

INTERMOUNTAIN WEST CLIMATE SUMMARY



by The Western Water Assessment

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April 2007 Climate Summary

Hydrological Conditions – Drought is expected to persist in Utah, most of Wyoming, and western Colorado. Streamflow forecasts for the runoff season are below average in most of the region, due to below average snowpack and warm temperatures; reservoir inflow forecasts are also below average across the region.

Temperature – Temperatures were above average in March, with record high temperatures in parts of Wyoming and Utah.

Precipitation/Snowpack – Precipitation was below average around most of the region in March, except eastern Wyoming and parts of the central Colorado mountains, which received above average precipitation. Seasonal snowpack is below average and has begun melting early in many areas due to warm weather.

ENSO – ENSO-neutral conditions continue, but a transition to La Niña conditions is possible within the next 3 months. ENSO is not a factor in forecasts of U.S. climate during May-July 2007 season; models suggest that a weak La Niña could develop by summer, but there is considerable uncertainty about when and how strong it might be.

Climate Forecasts – A warm summer and an increased chance for dry in May-July 2007 is forecast for most of the region.

IPCC RELEASES 2ND SUMMARY FOR POLICY MAKERS: IMPACTS, ADAPTATION & VULNERABILITY

The Intergovernmental Panel on Climate Change (IPCC) Working Group 2 recently released the Summary for Policymakers of its report, "Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability." This summary is one of three parts of the IPCC "Fourth Assessment Report," which builds on reports since 1990. Each report has found the state of the science is consistently moving forward, with increasingly firm conclusions on the climate change and the role of human activity.

Working Group 1 of the IPCC released its findings on the physical basis for climate change in February. Based on that science, Working Group 2 concludes that, "A global assessment of data since 1970 has shown it is likely that anthropogenic warming has had a discernible influence on many physical and



biological systems." The summary gives examples of impacts to environmental systems and sectors, including fresh water resources and ecosystems. "By mid-century, annual average river runoff and water availability are projected to ... decrease by 10-30% over some dry regions at mid-latitudes,...some of which are presently water stressed areas...Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk." The summary also describes adaptation measures that are in place or being developed to cope with these changes. WWA has created a new webpage designed to provide background, context, and links associated with the IPCC process: http://wwa.colorado.edu/resources/water_and_climate.

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

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Technical Workshops for Water Managers on Tree-Ring Reconstructions of Streamflow

By Jeff Lukas, University of Colorado and WWA, and Connie Woodhouse, University of Arizona and WWA

This article describes a series of workshops sponsored by WWA. Any one interested in participating in a future workshop is encouraged to contact the author Jeff Lukas at lukas@colorado.edu so that he can put you on their mailing list.

The annual growth rings of many trees in the western U.S. capture regional hydroclimatic variability, and tree-ring records can be used to extend, or reconstruct, gaged streamflow records. These flow reconstructions can provide water managers and stakeholders with a much longer window—300 years and more—into the past hydrologic variability of a river system, and thus have the potential to inform sustainable management of water resources.¹

We have found that the successful application of these paleohydrologic data to water management depends on sustained interaction between the scientists who develop the data and the managers who have interest in using them, with each group coming to better understand the operational environment and methodologies of the other. To this end, we have presented a series of workshops for water managers and stakeholders. An initial planning workshop was held in Tucson in May 2005.² In response to the feedback from participants in the planning workshop, we began developing and presenting one-day technical workshops in 2006.

The goal of these technical workshops is to comprehensively cover the methods of generating reconstructed streamflow from tree rings, so that water managers interested in applying these data have a better basis of understanding from which to work.

The core of the all-day workshop is a multi-section instructional presentation, interspersed with hands-on activities, lab tours, and group discussions. We also tailor each workshop's content to meet the needs and interests of the participants, as indicated by a pre-workshop survey.

The first workshop was held in Alamosa, CO, in late April 2006, as a follow-up to presentations Connie had made to board meetings for the Rio Grande Water Conservation District (RGWCD) the previous year. The participants—San Luis Valley water managers and natural resource managers—grasped the tree-ring data as an important means to convey to water users and stakeholders in the San Luis Valley the need to constrain demand, particularly groundwater pumping, to accommodate the inevitable sustained dry periods.

In early May 2006, we presented a second workshop in

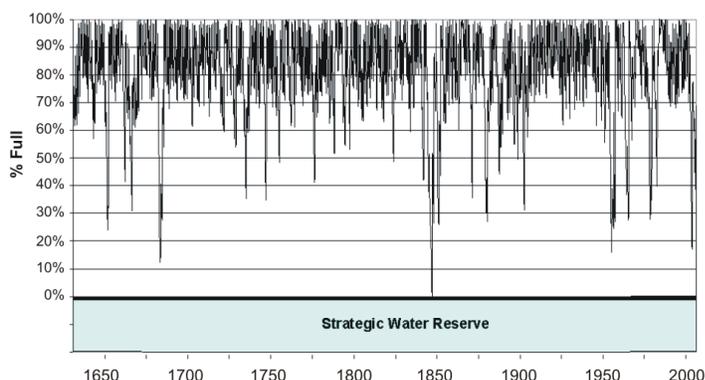


Figure 1a. Denver Water uses tree-ring reconstructed streamflows in a supplemental approach for water supply yield analyses, in addition to their standard approach based on the gaged flow record. The graph shows modeled reservoir contents for Denver Water's system from 1634 to 2005, with tree-ring reconstructed streamflows used as inputs to Denver Water's PACSM model, and progressive use restrictions implemented during droughts. While a particularly severe four-year drought in the mid-1840s nearly depletes reservoir contents to the strategic water reserve, demands are met throughout the 372-year period. (Image courtesy of Denver Water)

Boulder, CO, preceded by a half-day field trip in the foothills west of Boulder to demonstrate tree-ring field techniques. The fourteen participants represented a broad spectrum of water agencies and interests in Colorado and the Colorado River basin. We included more discussion of applications of the tree-ring data in this workshop, with each of the participants briefly describing their current and intended use of the data. Steve Schmitzer presented on Denver Water's use of tree-ring reconstructed streamflows to model water supply yield (Figure 1a).

In late October 2006 we presented a workshop and field trip in Tucson, AZ, to water managers from across the Southwest, and one from Canada (Figure 1b). Workshop hosts included staff and graduate students from CLIMAS (Climate Assessment of the Southwest), the Institute for Study of Planet Earth (ISPE) and the Laboratory of Tree-Ring Research (LTRR) at the University of Arizona. The second half of the workshop featured short presentations by Chris Cutler (U.S. Bureau of Reclamation), Charlie Ester (Salt River Project), and Bill Girling (Manitoba Hydro) on

"The workshop was very interesting and useful - hope to see more of them. My agency increasingly recognizes the growing public concern with climate change, and that paleodata is an important part of understanding that process."
**- Chris Cutler, Hydrologist
 U.S. Bureau of Reclamation**

¹ See feature article in the June 2005 Intermountain West Climate Summary and <http://www.ispe.arizona.edu/climas/conferences/CRBpaleo/index.html>.

² See feature article in the June 2006 Intermountain West Climate Summary for information on new reconstructions for the upper Colorado River Basin.





Figure 1b. (Top) Participants in the Tucson tree-ring workshop listen as Ellis Margolis (University of Arizona) relates the history of a ponderosa pine stand during a field trip to the Catalina Mountains north of Tucson. (Bottom) Jeff Lukas (University of Colorado and WWA) describes the characteristics of old trees during the Tucson tree-ring workshop. (Photos by Scott St. George)

their respective uses of the reconstructions (the presentations are available online; see On the Web box).

Based on the positive feedback from participants, the workshops have fulfilled our objective of conveying relevant information about the tree-ring data. They have also been a venue for water managers to share information with each other about applications of the data, and for us to learn yet more about water management in the region. Since we began working with water managers several years ago, our role has been to provide data and technical assistance, with the managers and their consultants developing particular application methodologies (e.g., disaggregating annual tree-ring data into daily time steps for model input). The workshops have clearly enhanced the communication needed to bridge from data to applications.

Future workshops will follow the present format of a mix of instruction and discussion of applications, as dictated by the participants' needs and backgrounds. In 2007 we will be holding a follow-up workshop in Boulder, CO, focusing on applications of the data (May 14), a half-day workshop in Durango, CO (May 31), and possibly other workshops in Albuquerque, Las Vegas, and Southern California. We encourage anyone who is interested

in participating in a workshop to contact us (lukas@colorado.edu) so that we can put you on our mailing list.

As a companion to the workshops, we have developed new web pages, hosted by WWA, which feature our instructional presentations as well as those given by water managers at the workshops (see On the Web box). The pages also list the water agencies that are currently using the tree-ring reconstructions, and describe several applications of the reconstructions to water resource planning. These pages also provide access to reconstruction data for the western US, which are archived at other websites.

Top Seven Things Western Water Managers Should Know About Tree-ring Reconstructions of Streamflows

We have condensed the workshop content into seven key points. For more detail on these points, please refer to the instructional presentations found on the WWA Tree Ring Reconstructions website (see On the Web box).

1) The science behind streamflow reconstructions has a long history. The first studies quantitatively relating tree-growth to streamflow in the western US were done in 1930s. The first modern tree-ring reconstructions of climate and streamflow (using computers and multiple linear regression techniques) were developed in the 1960s and 1970s. Techniques for calibrating and validating reconstruction models have been progressively refined since then.

