2008, in percentiles relative to the climatological period 1915-2003



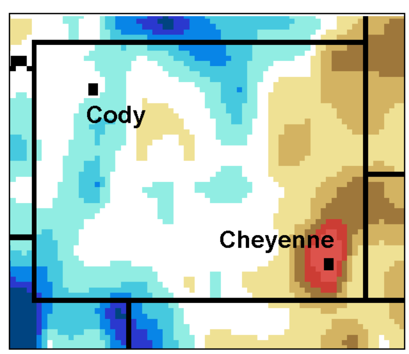
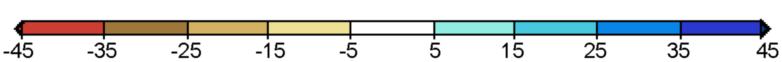


Figure 8c. Change in soil moisture percentiles for the week of August 28, 2008 to September 4, 2008.



On the Web

- For current streamflow information from USGS, Figure 9a, visit: http://water.usgs.gov/waterwatch/.
- For current soil moisture calculations from the Univ of Washington, Figures 9b and 9c, visit: http://www.hydro.washington.edu/forecast/monitor/.
  - -For current soil moisture estimates, select "VIC~CPC" in the "Current Conditions" under "Soil Moisture".
  - -For changes in soil moisture, select either 1 wk (shown on this page), 2 wk or 1 mo in the "Recent Changes" row, "Soil Moisture" column.
- The Lake Powell Status Summary is updated at the first of each month and is available at http://www.usbr.gov/uc/.
- Wyoming Water Resource Data system's drought page is located at: http://www.wrds.uwyo.edu/wrds/wsc/dtf/drought.html

Utah Water Availability

As of September 3, 2008, streamflows were near average across most of the state. Most of the streamflow sites reported near average conditions (25th – 75th percentile), with some exceptions (Figure 9a). One location reporting conditions in the above average category (93rd percentile) was Weber River near Coalsville, in the northern part of the state. The lowest streamflow reported (4th percentile), was in the Virgin Basin in southwestern Utah.

This month two new graphics of current soil moisture conditions are presented. Both are near real-time daily analysis of hydrologic conditions from the VIC hydrologic model at the University of Washington (Figures 9b and c; see Notes). As of September 1, 2008, soil moistures were near average (30th – 70th percentile) to above average (>70th percentile) across most of Utah (Figure 9b). Far northwestern Utah was the only location with below average soil moistures (20th – 30th percentile).

The second new graphic shows changes in soil moisture by percentiles. Above average precipitation during the month of August lead to increases in soil moisture percentiles across most of the state during the week of August 28 to September 4, 2008 (Figure 9c). Some areas in central Utah increased in percentiles by 35 or more. The only area to show a decrease in percentiles was southwestern Utah, where percentiles dropped by 5–15.

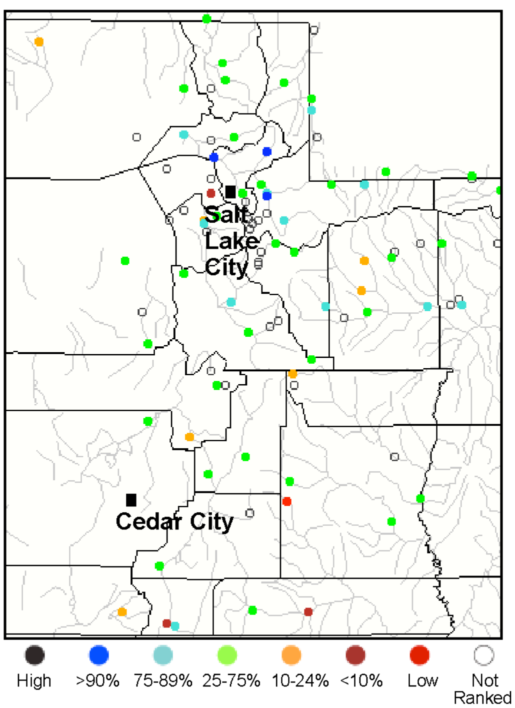


Figure 9a. 7-day average streamflow conditions for points in Utah as of September 3, 2008, recorded at USGS gauging stations.

Notes

The average streamflow conditions for 7 consecutive days are compared to streamflows during the same time period in past years (Figure 8a). The "near normal" or 25–75th percentile range indicates 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. These data are provisional and may be subject to significant change.

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See Colorado water availability page for a more detailed description of figures 9b and c.

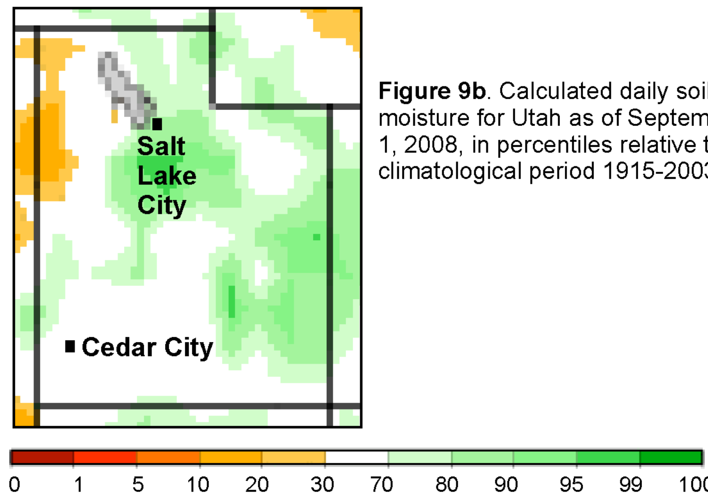


Figure 9b. Calculated daily soil moisture for Utah as of September 1, 2008, in percentiles relative to the climatological period 1915-2003.

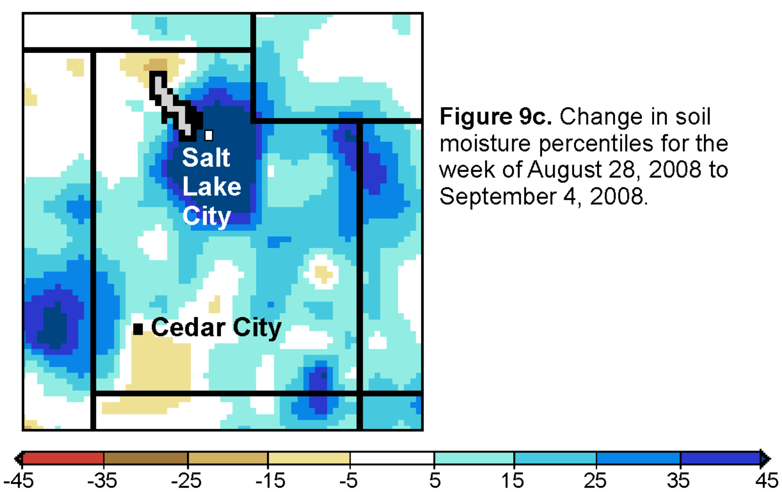


Figure 9c. Change in soil moisture percentiles for the week of August 28, 2008 to September 4, 2008.