2) Tree growth in the western US is often closely associated with moisture variability, leading to high-quality streamflow reconstructions. In semi-arid climates, the same climate factors, primarily precipitation and evapotranspiration, control both the growth of moisture-limited trees and the amount of runoff. Several widespread conifer species (ponderosa pine, pinyon pine, Douglas-fir) are particularly responsive

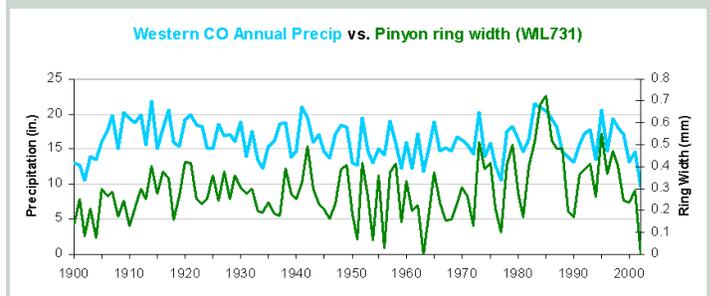


Figure 1c. The growth of a pinyon pine sampled in western Colorado near Delta very closely matches ($r = 0.7$) the annual precipitation for the Colorado Climate Division 2 (western Colorado). This strong moisture signal recorded in the trees is the basis for robust tree-ring reconstructions of streamflow in the region.



to the variability of moisture from year to year—a sensitivity that is even greater when they grow on dry, rocky sites (Figure 1c). Since the trees most sensitive to moisture are not those growing directly in river beds, but on steep slopes in the surrounding watersheds, the relationship between tree growth and streamflow is not direct. Instead, tree growth and streamflow are robustly linked by the regional climate that influences both.

3) With extensive field collections, the already-strong moisture signal in the trees is enhanced through replication. At each site, multiple trees are sampled (usually 20-30) to maximize the common climate signal. Each growth ring is cross-dated, assigning it to the exact year. Then measured ring-widths from multiple trees are averaged into one site “chronology.” Multiple tree-ring chronologies from the region are used to reconstruct streamflows for a particular stream gage.

4) The reconstruction process is based on the assumptions that the relationship between tree growth and streamflow over the gage period also existed in past centuries, and that the trees that perform the best in estimating the gaged flows will also do the best job of estimating earlier flows. One of several statistical methods, based on multiple linear regression, is used to determine the subset of tree-ring chronologies that best estimates the gaged streamflow, resulting in a regression equation (the reconstruction model). The skill of the model is evaluated using independent data or on subsets of the calibration data. The model is then applied to the full tree-ring record, generating the streamflow reconstruction extending back hundreds of years.

5) Trees generally do a very good job of estimating streamflow, but there is always uncertainty around the reconstructed flows. Generally, streamflow reconstructions in the western US explain 50-80% of the variance (R^2) in the gaged record. They also capture the important features, particularly droughts, of the gaged record. But trees are imperfect recorders of streamflow. We can assess the statistical uncertainty in the model using the errors (reconstructed flows minus gaged flows) to generate confidence intervals (Figure 1d). This is helpful since it represents each year’s reconstructed flow as a range of plausible flows, with the most probable value in the middle. There is also additional unquantified uncertainty related to the choices made in data treatment and modeling approaches, which affect the final result.

6) By providing a longer window into the past, the tree-ring reconstructions describe the natural variability of climate more completely than gaged records.

The tree rings clearly show that the hydrologic variability of

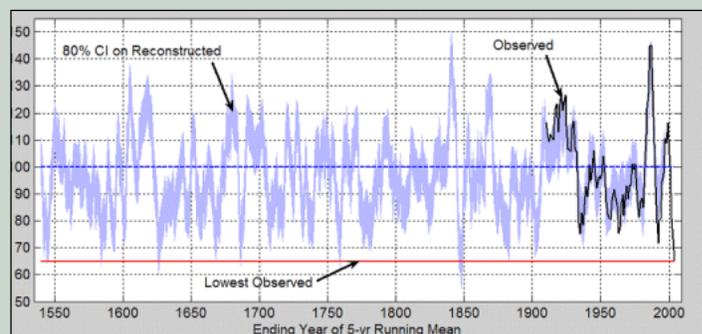


Figure 1d. A reconstruction of streamflow for the Colorado River at Lees Ferry (5-year running mean, with 80% confidence interval shown as purple band) is compared with the observed flow record (5-year running mean in black). The severity of the 2000-2004 drought (extended to the left by the red line) is likely to have been exceeded at least once in the previous 500 years. (Image courtesy of David Meko)

the 20th century does not simply repeat itself. Reconstructions indicate longer and more severe droughts than those in the gaged record—and longer and more pronounced wet periods too. They also demonstrate that the mean annual streamflow has changed over past centuries. Even as human activities exert a stronger influence on climate, this influence will still be superimposed on natural variability. Climate models project that the range of hydroclimatic variability will likely increase in the future relative to the recent past, and the variability seen in the multi-century tree-ring reconstructions of streamflow may be a useful analogue for enhanced future variability. Using the reconstructed flows, rather than just the gaged record, as the frame of reference for planning can lead to fewer “surprises” as we head into a climatically uncertain future.

7) The reconstructions can be applied to water management in different ways, depending on the needs and capabilities of the data user. These applications fall into three general categories:

1. As informal, qualitative guidance for water managers, stakeholders and decision makers.
2. For quantitative assessments of long-term hydrologic variability. For example, assessing the frequency of reconstructed droughts of a given duration and/or severity.
3. As direct inputs into hydrologic models of a water system (Figure 1a). This allows water managers to model system performance under the tree-ring reconstructed hydrology, as they would do with the gaged hydrology. This typically requires additional processing of the reconstruction (annual values) to ingest it into the system model, which may have monthly, weekly, or daily time steps.

On the Web

- New Web Resource at WWA: Tree-Ring Reconstructions of Streamflow
 - Technical workshop content, applications of tree-ring data, access to data: <http://wwa.olorado.edu/resources/paleo/>



Temperature 3/1/07 - 3/31/07

Monthly average temperatures for March 2007 for the Intermountain West (IMW) region ranged from the mid-20s in western and south central **Wyoming** and north central **Colorado** to the upper-40s in southeast Utah and eastern **Colorado** (Figure 2a). These temperatures were all above average (Figure 2b). Northeast and northwest **Wyoming** and northeast **Colorado** had the highest departure from average with temperatures ranging from 6-10°F above average. The remaining parts of the IMW region was above average by 2-6°F.

The NWS Salt Lake City reports that many record high temperatures were set in **Utah** between March 12th – 19th. The NWS Riverton, **Wyoming** reports that March 2007 was the fourth warmest on record for Casper and the third warmest for the Lander area with several daily maximum high records being broken. The northeastern section of **Colorado** had the highest temperatures, with March 2007 finishing as Denver’s 8th warmest on record.

In comparison to March 2006, temperatures in March 2007 were higher throughout the IMW region (Figure 2c). **Utah** had the largest difference between years, with temperatures across the state below average by 2-6°F in March 2006, whereas in March 2007, all of **Utah** was above average by 2-6°F. Much of western and southeast **Wyoming** was below average in 2006, but 2-8°F above in 2007.

Notes

Figures 2a-c are experimental products from the High Plains Regional Climate Center. These data are considered experimental because they utilize the newest data available, which are not yet quality controlled. These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known points to produce continuous categories. Interpolation procedures can cause aberrant values in data-sparse regions. For maps with individual station data, please see web sites listed below. 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.

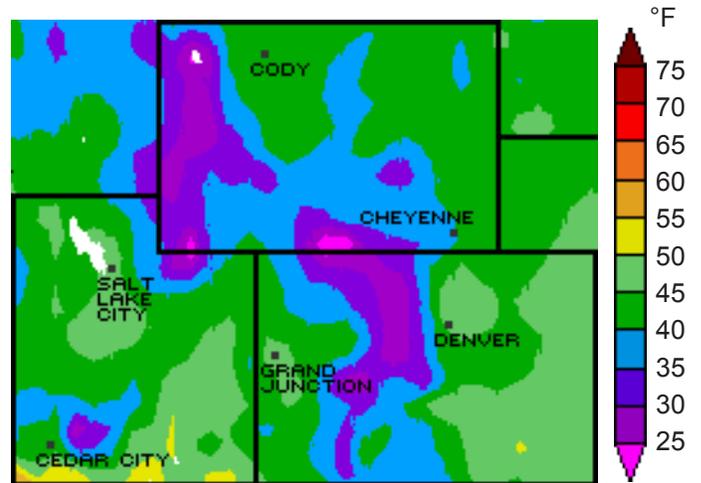


Figure 2a. Average temperature for the month of March 2007 in °F.

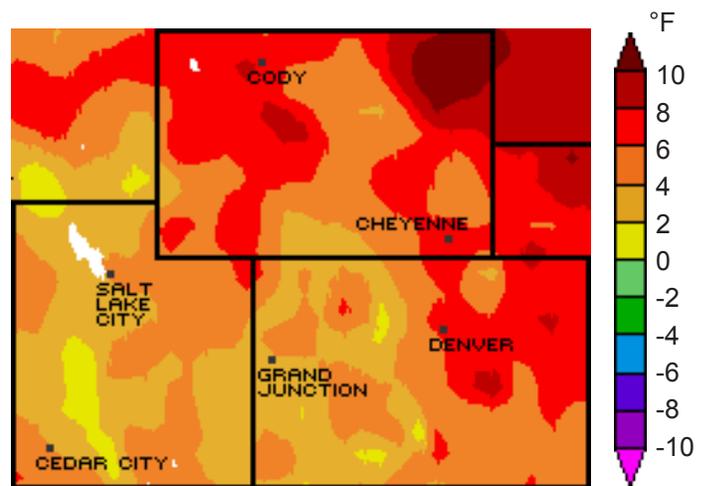


Figure 2b. Departure from average temperature for the month of March 2007 in °F.

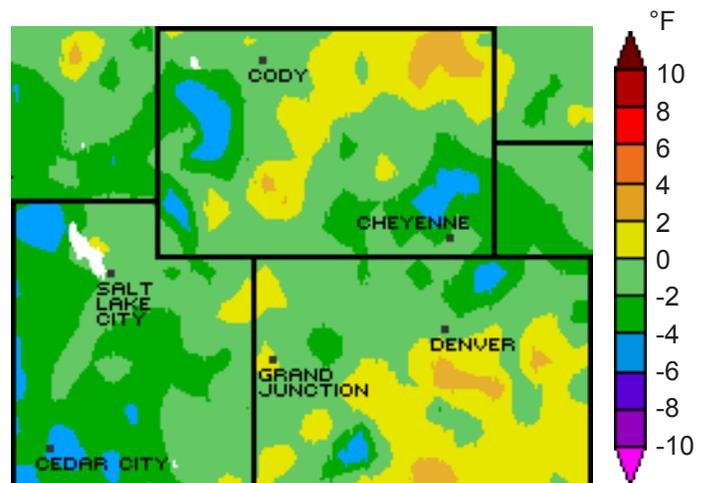


Figure 2c. Departure from average temperature in °F for last year, March 2006.

On the Web

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



Precipitation 3/1/07 - 3/31/07

Total precipitation for March 2007 in the Intermountain West regions ranged from 0 to 3+ inches (Figure 3a). Central, north-central, and southeastern **Wyoming** received the highest totals. The rest of **Wyoming**, north-central **Colorado**, and north-central **Utah** received from 1-3 inches. However, much of the rest of **Colorado** and **Utah** received < 0.25 to 1 inch.

Much of central and eastern **Wyoming** received 120–200% of average precipitation in March (Figure 3b). According to the NWS Riverton, **Wyoming**, March precipitation was above normal for the Casper and Lander areas. However, the rest of the IMW region (western **Wyoming**, all of **Utah** and most of **Colorado**) are near average to < 40–80% of average, with the lowest percent of average in southwest **Utah** and southeast **Colorado**. The NWS Denver-Boulder reports that area precipitation for March 2007 finished below average, with a total of 0.57 inch or 0.71 inch below average.

Percent of average precipitation since the start of the water year (Figure 3c) is near average or above for most of **Colorado**, **Utah** and southeast **Wyoming**. Southeast **Utah** and eastern **Colorado** are at 150–200% of average. Most of **Wyoming** is now near average, with a few areas at 40–80% of average.

Notes

The data in Figs. 3 a-c come from NOAA's Climate Prediction Center. The maps are created by NOAA's Earth System Research Laboratory and are updated daily (see website below). These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known data points to produce continuous categories. The water year runs from October 1 to September 30 of the following year. As of October 1, 2006, we are in the 2007 water year (Figure 3c). The water year is more representative of climate and hydrological activity than the standard calendar year. It reflects the natural cycle of accumulation of snow in the winter and run-off and use of water in the spring and summer. Average refers to the arithmetic mean of annual data from 1996-2005. This period of record is only ten years long because it includes SNOTEL data, which have a continuous record beginning in 1996. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

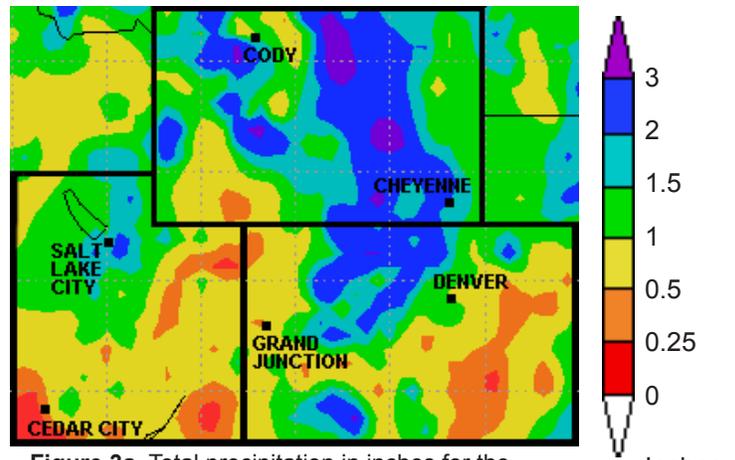


Figure 3a. Total precipitation in inches for the month of March 2007.

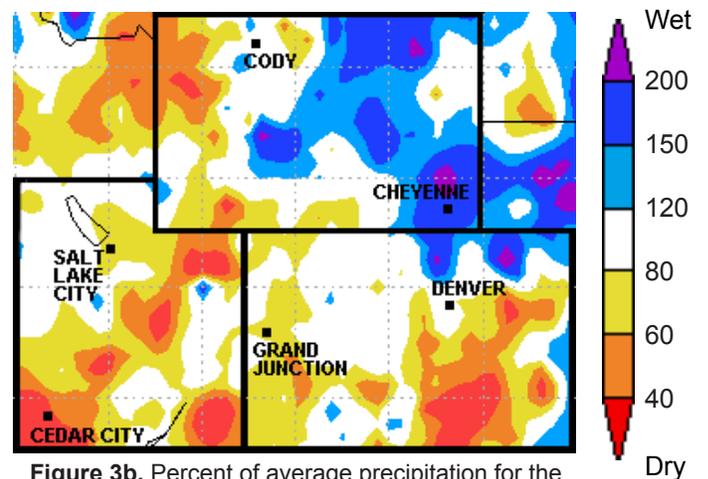


Figure 3b. Percent of average precipitation for the month of March 2007.

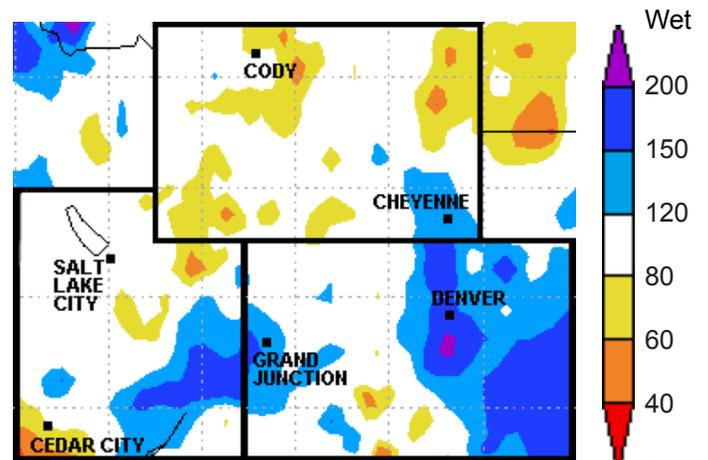


Figure 3c. Percent of average precipitation accumulation since the start of the water year 2007 (Oct. 1, 2006 - March 31, 2007).

On the Web

- For the most recent versions of these and maps of other climate variables including individual station data, visit: <http://www.hprcc.unl.edu/products/current.html>.
- For precipitation maps like these and those in the previous summaries, which are updated daily visit: <http://www.cdc.noaa.gov/Drought/>.
- For National Climatic Data Center monthly and weekly precipitation and drought reports for Colorado, Utah, Wyoming, and the whole U. S., visit: <http://wlf.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>.



U.S. Drought Monitor conditions as of 4/17/07

According to the National Drought Monitor on April 17th, drought intensity status has decreased slightly since last month in central and western **Wyoming**, moving from extreme (D3) to severe (D2) in most of that area (Figure 4). Drought intensity status increased in **Utah** and western **Colorado** from abnormally dry (D0) to moderate (D1). The northeast corner of **Colorado** is also in D1 drought status, but the rest of the state does not have a drought designation at this time. In the region, the Impact lines were redrawn to emphasize short to medium-term drought (A) in westernmost areas since hydrologic concerns (e.g. reservoirs) are currently adequate; H was placed in easternmost areas where long-term hydrologic concerns lingered but short-term moisture was adequate or excessive; and AH was labeled in transitional areas where both short- and long-term drought impacts were occurring.

According to the Drought Impact Reporter, the Northern Colorado Water Conservancy District, a large water provider for north-central Colorado, set their annual water quota at 80 % due to low reservoir levels from drought.