On the Web

- For current streamflow information from USGS, Figure 8a, visit: http://water.usgs.gov/waterwatch/.
- For current soil moisture calculations from the Univ of Washington, Figures 8b and 8c, visit: http://www.hydro.washington.edu/forecast/monitor/.
  -For current soil moisture estimates, select "VIC~CPC" in the "Current Conditions" under "Soil Moisture".
  -For changes in soil moisture, select either 1 wk (shown on this page), 2 wk or 1 mo in the "Recent Changes" row, "Soil Moisture" column
- The Lake Powell Status Summary is updated at the first of each month and is available at http://www.usbr.gov/uc/.

Temperature Outlook October 2008 – January 2009

The latest temperature outlooks for October 2008 from the NOAA Climate Prediction Center indicate a slightly enhanced risk of above average temperatures in the southernmost border of **Utah**, **Arizona**, and New Mexico, and equal chances for above-, near-, or below-average temperatures for the rest of the Intermountain West. This is due mostly to early autumn temperature trends in the Southwestern U.S. as indicated in statistical forecast tools (Figure 10a).

In the October–December (OND) and November 2008– January 2009 (NDJ) seasons, the entire Intermountain West has an increased chance of above average temperatures as part of a region that extends across much of the western and central U.S. in OND, and all but the coasts in NDJ (Figures 10b–c). The expectations for above average temperatures during the upcoming seasons are largely due to recent temperature trends; ENSO conditions are neutral and have little influence on the CPC outlooks.

The October 2008 precipitation forecast will be updated on September 30th on the CPC web page. Because of the shorter lead-time, the "zero-lead" forecast (i.e. on the last day of the previous month) often has increased skill over the half-month lead forecasts shown here. The Seasonal Temperature Outlooks are updated on the third Thursday of the month, and the next one will be issued on October 16th.

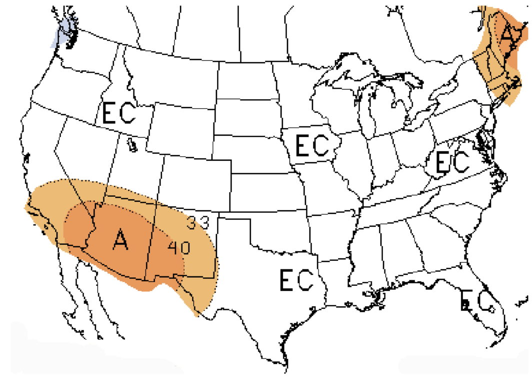


Figure 10a. Long-lead national temperature forecast for October 2008 (released Sept. 18, 2008).

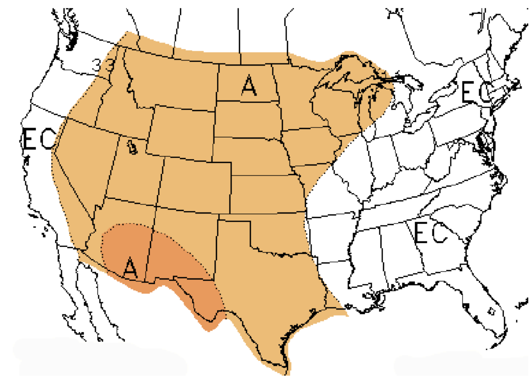


Figure 10b. Long-lead national temperature forecast for October – December 2008 (released Sept. 18, 2008).

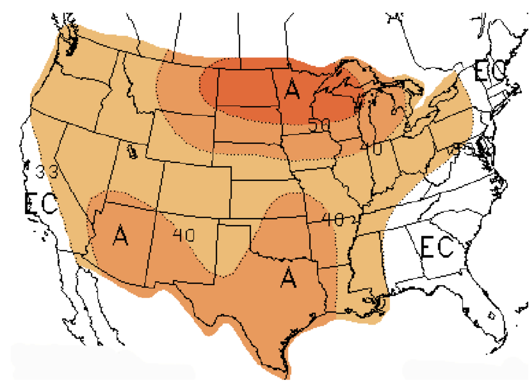


Figure 10c. Long-lead national temperature forecast for November 2008 – January, 2009 (released Sept. 18, 2008).

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

Notes

The CPC seasonal temperature outlooks predict the likelihood (percent chance) of temperatures occurring in the above-average, near-average, and below-average categories. The numbers on the maps do not refer to actual temperature values, but to the probability, in percent, that temperatures will be in one of these three categories. The skill of the temperature outlooks largely comes from the status of ENSO and recent trends. The categories are defined based on the 1971–2000 climate record; each 1- or 3-month period is divided into 3 categories (terciles), indicating the probabilities that the temperature in the period will fall into the upper third of the years (upper tercile), the middle third of the years (middle tercile, or around average), or the lowest third of the years (lower tercile). The forecast map depicts the probability that temperature will be in the above-average (A, orange shading) or below-average (B, blue shading) tercile--with a corresponding decrease in the opposite category. The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high. Equal Chances (EC) represents equal chances or a 33.3% probability for each tercile, indicative of areas where signals are weak or conflicting and the reliability (i.e., 'skill') of the forecast is poor. For a more detailed description, see notes on the precipitation outlook page.

On the Web

- For more information and the most recent forecast images, visit: http://www.cpc.ncep.noaa.gov/products/predictions/90day/. 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 October 2008 – January 2009

The CPC precipitation outlook for October 2008 (Figure 11a) through November 2008–January 2009 (Figure 11b-c) shows "EC" or equal chances for above-, near-, or below-average precipitation for the interior West and for much of the country, except for a slight increase in the chance of below average precipitation in the southwest, including the southernmost border of **Utah**, **Arizona** and New Mexico. These anomalies are derived from the consolidation forecast (CON, see feature article in the June 2008 Summary). EC indicates that no skillful information on precipitation.

Another exception is the expected above-average precipitation expected along the Gulf coast and Florida. According to CPC, above average precipitation is expected because of the continuing, multi-decadal period of enhanced tropical cyclone activity, and by the active Atlantic hurricane season thus far. This outlook is also due to the fact that climatologically, October tropical cyclones tend to form in the Caribbean and Gulf of Mexico.

The October 2008 precipitation forecast will be updated on September 30th. on the CPC web page. Because of the shorter lead-time, the "zero-lead" forecast (i.e. on the last day of the previous month) often has increased skill over the half-month lead forecasts shown here. The Seasonal Outlooks are updated on the third Thursday of the month, and the next one will be issued on October 16th.

Notes

The seasonal precipitation outlooks predict the likelihood (percent chance) of precipitation occurring in the above-average, near-average, and below-average categories. The numbers on the maps do not refer to actual precipitation values, but to the probability in percent that precipitation will be in one of these three categories. The categories are defined based on the 1971–2000 climate record; each 1- or 3-month period is divided into 3 categories (terciles), indicating the probabilities that the precipitation in the period will fall into the upper third of the years (upper tercile), the middle third of the years (middle tercile, or around average), or the lowest third of the years (lower tercile), 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 occurring in the below-average (B, brown shading) or above-average (A, green shading) --with a corresponding decrease in the opposite category, The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high.

Thus, areas with dark brown shading indicate a 40.0–50.0% chance of below-average, a 33.3% chance of near-average, and a 16.7–26.6% chance of above-average precipitation. Light brown shading displays a 33.3–39.9% chance of below-average, a 33.3% chance of near-average, and a 26.7–33.3% chance of above-average precipitation and so on. Equal Chances (EC) represents equal chances or a 33.3% probability for each tercile, indicative of areas where signals are weak or conflicting and the reliability (i.e., 'skill') of the forecast is poor. "N" indicates an increased chance of near-average conditions, but is not forecast very often.