Notes

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

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

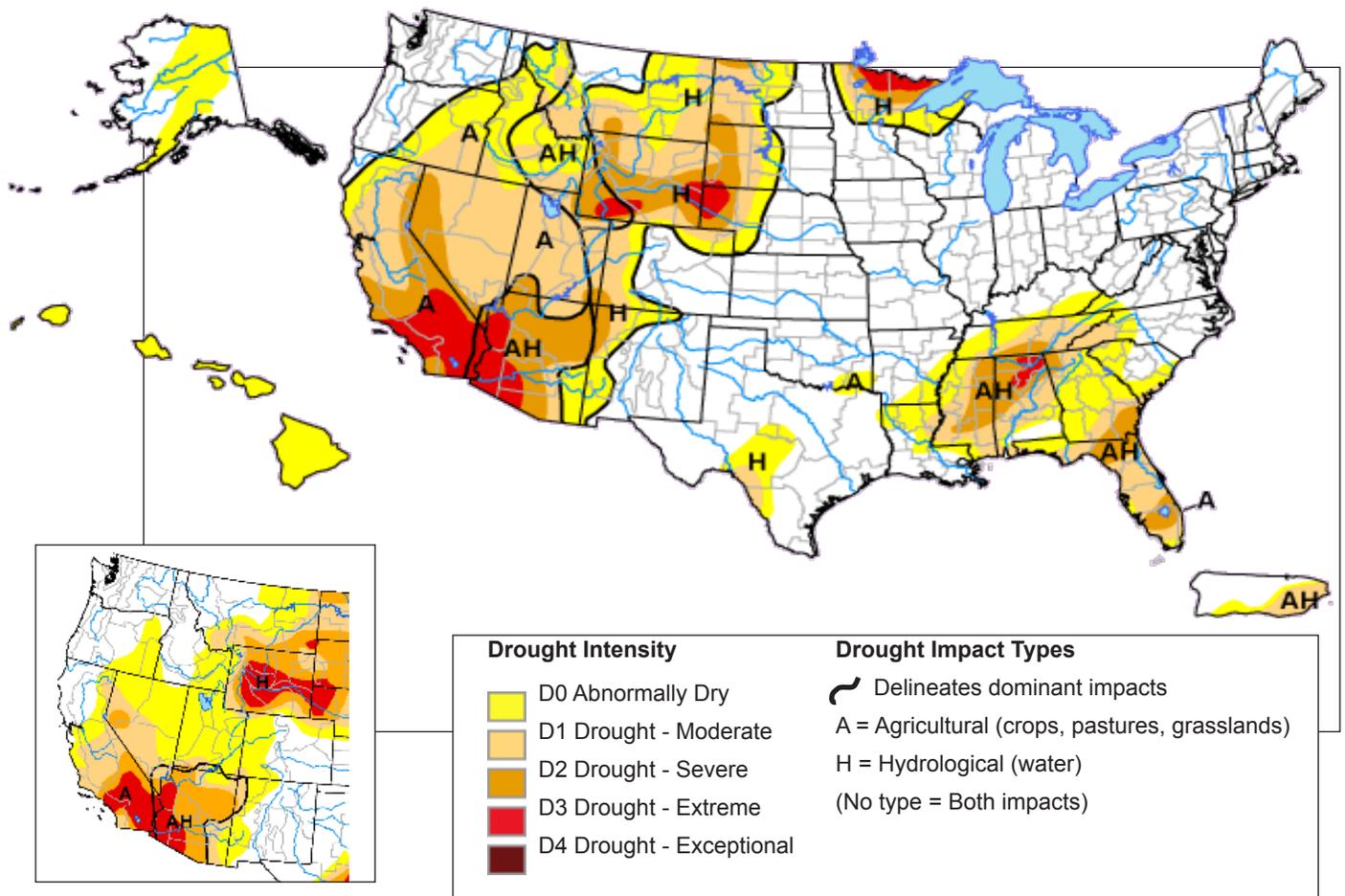


Figure 4. Drought Monitor released April 19, 2007 (full size) and last month, March 20, 2007 (inset, lower left) for comparison

On the Web

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



Intermountain West Snowpack data through 4/1/07

The snowpack percent of average declined last month across the Intermountain West region due to below average snowfall amounts in March. Most of the region has below average SWE values as of April 1, with just a few exceptions in eastern **Colorado** and **Wyoming**. The lowest snowpack values are in **Utah**, where most of the state has 25–69% of average SWE. Southeastern and southwestern **Utah** have the lowest SWE, 36% and 37% of average respectively, and the state has the lowest April 1 SWE since 1977. Other basin averages are: Bear - 56%, Weber - 54%, Provo - 50%, Uintahs - 57%, and Sevier - 45%.

Both **Wyoming** and **Colorado** have slightly higher SWE values with most of each state at 50–89% of average. Despite two big storms in **Colorado** in March, temperatures rose enough between those storms in the lower elevation mountains to melt a lot of the snowpack. The Rio Grande Basin had the greatest decrease, dropping from 93% of average on March 1 to only 70% of average on April 1. The lowest snowpack percentages are in the combined San Juan, Animas, Dolores, and San Miguel basins at only 58% of average. This is now the second consecutive year of well below average snowpacks across southwestern **Colorado**. The highest percentage was measured in the South Platte basin, which is now 94% of average.

Wyoming also had a big snowstorm at the end of March, which brought 70 inches of snow to eastern parts of the state, but did not hit the western half, according to State Climatologist Steve Gray. The Powder and Tongue River basins, parts of the Wind/Big Horn river basins, and parts of Lower North Platte River basins have SWE values 10 percentage points higher than last month. These are the only basins with SWE in the near average range of 90–109% of average. However, like **Colorado**, warmer temperature melted a lot of the new snow leaving the state with slightly less than they had on March 1.

Refer to the **Colorado**, **Wyoming**, and **Utah** state water availability pages, 12-15, for more information on streamflow forecasts, snowpack, and precipitation by state.

Notes

Snow water equivalent (SWE) or snow water content (SWC) refers to the depth of water that would result by melting the snowpack at the measurement site. Snowpack telemetry (SNOTEL) sites are automated stations operated by NRCS that measure snowpack. In addition, SWE is measured manually at other locations called snow courses. SWE is determined by measuring the weight of snow on a "pillow" (like a very large bathroom scale) at the SNOTEL site. Knowing the size of the pillow and the density of water, SWE is then calculated from

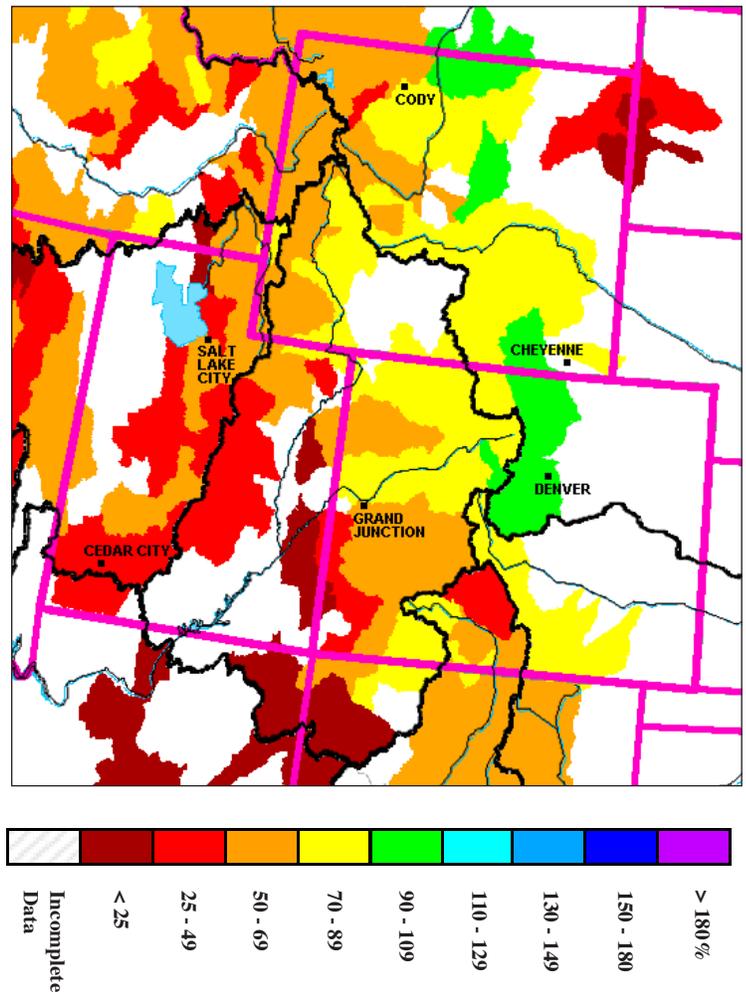


Figure 5. Snow water equivalent (SWE) as a percent of average for available monitoring sites in the Intermountain West as of April 1, 2007 courtesy of the Natural Resources Conservation Service.

the weight measurement. Given two snow samples of the same depth, heavy, wet snow will yield a greater SWE than light, powdery snow. SWE is important in predicting runoff and streamflow.

Figure 5 shows the SWE based on SNOTEL and snow course sites in the Intermountain West states, compared to the 1971-2000 average values. The number of SNOTEL or snow course sites varies by basin. Individual sites do not always report data due to lack of snow or instrument error, these basins with incomplete data are designated in white on the map. To see the locations of individual SNOTEL sites, see each state's water availability page.

On the Web

- For graphs like this and snowpack graphs of other parts of the western U.S., visit: http://www.wcc.nrcs.usda.gov/snowcourse/snow_map.html.
- For snow course and SNOTEL data updated daily, please visit one of the following sites:
 - River basin data of SWE and precipitation: <http://www.wrcc.dri.edu/snotelanom/snotelbasin>.
 - Individual station data of SWE and precipitation for SNOTEL and snow course sites: http://www.wcc.nrcs.usda.gov/snowcourse/snow_rpt.html or <http://www.wcc.nrcs.usda.gov/snotel/>.
 - Graphic representations of SWE and precipitation at individual SNOTEL sites: <http://www.wcc.nrcs.usda.gov/snow/snotel-data.html>.



April 2007 Reservoir Supply Conditions

Starting in January, the Natural Resources Conservation Service (NRCS) and the NOAA/NWS River Forecast Centers project seasonal streamflow volumes for the runoff season (usually April – July). They update these forecasts at the beginning of each month through June. Seasonal runoff volume forecasts are made for a specific location on a river and they are for natural flows. These forecasts are also called reservoir inflow forecasts when the forecast point is located just upstream from a reservoir. Reservoir managers, including the Bureau of Reclamation, use these naturalized streamflow projections when making decisions about actual water use throughout the year. Water management and prior appropriation water rights determine the actual volume of inflow to each reservoir.

NOAA/NWS has developed a new website to show seasonal runoff volume forecasts for the West that includes additional site-specific runoff volume forecast information. The website is shown in Figure 6a, and the URL is below in the On the Web box.

The April-July seasonal reservoir inflow forecasts are projec-

tions of naturalized reservoir inflows shown as a probability of exceedance for selected reservoirs in **Colorado, Wyoming, and Utah** (Table 6a). Inputs to these forecasts include basin snowpack conditions, precipitation amounts, and regional temperatures entering the runoff season. While March usually brings a large percent of the total winter snowfall, this year snowfall was below average and total snow water equivalent was lower on April 1 than on March 1 on most basins. In addition, temperatures were above average in March throughout most of the Intermountain West, which initiated an early melting and runoff. As a result, most seasonal streamflow volume projections are below average. (See pages 5–6 for current temperature and precipitation conditions and page 8 for snowpack conditions.)

Despite average snowpack levels on March 1, warm and dry conditions last month led to early melting of snow in **Colorado**, which reduced April-July reservoir inflow forecasts across the state. The CBRFC anticipates that Blue Mesa in the Gunnison River Basin may not fill by the end of July as projected inflow is 64% of average and it is currently at 64% storage

Seasonal Runoff Volume Forecast (April - July)					
State	Reservoir	Minimum: 90% exceedance (KAF)	Most Probable: 50% exceedance (KAF)	Most Probable: 50% exceedance (percent of average)	Maximum: 10% exceedance (KAF)
COLORADO	Dillon Reservoir	116	150	90%	190
	Lake Granby	153	195	87%	242
	Blue Mesa	349	460	64%	593
	Pueblo Reservoir	191	315	85%	470
UTAH	Strawberry (at Soldier Springs)	2.5	11.5	20%	27
	Utah Lake	53	103	32%	235
	Bear Lake (above res near Woodruff)	28	64	47%	114
	Lake Powell	1450	4000	50%	3550
WYOMING	Fontenelle	210	370	43%	575
	Flaming Gorge	256	525	44%	889
April - September Forecast Period					
	Seminole	430	650	81%	870
	Boysen	205	525	65%	845
	Buffalo Bill	475	630	78%	780

Table 6a. Seasonal runoff (April-July) volume forecast data as of April 1, 2007.

On the Web

- Data on seasonal streamflow volume forecasts, including reservoir inflows can be found at these sites:
 - The latest NWS seasonal runoff volume forecasts maps at <http://www.cbrfc.noaa.gov/westernwater/map.php?map=wsup>. 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.
 - Monthly reports from NRCS on water supply conditions & forecasts for major CO river basins, visit: <http://www.wcc.nrcs.usda.gov/cgibin/bor.pl>.
 - Water Supply Outlook for the Upper Colorado River Basin, produced by the CBRFC at: <http://www.cbrfc.noaa.gov/wsup/wsupsup.cgi>.



April 2007 Reservoir Supply Conditions cont.

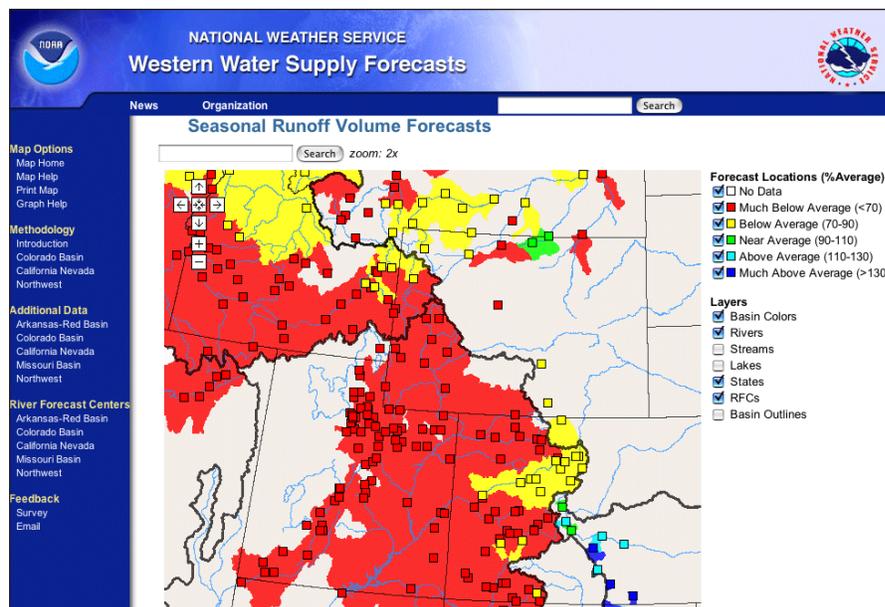


Figure 6a. New NOAA/NWS seasonal runoff volume forecast map for the West as a percent of average streamflows. (Data through April 1, courtesy NOAA/NWS).

capacity, Other reservoir projections are not as low, for example, reservoir inflow forecasts for Dillon Reservoir and Lake Granby, both in the Upper Colorado River basin are 90% and 87% of average, respectively.

For **Utah**, projections for the upcoming runoff season are below average across the state due to below average snowpack conditions throughout the winter. However, according to the NRCS most areas of the state have good reservoir carryover from the 2006 snowmelt season. For example, while Strawberry Reservoir and Utah Lake are projected to have 20% and 32% of average inflow volumes, their current storage is 144% and 106% of average on April 1, respectively. Current storage levels are due to both early snowmelt and to adequate storage carried over from the 2006 runoff season. April – July inflow volume for Lake Powell is also low, 50% of average. This is just below 4 million AF for the season. While early melting brought 120% of average inflows in March, the result is a significantly reduced April through July runoff projection. This inflow projection is lower than April 2006, when projected April-July inflow was 73% of average. In the last seven years, the NRCS and the Colorado Basin River Forecast Center (CBRFC) projected below average inflows for Lake Powell for all years except 2005.

Throughout **Wyoming**, seasonal volume runoff forecasts are below average due to low winter snowfall levels, with the exception northwestern Wyoming. The NRCS and NWS expect near average runoff volumes. In southwestern **Wyoming**, projections for Flaming Gorge and Fontenelle Reservoirs are 44% and 43% of average, respectively. The CBRFC does not expect Fontenelle to fill this year. The forecast period for the other **Wyoming** reservoirs featured on this page (Seminoe, Boysen and Buffalo Bill)

is April – September, rather than April – July, due to the needs of the individual reservoir managers. Of these reservoirs, Seminoe on the North Platte River is projected to have the highest inflow as a percent of average at 81%.

For additional information on regional water supply information, also visit the state water availability pages 12-15.

Notes

April-July seasonal streamflow volume projections in Table 6a are listed in total volume (kaf) and as a percentage of average. The average is computed for the 1971-2000 base period. These inflow projections are based on 10, 50, and 90 percent exceedence projections, which means there is a 10, 50, or 90 percent chance that the actual streamflow volume will exceed the amount in the table. April-July inflow projections are natural volume projections, and actual volume will be affected by hydrologic conditions as well as upstream water management. Reservoir inflow projections, streamflow forecasts, and current surface streamflows are based on data collected from April 1-5, 2007, courtesy NRCS and NOAA/NWS.

Seasonal runoff volume forecast map in Figure 6a are based on NRCS monthly forecasts and other NOAA/NWS River Forecast Center forecast points. For site-specific seasonal volume forecast information go to <http://www.cbrfc.noaa.gov/westernwater/>, click on map to zoom into desired region, and place cursor over forecast location box to show forecast information including forecast period, forecast exceedence range as a percent of average, and in acre feet. While this graphic is similar to the spring and summer streamflow volume forecast graphic generated by the NRCS, (see page 20) shading extrapolation and percent of average range categories are different because the NRCS issues forecasts for smaller basins and incorporates additional forecast points.

Regional Standardized Precipitation Index data through 3/31/07

The Standardized Precipitation Index (SPI) can be used to monitor conditions on a variety of time scales. 3- and 6-month SPIs are useful in short-term agricultural applications and longer-term SPIs (12 months and longer) are useful in hydrological applications. The 12-month SPI for the Intermountain West region (Figure 7) reflects precipitation patterns over the past 12 months (through the end of February 2007) compared to the average precipitation of the same 12 consecutive months during all the previous years of available data.

The April SPI remains largely the same as the March SPI: **Wyoming** is still dry and **Utah** and **Colorado** are average to moderately wet (Figure 7). **Wyoming** had the most changes this month. The Upper Platte climate division in south-central **Wyoming** moved from extremely dry to the very dry category due to above average precipitation in parts of the region. In northern **Wyoming**, the Powder/Little Missouri/Tongue climate division moved into a drier category, going from moderately dry to very dry. This is counterintuitive because that region also received above average precipitation in March, however, the SPI reflects conditions for the previous 12 months, not just the past month. The Snake Drainage climate division in western **Wyoming** also had below average precipitation in March and moved from the near normal category to the moderately dry category.

Utah's SPI categories did not change this month, with most of the state in the near normal category except the Southeast division that is still in the moderately wet category. Most of **Colorado** is still in the near normal category and the Arkansas River Basin in the southeast is still in the moderately wet

category. This month, the Rio Grande division in south-central **Colorado** moved into the moderately wet category from the near normal category due to above average precipitation in March.

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.