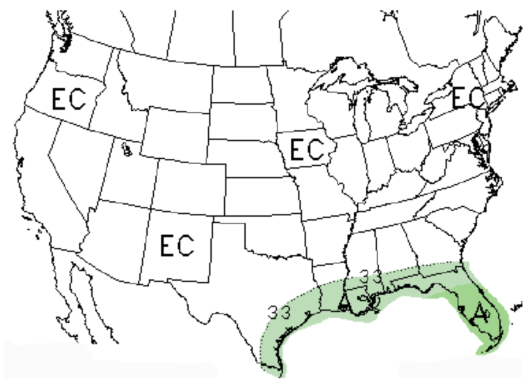


Figure 11a. Long-lead national precipitation forecast for October (released September 18, 2008).

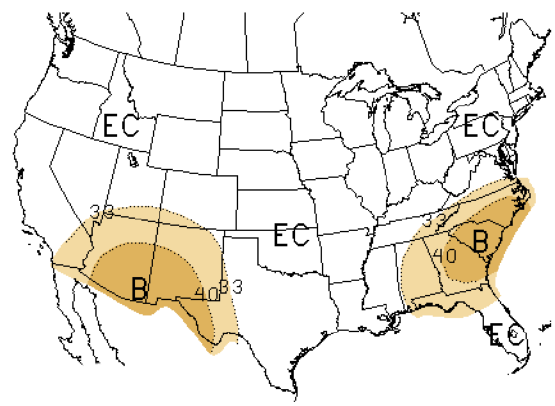


Figure 11c. Long-lead national precipitation forecast for Nov. – Jan. 2009 (released July 17, 2008).

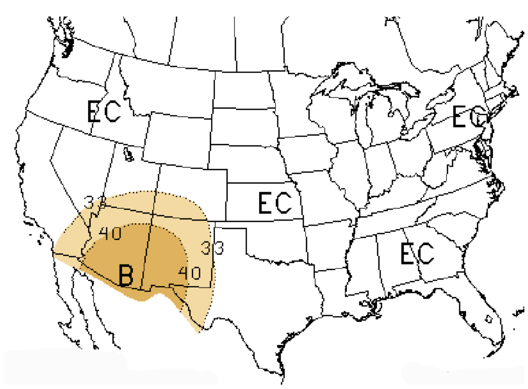
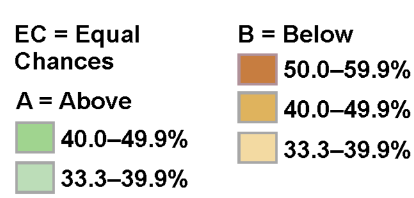


Figure 11b. Long-lead national precipitation forecast for Oct.– Dec. 2008 (released September 18, 2008).



Precipitation Outlook cont.

Compared to July, the last six weeks have brought much cooler and wetter weather to eastern **Colorado** in particular, which has ameliorated drought in that area. The next two weeks appear on track for more stable fall-like weather, especially during the last week of September.

The experimental forecast guidance for October–December is somewhat dry from **Arizona** and New Mexico into southern **Utah** and **Colorado** (Figure 11d), hinting at the return of atmospheric circulation anomalies with a La Niña footprint. While August and early September bucked this dry trend, a rapid transition into El Niño and its associated fall wetness in much of the southwestern U.S. is highly unlikely. A first look at the late winter season, January–March 2009, projects an enhanced risk for dry conditions in Arizona and northeastern Colorado, while leaving the door open for an 'average' to wet winter from New Mexico northwestward into western **Colorado** and northern **Utah** (Figure 11e). This first look at the winter season shows the possibility of at least adequate moisture (i.e. around average conditions) in the mountains of **Utah, Colorado** and New Mexico.

For a discussion of the verification of the summer forecast, see Klaus Wolter's experimental guidance webpage (see On the Web). This outlook is based on a variety of forecast indicators that include near-coastal SST in the Gulf of Mexico and eastern Pacific in particular in addition to ENSO conditions. This forecast is one of those included in discussions to develop the CPC offical outlooks. A more detailed discussion of these forecasts will be updated on the web by September 24th, 2008.

Notes

The experimental guidance for seasonal future precipitation (in Figure 11c) shows the most recent forecast of shifts in tercile probabilities precipitationfor October–December 2008. 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 signifi cant. Positive (negative) shifts between three and fi ve percent are indicated by a green (red) plus (minus) sign, while minor shifts of one or two percent are left blank in this display.

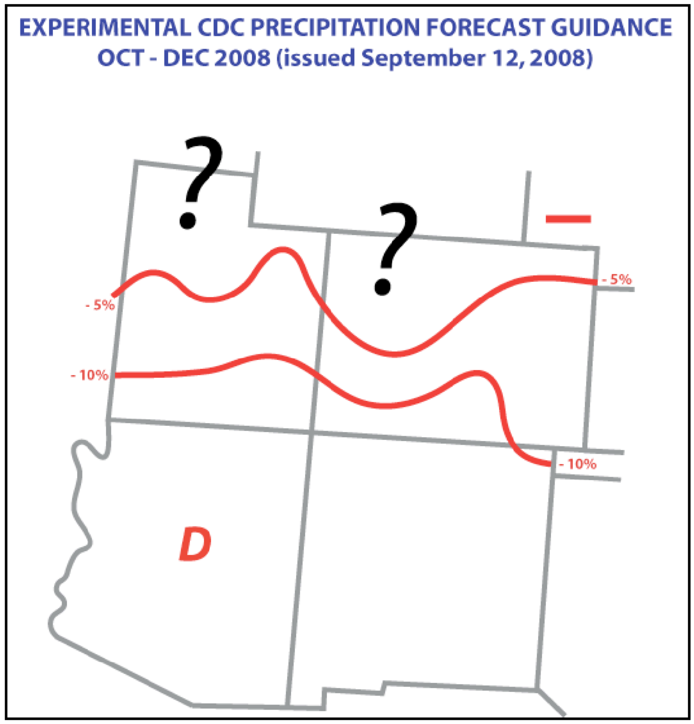


Figure 11d. Experimental precipitation forecast guidance. Forecasted shifts in tercile probabilities for October–December 2008.

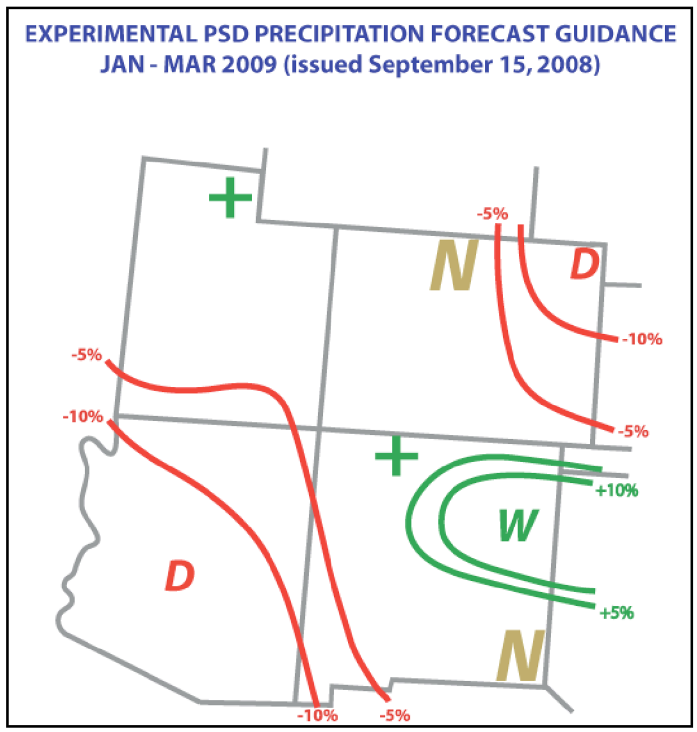


Figure 11e. Experimental precipitation forecast guidance. Forecasted shifts in tercile probabilities for January - March 2009.

On the Web

- For more information and the most recent CPC forecast images, visit: http://www.cpc.ncep.noaa.gov/products/predictions/90day/. 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 precipitation 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.
- The NOAA/ESRL experimental guidance product (figure 11c) 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 October 2008

According to the U.S. Drought Monitor (page 11), hydrologic drought conditions have persisted since earlier in the summer across a swath of central **Wyoming**, most of **Colorado** east of the Continental Divide, and along the western border of **Utah**. The U.S. Seasonal Drought Outlook (DO) builds on the DM categories to project how these drought areas might change or where new drought areas might develop. The DO issued September 18th, projects that drought is likely to persist or intensify in southwestern Wyoming, and projects some improvement in southeastern Colorado over the next three months. These projections indicate at least a one-category change in drought status.

The DO provides the following basis for the area of some improvement in southeastern Colorado: "little rain is expected for days 1-5 while medium and longer range forecasts show near normal precipitation or equal chances for above/below. Soil moisture anomaly change indicators are mixed and weak. The seasonal CFS precipitation forecast for Oct-Nov-Dec shows a slight tilt of the odds towards drier than normal." The confidence in this outlook for eastern Colorado/southwest Kansas is "Moderate"

Monsoon rains typically continue into September, then precipitation decreases in October and November. In Colorado recent rains have reduced the Drought Monitor drought category near Denver to DO (anomalously dry), and there is no indication of continued drought in this area in the DO. Also, there are no new areas of drought development elsewhere in the Interior West indicated in this DO. The next Seasonal Drought Outlook will be issued in two weeks, on October 2nd.

Notes

The Seasonal Drought Outlook (DO) depicts general, large-scale trends from that date through the end of the forecast period (3 to 3.5 months, depending on the date of issue). The delineated areas in the DO (Figure 12) are defined subjectively based on expert assessment of numerous indicators described above, including outputs of short- and long-term forecasting models. Areas of continuing drought are schematically approximated from the Drought Monitor (D1 to D4). For weekly drought updates, see the latest Drought Monitor text on the website (updated weekly) see: 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.

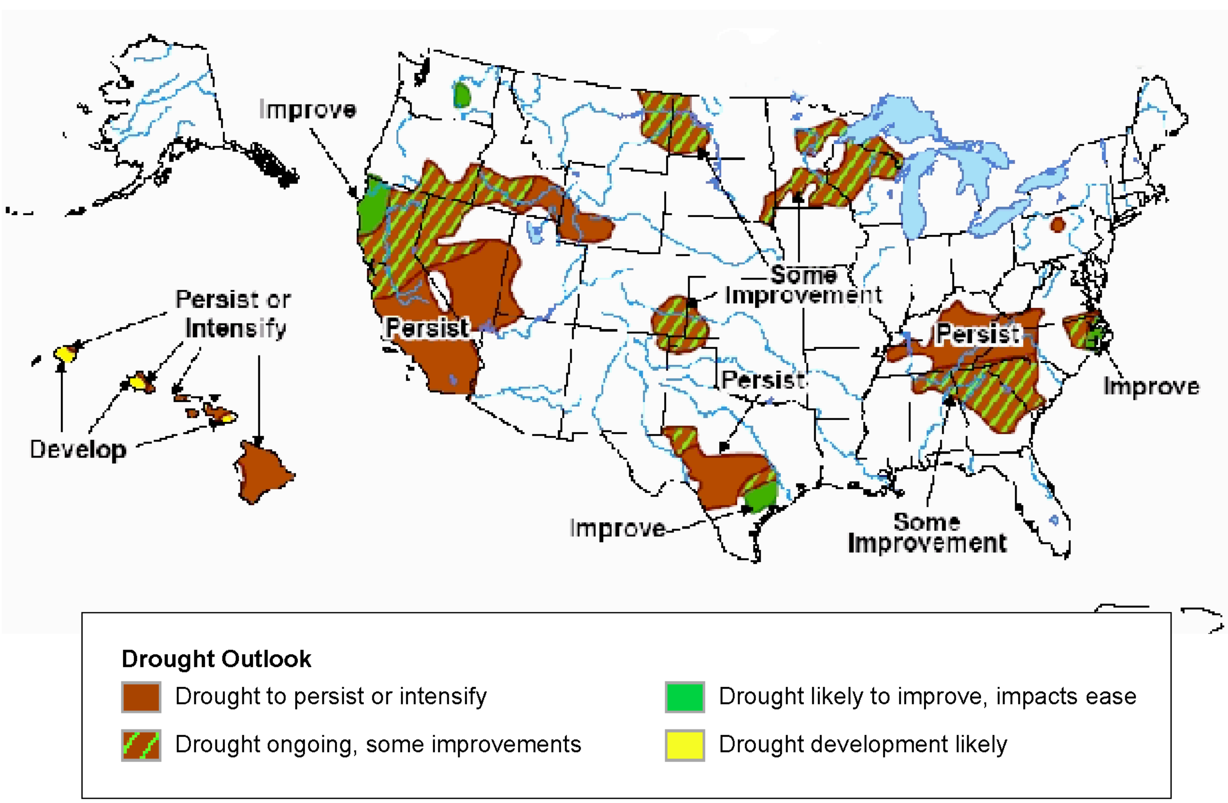


Figure 12. Seasonal Drought Outlook for September 18, 2008–December 2008.

On the Web

- For more drought information, visit: http://www.drought.noaa.gov/.
- Forecasts of drought termination probabilities can be found at: http://www.ncdc.noaa.gov/oa/climate/research/drought/current.html.

El Niño Status and Forecast

The equatorial Pacific returned to ENSO neutral conditions during June 2008, and continued through August 2008 (Figure 13a), according to NOAA and its partner the International Research Institute for Climate and Society (IRI). Although ENSO-neutral conditions have been in place since June 2008, the atmospheric circulation over the western and central tropical Pacific continues to reflect lingering aspects of La Niña.

The dynamical and statistical model forecasts issued during late August and early September 2008 are largely in agreement regarding ENSO-neutral conditions throughout the forecast period (Figure 13b). Based on current atmospheric and oceanic conditions, recent trends, and model forecasts, ENSO-neutral conditions are expected to continue through the end of 2008. While the model spread continues to include the possibility of an El Niño, the decrease in subsurface and surface temperatures makes this outcome unlikely during the next several months. There is also the possibility of a La Niña.