A 12-month SPI is used for the Intermountain West region (Figure 7) and compares precipitation patterns for 12 consecutive months with the same 12 consecutive months during all the previous years of available data. The SPI at these time scales reflect long-term precipitation patterns. The graphic in Figure 7 comes from the Western Regional Climate Center, which uses data from the NCDC and the NOAA Climate Prediction Center.

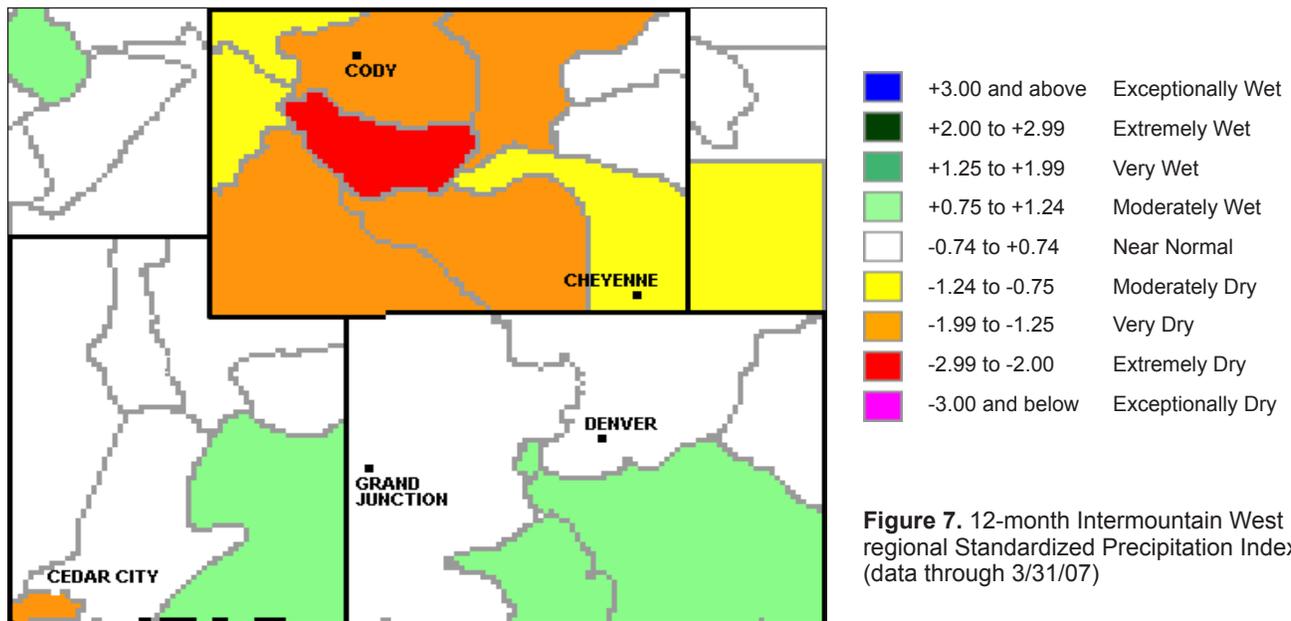


Figure 7. 12-month Intermountain West regional Standardized Precipitation Index. (data through 3/31/07)

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 from the NCDC, visit: <http://wlf.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html>. These maps use the same data as Figure 6, but the categories are defined slightly differently.



Colorado Water Availability

As we move into the upcoming runoff season, water supply conditions are shaped by snowpack, precipitation, and rate of snowmelt. April is a transition month in the water supply year, when precipitation may fall as rain rather than accumulate as snow causing low to mid-elevation snowpack to melt. Runoff volumes usually accelerate in May and continue through the end of July.

Below average snowpack and precipitation conditions coupled with above average temperatures across the state in March caused percent of average snowpack to fall to 75% of average on April 1, down from 92% of average on March 1. The Rio Grande basin suffered the biggest loss in snowpack from 93% of average on March 1 to 70% of average on April 1. The lowest SWE percentages are in the Rio Grande and San Juan, Miguel, and Dolores basins (Figure 7a). SWE percentages are highest along the Northern Continental Divide. Near average snowpack

conditions in the South Platte basin have persisted in part due to above average snowfall during December.

SWE projections of individual river basins in Colorado can provide water managers with water supply scenarios useful for planning purposes. The SWE non-exceedance projection models generated by the NRCS provide SWE scenarios based on a range of precipitation amounts. As of April 1 for the Upper Rio Grande basin, it would take near record high snowfalls to reach around average SWE by May 1 (indicated by the colored lines on the right side of the graph), (Figure 8b, next page). Given that only a few weeks remain in the snow accumulation season, boosting statewide snowpack levels near or above average would require April and May precipitation to be greatly above average and regional temperatures to be at or below average. Visit the seasonal temperature and precipitation forecasts pages 16-17 to see current forecasts.

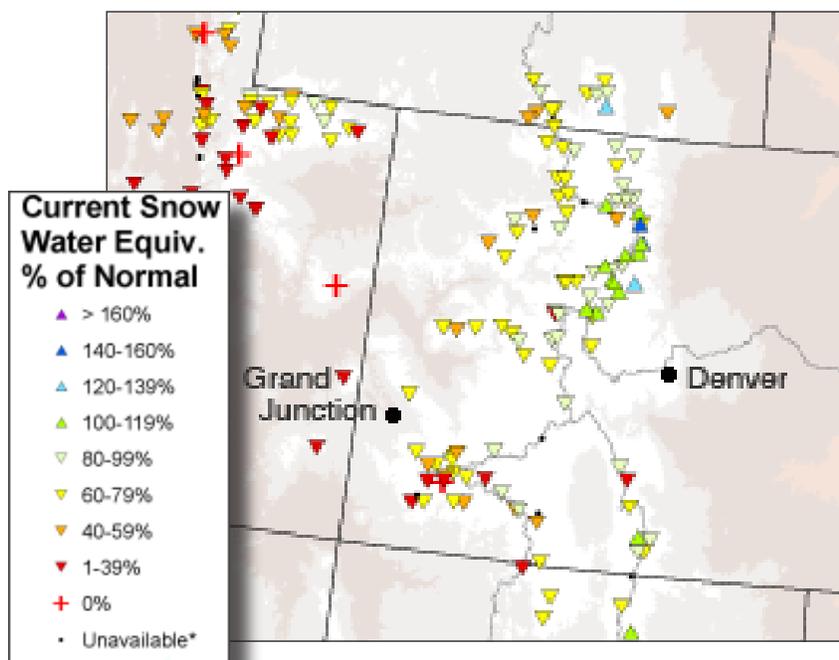


Figure 8a. Current snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Colorado as of April 3, 2007, courtesy NRCS. Note: this is provisional information.

On the Web

- For current maps of SWE as a percent of normal as shown in Figure 8a, visit: <http://www.wcc.nrcs.usda.gov/gis/snow.html> and select the desired state using the embedded scroll bar.
- For current SNOTEL data and plots of specific sites, visit: <http://www.wcc.nrcs.usda.gov/snotel/>.
- For current graphs of SWE projections as a percent of normal as seen in Figure 8b, visit http://www.co.nrcs.usda.gov/snow/snow/watershed/current/daily/maps_graphs/swe_projections.html and click on desired basin or statewide graph.
- 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/index.html>
- For monthly reports on water supply conditions & forecasts for major CO river basins, visit: <http://www.wcc.nrcs.usda.gov/cgibin/bor.pl>
- Water Supply Outlook information for the Upper Colorado River Basin, produced by the Colorado Basin River Forecast Center, is available at: <http://www.cbrfc.noaa.gov/wsup/wsup.cgi>
- For current streamflow information from USGS, visit: <http://water.usgs.gov/waterwatch/>



Colorado Water Availability cont.

Notes

Figure 8a is the SWE as a percent of normal (average) for SNOTEL sites from the NRCS. Figure 8b is the non-exceedance projection of SWE as a percent of normal (average) based on provisional SNOTEL data from the NRCS. The heavy red line shows the observed accumulation to date. The remaining colored lines indicate the range of possible futures. The blue line indicates the SWE that would occur from the wettest precipitation scenario on record, while the red line indicate the driest scenario. Also shown are the 10%, 30%, 50%, 70%, 90% non-exceedance scenarios and the minimum and maximum values. The smooth

black line is the long-term normal (average) data on that date.

Historic data since the mid 1980's is shown in black and gray bands. The gray bands show the historical range of all of the daily data. The upper and lower edges of the gray area are the highest and lowest historical values. The gray bands show the historical 10%, 30%, 70%, and 90% non-exceedance bounds of the data with the lightest gray band representing the 30-70% of the historic range, closest to average. The historical median (50% non-exceedance) is shown as a faint dashed black line.