Based on model forecasts and current observations of the ocean surface and subsurface, there is a 80% probability of ENSO-neutral conditions persisting over the Aug–Oct season in progress, the probability of La Niña conditions is estimated at 5%, of El Niño conditions 15%.

Observed Sea Surface Temperature Anomalies (C°)

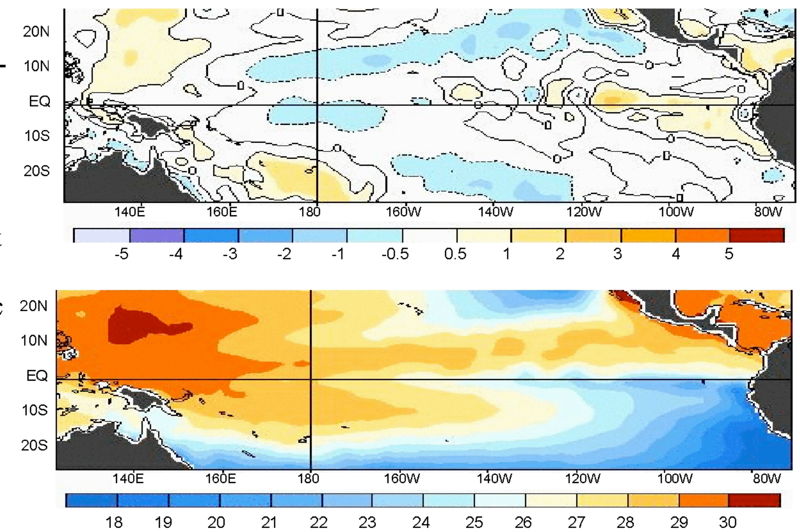


Figure 13a. Observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. The Niño 3.4 region encompasses the area between 120°W–170°W and 5°N–5°S. The graphics represent the 7-day average centered on September 10, 2008.

Notes

Two NOAA graphics in Figure 14a show observed SST (upper) and SST anomalies (lower) in the Pacific Ocean, averaged over a recent 7-day period. Data are from satellite observations and the NOAA TAO array of 70 moored buoys spread out over the Pacific Ocean, centered on the equator. The buoys measure temperature, currents, and winds and transmit data in real-time. NOAA uses these observations to predict short-term (a few months to one year) climate variations.

Figure 14b shows forecasts for SST forecastsin the Niño 3.4 region for nine overlapping 3-month periods. “Niño 3.4” refers to the region of the equatorial central Pacific from 120°W to 170°W and 5°N to 5°S, which is used as an SST-based index for defining ENSO. Abbreviations represent groups of three months (e.g. SON = Sept–Nov). The expected skills of the models, based on historical performance, vary among the models, and skill generally decreases with lead-time. Forecast skill also varies over the year because of seasonal differences in predictability of SSTs, e.g., forecasts made between June and December are generally better than those made between February and May (the spring predictability “barrier”). Differences among model forecasts in Figure 13b reflect differences in model design, which in turn reflect uncertainty in the forecast of the possible future SST scenarios.

Model Forecasts of ENSO from September 2008

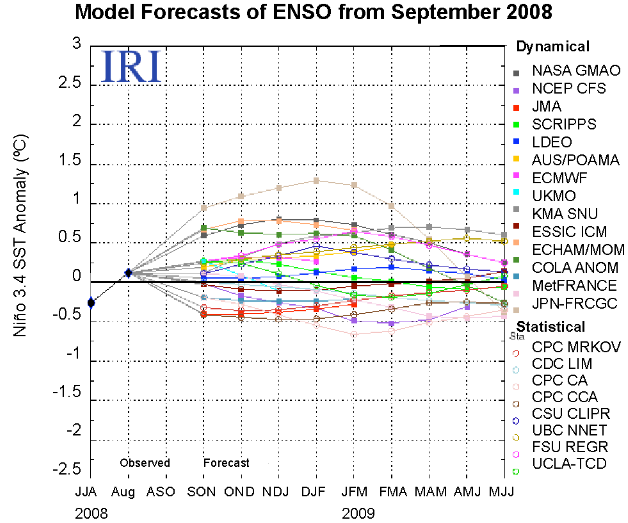


Figure 13b. Forecasts made by dynamical and statistical models for sea surface temperatures (SST) in the Niño 3.4 region for nine overlapping 3-month periods from September 2008–July 2009 (released September 18, 2008). Forecast graphic is from the International Research Institute (IRI) for Climate and Society.

On the Web

- For a technical discussion of current El Niño conditions, visit the ENSO Diagnostic Discussion, a collaborative effort of the several parts of NOAA, including the research labs, the IRI, and other institutions funded by NOAA: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ (updated on the second Thursday of the month).
- For updated graphics of SST and SST anomalies like figure 13a, 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 Niño, including the most recent forecasts (Figure 13b), visit: http://portal.iri.columbia.edu/climate/ENSO/. The “forecast plume” showing multiple model projections is updated on the third Thursday of the month.
- The Multivariate ENSO Index is available at: http://www.cdc.noaa.gov/people/klaus.wolter/MEI/.

Monthly and Annual "State of the Climate" Reports from the National Climatic Data Center

By Kristen Averyt , WWA

The National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) issues monthly and annual reports on the state of the climate in the United States. These reports place temperature, precipitation and other physical observations related to climate in a historical context. Key climate hazards and extreme events (e.g. drought, floods and hurricanes) across the US are highlighted and placed within a global framework (Figure 14a). Monthly reports are released on the 15th of the subsequent month, and annual reports are typically released by January 15th of the following year.

Monthly Reports

One can access the most recent monthly NCDC report by going to http://www.ncdc.noaa.gov/oa/climate/research/monitoring.html, selecting "state of the climate" tab and "latest report". Here major weather events are highlighted in a straightforward style. For example, for July 2008, the headline statement is "U.S. Temperature Above Normal in July, Fifth Warmest July on Record for Globe. Other notable information is also outlined and includes the following:

1. U.S. Temperature Highlights
2. U.S. Precipitation Highlights
3. Midwest U.S. Flooding
4. U.S. Wildfires
5. Other U.S. Events (including tornadoes, hurricanes and tropical storms)
6. Global Temperatures
7. Global Highlights (such as El Niño)
8. Other Key Global Events (major storms)

Additional discussions regarding the monthly climatology can be accessed through links at the bottom of the summary page. These subsections include global analyses of many observational datasets, a listing of global hazards, an enhanced discussion of U.S. climate (including regional trends), and observations of extremes. The detailed content available is outlined in Table 14.

Of particular note are the regional overviews provided in the subsections. The summaries describe conditions in the six regions of the Regional Climate Centers (see On the Web Box). Information for Colorado and Wyoming are contributed by the High Plains Regional Climate Center (http://www.hprcc.unl.edu/index.php) and data for Utah are reported by the Western Regional Climate Center (http://www.wrcc.dri.edu/index.html).

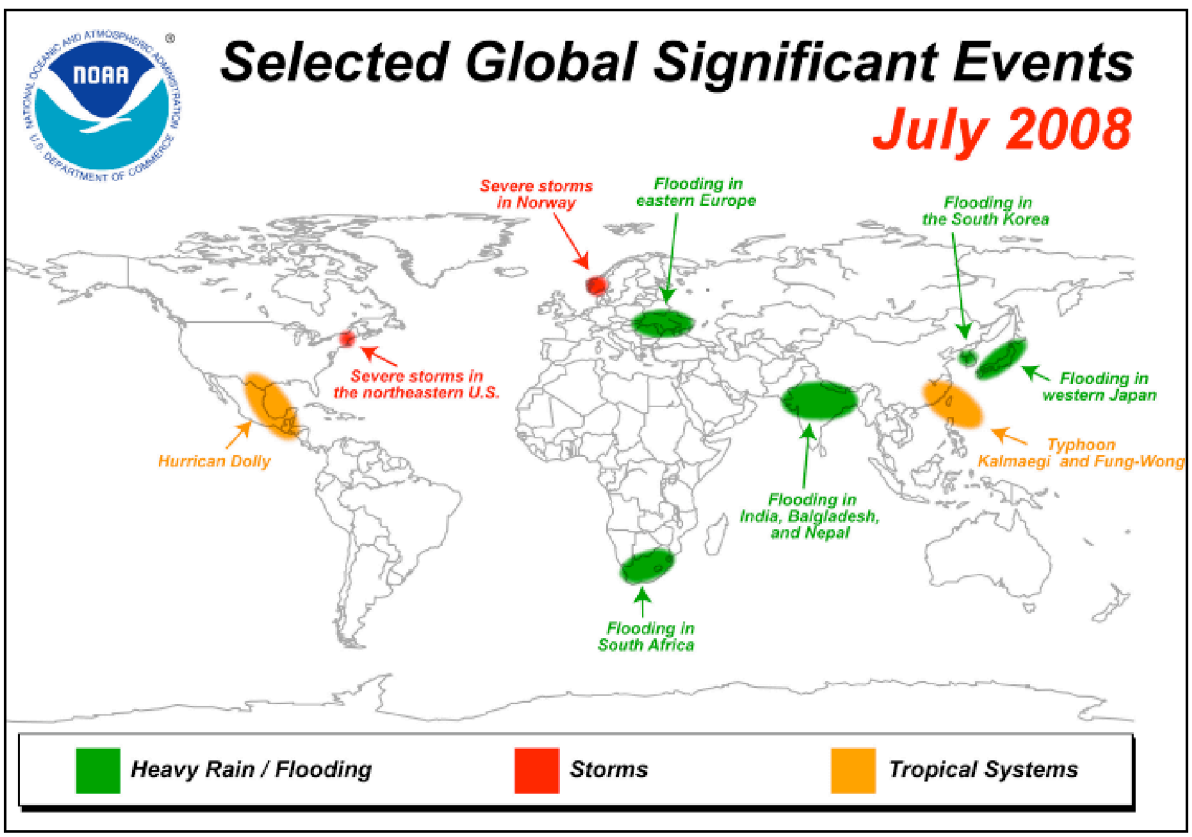


Figure 14a. Extreme climate events that occurred around the world in July 2008.

Annual Reports

Together, the monthly reports are used to develop the Annual State of the Climate Report, also issued by NCDC. For example, as 2008 progresses, content from the monthly climate reports is added to a page called "Climate of 2008" (see On the Web Box). At the end of the year, the data from 2008 will be collated and presented in a similar format to the monthly reports (click Annual Report at the bottom of the list of monthly reports). The annual report provides a succinct resource of the extreme events that occurred throughout the U.S. and places observations into a historical context. Major weather events are also highlighted in a map (Figure 14b; click on U.S. Summary and then Significant Events).

The Annual Reports also provide information and maps of temperature and precipitation ranks for each state on an annual and seasonal time scale (click on U.S. Summary and scroll down). For example, Figure 14c shows the historical ranking of annually averaged precipitation by state and region from the 2007 Annual State of the Climate Report. A pattern of relatively extreme dry conditions emerges in the southeastern and western U.S., but conditions were moderate to dry in the Intermountain West relative to the observational record. Similar data are also available for temperature records (Figure 14d).

Special Reports

In addition to the monthly and annual climate reports, special reports are also issued that outline notable global hazards and extreme events such as tornadoes, typhoons, droughts and other storms. To find special reports on significant extreme events from recent years (including the July 2000 wildfires, the August 2007 heatwave, and Hurricane Katrina) select the "Special Reports" tab at http://www.ncdc.noaa.gov/oa/climate/research/monitoring.html. Links to the special reports relevant to the current year can be found on the "Climate of 2008" page. These reports are issued monthly and are released at the same time as the monthly climate summary. The July 2008 special report, for instance, focused on Hurricane Dolly, Typhoon Kalmaegi, flooding in China, and flooding in eastern Europe. Information relevant to global hazards and climate extremes for the current month is often available in advance of release of the monthly climate report. For example, although the August 2008 monthly report is not yet online, details of the hazards and significant events are already available (see On the Web). For comparison with current climate events, archival

Global Analysis
- Global Temperatures
- Global Precipitation
- ENSO SST Analysis
- ENSO Monitoring
- Sea Ice Extent
- Troposphere
- Stratosphere

National and Regional Overview
- National Overview
- Regional Overview
- Atlantic Hurricane 2008 Seasons
- Eastern North Pacific Hurricane 2008
- Seasons
- Western Fire 2008 Season
- Tornadoes 2008 Season
- 200 8 Midwestern US Flood Overview
- 2007–08 Northern Hemisphere Winter
- Season: Snow and Ice

Selected US City and State Extremes
- Temperature/Dewpoint
- Rainfall/Thunderstorms
- Snowfall

Global Hazards
- Special Focus
- Drought and Excessive Heat
- Flooding
- Severe Storms
- Tropical Cyclones
- Extratropical Cyclones
- Severe Winter Weather
- US Drought

National Drought Overview
- Detailed Drought Discussion
- State/Regional/National Moisture Status
- Pre-Instrumental Perspective
- Drought Indicators
- Additional Contacts
- Questions

Table 14. Subsections at the bottom of each monthly State of the Climate Report page.