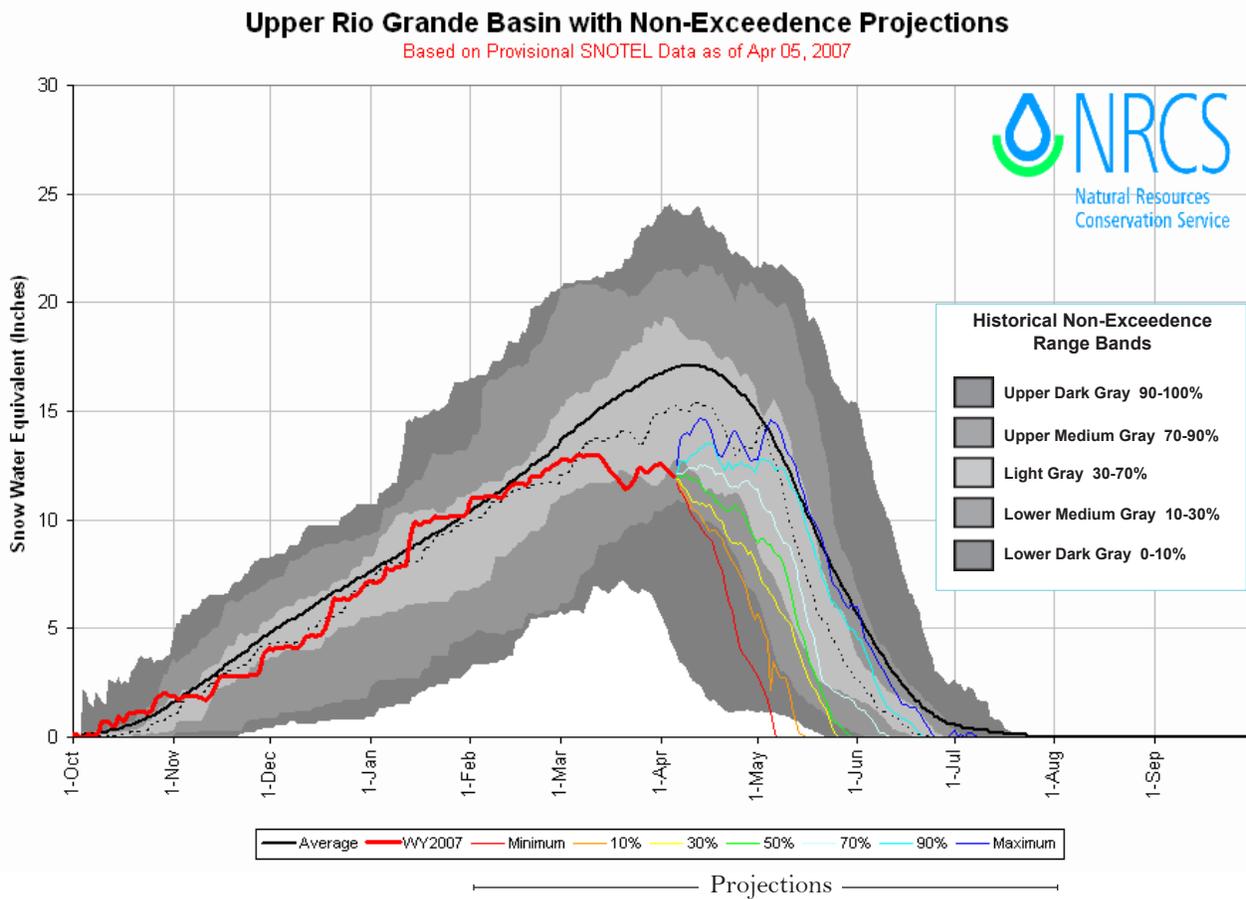


Figure 8b. Non-exceedance projections for SWE as a percent of normal for Rio Grande Basin SNOTEL sites as of April 4, 2007, courtesy of the NRCS.



Wyoming Water Availability

Wyoming’s SNOTEL data shows that as of April 1, 2007 the current SWE is generally below average (Figure 9a). In the western and southern mountains, SWE is mostly in the 60–79% of average range, but there are a few SNOTEL sites reporting closer to average. The central mountains on the border of the Big Horn and Powder-Tongue river basins are in the 100–119% of average range. These basins were the only ones to receive above average precipitation in March, receiving 125% and 149% of average, respectively.

According to the latest Drought Status Update for early April, 2007 Wyoming is still facing drought conditions. State Climatologist Steve Gray writes, “Of particular concern are precipitation deficits over 12-month and longer windows in the west-central and southwestern parts of the state. Even after the late-March storms, inflows to many of the state’s reservoirs are forecast to be < 70% of average. Overall, this leaves the majority of the state in moderate to severe drought, with some areas (e.g. Sweetwater County and the Goshen-Platte-Niobrara region) in extreme drought conditions.” Information about the Wyoming Drought Status is on the WRDS page (see On the Web box).

The state’s drought status is also evident in the current SWSI map from NRCS (Figure 9b). Almost all basins have negative SWSI values, with the lowest numbers in the Upper Green (-3.70) and Big Sandy (-3.70) basins, which are in the severe to extreme drought categories. Despite above average precipitation in March, the Big Horn basin is still in the moderate to severe drought category with a SWSI value of -2.40. Only the Laramie basin in southeastern Wyoming has a SWSI value in the near normal category.

Notes

Figure 9a shows the SWE as a percent of normal (average) for SNOTEL sites in Wyoming, courtesy of the Natural Resources conservation Service (NRCS). According to the WY NRCS, “The Surface Water Supply Index” (SWSI – Figure 9b) is computed using only surface water supplies for each drainage basin. The computation includes reservoir storage, if applicable, plus the runoff forecast. The index is purposely created to resemble the Palmer Drought Index, with normal conditions centered near zero. Adequate and excessive supply has a positive number and deficit water supply has a negative value. The SWE does not use soil moisture and precipitation forecast, but the runoff forecast may include these values.

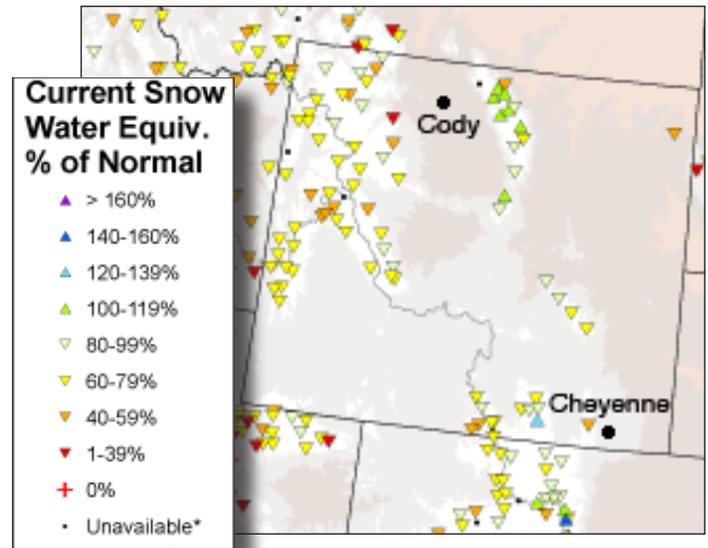


Figure 9a. Current snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Wyoming as of April 1, 2007, courtesy of NRCS. Note: this is provisional data.

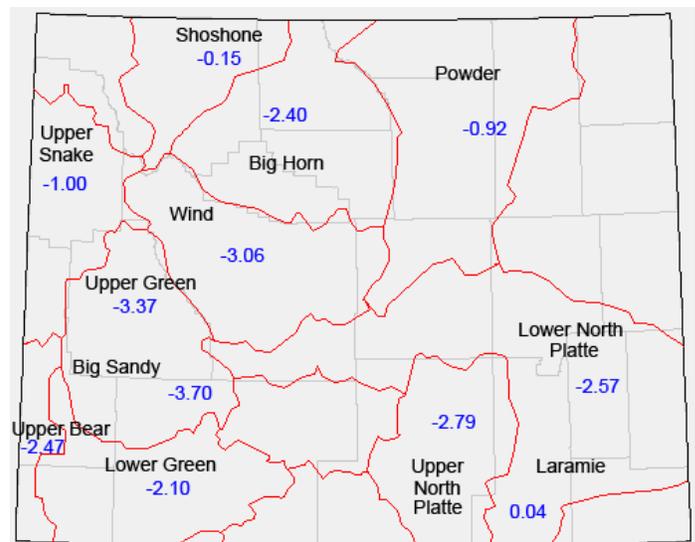


Figure 9b. Wyoming Surface Water Supply Index (data through 4/01/07) courtesy of NRCS and Water Resources Data System (WRDS) of Wyoming.

On the Web

- For current maps of SWE as a percent of normal as shown in Figure 9a, visit: <http://www.wcc.nrcs.usda.gov/gis/snow.html>.
- For current SNOTEL data and plots of specific sites, visit: <http://www.wcc.nrcs.usda.gov/snotel/>.
- The Wyoming SWSI, along with more data about current water supply conditions for the state can be found at: <http://www.wrds.uwyo.edu/wrds/nrcs/nrcs.html>.
- For monthly State Basin Outlook Reports on water supply conditions and forecasts for WY river basins, visit: <http://www.wcc.nrcs.usda.gov/cgibin/bor.pl>.
- Wyoming Water Resource Data system’s drought page is located at: <http://www.wrds.uwyo.edu/wrds/wsc/df/drought.html>.



Utah Water Availability

According to the NWS Salt Lake City, Utah's climate conditions for March 2007 were warm and dry. As of April 3, 2007, all of Utah's SNOTEL sites report below average SWE (Figure 10a). Utah needed above average snow accumulation in March to bring seasonal totals up to average, but instead across the state they had one of the lowest March snowfall totals in recorded history. As of April 1, snowpacks in Utah range from 36–37% of average in southeast and southwest to 56–57% of average in the northern Bear and Uintah basins, respectively. In addition to below average accumulation, warm temperatures in March caused snowpacks to start melting about three weeks early. As a result, soil moisture is increasing across the state and all basins have between 61–74% of saturation.

Below average snowfall all winter, and especially in March, contributed to the state having below average SWSI numbers (Figure 10b). The lowest values are in the San Rafael (-3.24) and Weber (-3.15) basins. The highest values are close to average, but still negative. These are the Provo (-0.17) and both Sevier (-0.60) basins. Despite low SWSI numbers, the NRCS reports that Utah has excellent reservoir carryover from last year.