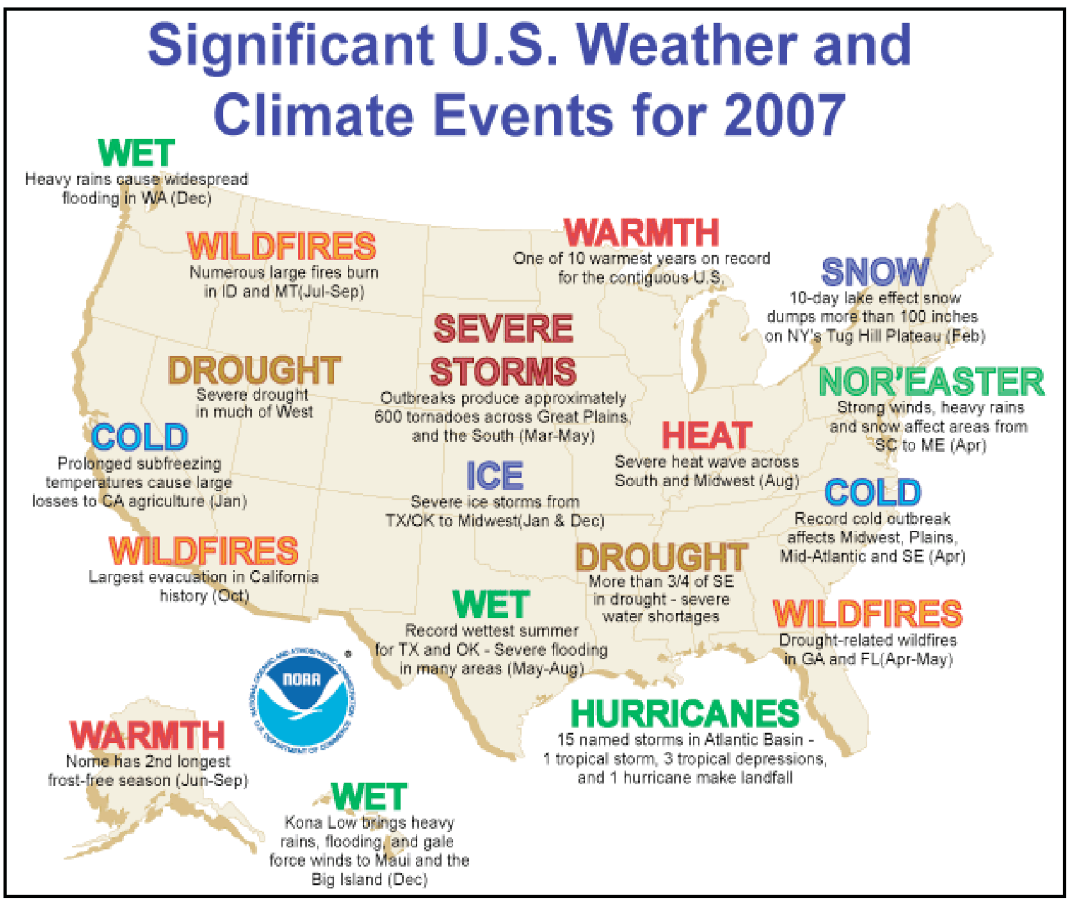


Figure 14b: Significant climate anomalies and events in 2007.

reports and records of historic extreme events can also be accessed through the NCDC (see On the Web).

The NCDC climate portal provides access to a spectrum of information relevant to the Intermountain West, including drought and storm activity. Accessing the available products can be tricky, but the information is valuable.

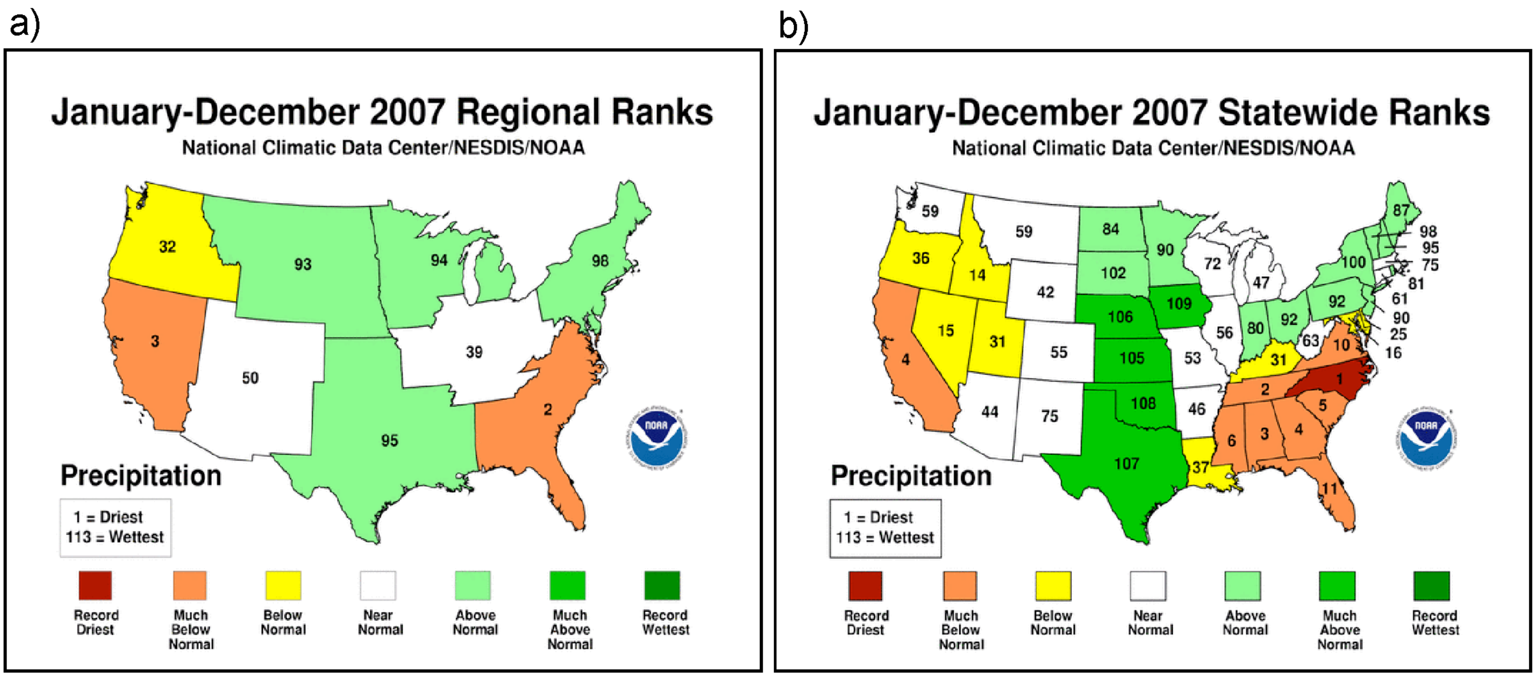


Figure 14c. Panel a shows the state precipitation ranks across the US in 2007; panel b shows the rankings by region. Data are available for a 113 period, so rankings are out of 113.

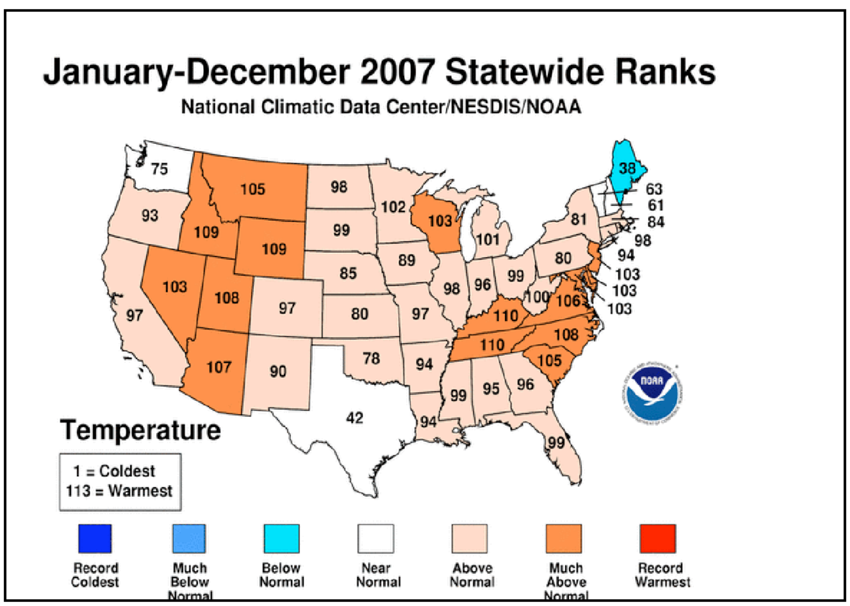


Figure 14d. State temperature ranks across the US in 2007.

On the Web

- NCDC monthly and annual "State of the Climate" reports: http://www.ncdc.noaa.gov/oa/climate/research/monitoring.html.
- The "Climate of 2008" report: http://www.ncdc.noaa.gov/oa/climate/research/2008/perspectives.html.
- Extreme Weather and Climate Events: http://www.ncdc.noaa.gov/oa/climate/severeweather/extremes.html.
- Global Hazards and Extreme Events (updated more often than the Special Reports) http://www.ncdc.noaa.gov/oa/climate/research/hazards/index.php .
- Map of and links to Regional Climate Centers: http://lwf.ncdc.noaa.gov/oa/climate/rcccontactlist.html.

Research Notes

Compiled and written by Koren Nydick, Mountain Studies Institute (http://www.mountainstudies.org)

McAfee, SA and JL Russel. 2008. Northern Annular Mode impact on spring climate in the western United States. *Geophysical Research Letters*, 35, L17701.

Analyses of meteorological data from the U.S. National Oceanic and Atmospheric Administration show that since the 1980s, the jet stream that brings storms from the Pacific Ocean over the western U.S. has been shifting northward. This poleward shift has resulted in warmer temperatures and less rain and snow fall from January to April west of the Rocky Mountains, especially in the Southwest. At the same time, this shift is associated with wetter conditions just east of the Rocky Mountains.

The Northern Annular Mode (NAM) is an index of sea-level pressure associated with this jet stream. High values of the index correlate with warmer than normal temperatures in the tropical Pacific Ocean during mid-winter, a northerly shift and fragmentation of the storm track, and the observed changes temperature and precipitation during late winter to spring in the western U.S. The result is a shorter rain/snow season and an earlier shift to summer circulation patterns, which is consistent with recent observations of an earlier onset of spring in the western U.S. Global circulation models project higher values of the NAM and more northerly shifts in the storm track for the future.

The total amount of change in precipitation is small, study author Stephanie McAfee notes, but this is lengthening "the dry season in parts of the country that are already quite arid," An earlier onset to spring and summer causes earlier snowmelt, alters timing of ecological processes like plant growth and animal behavior, and could lengthen the wildfire season.

Rauscher, S.A, et al. 2008. Future changes in snowmelt-driven runoff timing over the western US, *Geophysical Research Letters*, 35, L16703.

This investigation projects earlier snowmelt-driven runoff (SDR) for part of the western U.S. that is greater than previous model studies. It uses a high resolution climate model, which differs from other models in that it better incorporates the topographic complexity of mountains. While a comparison of modeled and observed runoff data shows general good agreement, the model does best over eastern Oregon, western Idaho, western Montana, and the Sierra Nevadas, and poorly over northern Nevada, southern Utah, and southern Colorado. The future simulation (2071–2099) uses the A2 scenario from the IPCC report, which assumes fairly weak concern for the environment, high global population and greenhouse gas emissions, and a warming of 3° to 5°C. It is one of the more severe scenarios used by the IPCC.

Results from this future scenario vary spatially. The largest earlier shifts in SDR of 70 days or more are projected to occur in the Sierra Nevada of California, the Cascades of Washington, and in the Bitterroot Range of northeastern Idaho and western Montana. Earlier timing of 20–40 days is projected in the Colorado Front Range, the Wasatch of northern Utah, and the Sangre de Cristo in southern Colorado and northern New Mexico. This spatially high-resolution projection suggests greater changes than previous lower resolution models. This is explained by the high-resolution model's ability to capture snow-albedo feedback whereby the temperature increases reduce the amount of land covered by snow and hence the surface albedo (reflectivity). This results in an increase in the amount of surface absorbed solar radiation and further enhances the surface warming, resulting in additional melting.

Jain, S and JK Eischeid. 2008. What a difference a century makes: Understanding the changing hydrologic regime and storage requirements in the Upper Colorado River basin, *Geophysical Research Letters*, 35, L16401.

Hydrologic conditions in the Upper Colorado River basin (UCRB) have changed over time as recorded by a tree-ring reconstruction going back to 762 AD. Periods of drought of varying length and severity have alternated with wet periods – and it has been shown previously that the early 20th century period that served as the baseline for the 1922 Compact was the wettest period in the past twelve centuries.

This article highlights the importance of looking at multiple streamflow variables - the mean, interannual variability, and persistence – to characterize reservoir storage needs. Even with similar mean conditions, changes in standard deviations can dramatically alter the reliability with which water demands can be met. The combination of changes in the mean and variability determine changes in the extreme event probabilities and allow a robust characterization of the storage requirements. For example, considering the standard deviation and one-year lag serial correlation in addition to the mean shows that there is a higher risk that storage requirements may not be met than when considering the mean alone.

Rapid and nearly abrupt changes in the storage requirement, occurring on decadal time scales, are evident in the UCRB runoff record. Modest shifts in the three runoff statistics may work together to produce sudden and otherwise unexpected changes in decision variables (such as storage requirement). Water managers and hydro-climatic modelers should consider all three variables, and their interaction in climate change studies and hydrologic assessment.

Makropoulos, CK et al. 2008. Futures: an exploration of scenarios for sustainable urban water management. *Water Policy*, 10(4): 345-373.

Scenarios provide representations of multiple possible futures and often include a narrative element—a 'storyline' to help guide policy and management decisions. In this paper, scenario development (with examples from the UK) is discussed under the assumptions that the future is unlike the past and is shaped by human action and choice; the future cannot be foreseen but its exploration can inform decisions; and there are many possible futures and scenarios can map a "possibility" space.

Seven scenarios are presented (business as usual, green policy technocratic, free market, sustainable world, eco-communalism, and fortress world) and analyzed in terms of societal, economic, environmental, and crosscutting drivers. Examples of these drivers include demography/population growth and lifestyle/values/perceptions (societal); cost of service, cost of failure, and disposable income (economic); resource availability/climate change and sustainability agenda (environmental); and regulations/legislation (crosscutting). Finally, the result of these drivers on major urban water management components (i.e., water supply, storm water, waste water, and recycling) is discussed. For example, under the "business as usual" scenario

Propst, DL, et al. 2008. Natural flow regimes, nonnative fishes, and native fish persistence in arid-land river systems. *Ecological Applications*, 18(5): 1236–1252.

In the relatively unmodified warm waters of the upper Gila River basin of New Mexico, a 19 year data set covering six study sites was used to investigate how natural flow regimes and presence of non-native fishes (catfish, trout, bass, carp, etc.) affected long-tem stability of native fishes (chubs, dace, suckers and a minnow). The authors hypothesized that a natural flow regime would maintain native fish assemblages, suppress abundance and prevent spread of nonnative fishes, and that the native fish community would persist, with variation over time. The results showed otherwise.

Both native and non-native fishes responded to climate cycles. Native fish density was greatest during a wet period at the beginning of the study and declined during a dry period at the end of the study. Nonnative fishes, particularly the predators, showed opposite responses to the climate cycles. The combination of non-native species combined with low flows reduced native species abundance and threatened their persistence in the system. The study demonstrated that even with a relatively unmodified flow regime, native fishes may not persist if non-native fish are able to enter the system. Management should strive to maintain natural flow regimes while also suppressing or reducing non-native fish.