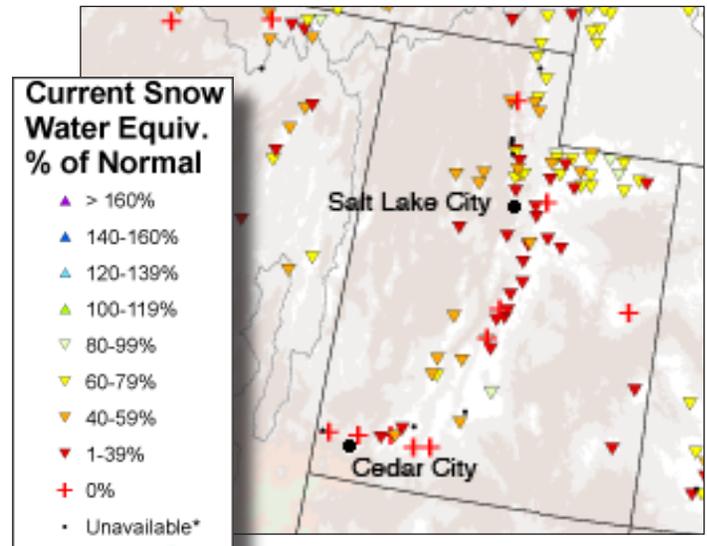


Figure 10a. Current snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Utah as of April 1, 2007, courtesy of the NRCS. Note: this is provisional data.

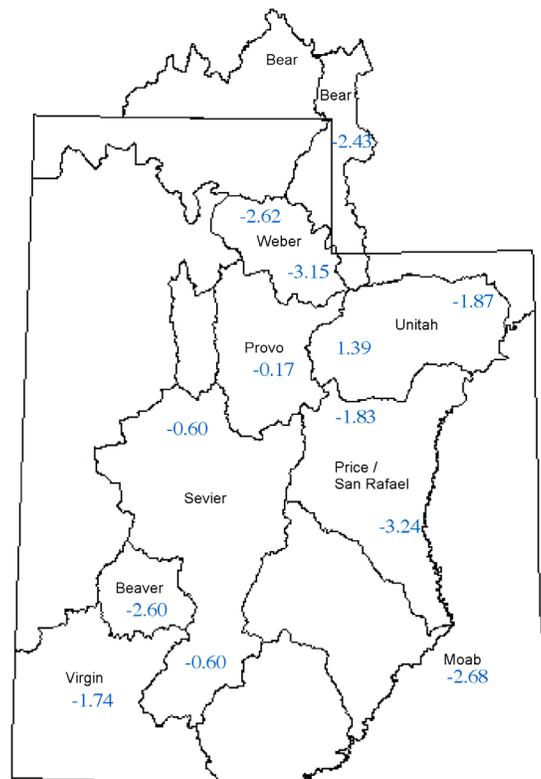


Figure 10b. Utah Surface Water Supply Index (data through 4/1/07). Maps are courtesy of Utah NRCS.

Notes

Figure 10a shows the SWE as a percent of normal (average) for SNOTEL sites in Utah, courtesy of the Natural Resources Conservation Service (NRCS). According to the UT NRCS, "The Surface Water Supply Index (SWSI) (Figure 9b) is a predictive indicator of total surface water availability within a watershed for the spring and summer water use seasons. The index is calculated by combining pre-runoff reservoir storage (carryover) with forecasts of spring and summer streamflow, which are based on current Snowpack and other hydrologic variables. SWSI values are scaled from +4.1 (abundant supply) to -4.1 (extremely dry) with a value of zero (0) indicating median water supply as compared to historical analysis. SWSI's are calculated in this fashion to be consistent with other hydroclimatic indicators such as the Palmer Drought Index and the [Standardized] Precipitation Index." See page 11 for the SPI.

On the Web

- For current maps of SWE as a percent of normal as shown in Figure 10a, visit: <http://www.wcc.nrcs.usda.gov/gis/snow.html>.
- For current SNOTEL data and plots of specific sites, visit: <http://www.wcc.nrcs.usda.gov/snotel/>.
- The Utah SWSI, along with more data about current water supply conditions for the state can be found at: <http://www.ut.nrcs.usda.gov/snow/watersupply/>.
- For monthly reports on water supply conditions & forecasts for major CO river basins, visit: <http://www.wcc.nrcs.usda.gov/cgibin/bor.pl>.
- Water Supply Outlook information for the Upper Colorado River Basin, produced by the Colorado Basin River Forecast Center, is available at: <http://www.cbrfc.noaa.gov/wsup/wsup.cgi>.



Temperature Outlook May - September 2007

The NOAA/CPC temperature outlook for May 2007 indicates an increased risk of above average temperatures across the Intermountain West and the Rio Grande Valley. In the May-July 2007 and subsequent forecast periods, areas with probabilities for above average temperatures include most or all of the Intermountain West and the Southwest (Figure 11a-d). The IRI multi-model world temperature forecast also indicates a slightly increased risk for above average temperatures across much of the region in its May- July 2007 forecast period (not shown, see On the Web box).

CPC does not expect any El Nino or La Nina impacts on the climate of the United States during the May-July 2007 season; although models suggest that a weak La Nina could develop by summer, the certainty in these projections is too weak to put much confidence in this for U.S. climate impacts later in the year. An updated May 2007 temperature forecast will be available on April 30th, on the CPC web page. Because of the shorter lead-time, the updated monthly forecast maps often have increased skill over the half-month lead forecasts.

Notes

The seasonal temperature outlooks in Figures 11a-d predict the likelihood (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 NOAA-CPC outlooks are a 3-category forecast based largely on the status of ENSO and recent trends. As a starting point, the 1971-2000 climate record for 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 indicates the likelihood of the temperature being in the above-average (A) or below-average (B) tercile--with a corresponding adjustment to the opposite category. The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high. For a detailed description, see notes on the precipitation outlook page.

Equal Chances (EC) indicates areas for which the models do not have sufficient skill to predict the temperature with any confidence. EC is used as a "default option" representing equal chances or a 33.3% probability for each tercile, indicating areas where the reliability (i.e., 'skill') of the forecast is poor.

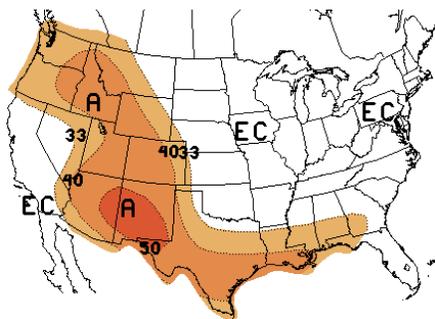


Figure 11a. Long-lead national temperature forecast for May 2007. (released April 19, 2007)

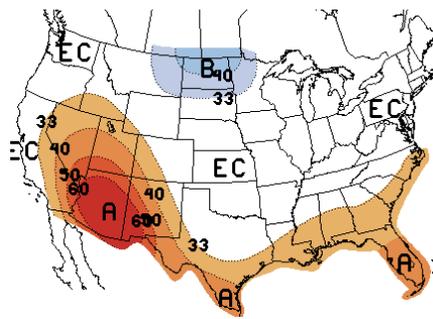


Figure 11b. Long-lead national temperature forecast for May - July 2007. (released April 19, 2007)

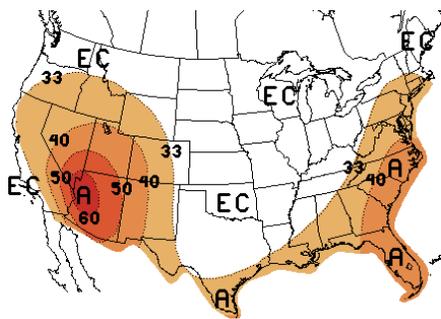


Figure 11c. Long-lead national temperature forecast for June - August 2007. (released April 19, 2007)

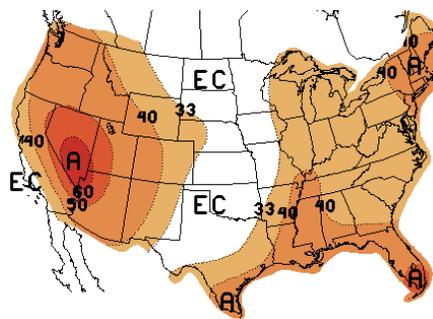


Figure 11d. Long-lead national temperature forecast for July - September 2007. (released April 19, 2007)

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

B = Below
 40.0-49.9%
 33.3-39.9%

EC = Equal Chances

On the Web

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



Precipitation Outlook May - August 2007

The NOAA/CPC forecasts issued April 19th indicate “EC” or “equal chances” of above-average, near-normal or below-average precipitation for the May 2007 (Figure 12a). For the May-July period, there is an increased risk of dry conditions for the region except eastern Colorado (Figure 12b). “EC” is the forecast for subsequent periods through the summer and fall (Figure 12c and see CPC in On the Web box). According to CPC, these outlooks are based on the NOAA consolidation tool, which is a skill-weighted objective blend of forecast models, that also consider trends in precipitation; however, these trends appear only in scattered areas and are weak. The forecast tools provide no significant skillful indications for precipitation anomalies, and the uncertainty and lack of significant trends leads to “EC” forecasts over the region.

Two precipitation forecasts from other forecasters also indicate a slightly increased risk of dry conditions in the Intermountain West. The Experimental Forecast Guidance for the Interior Southwest updated April 18 indicates the possibility that La Niña conditions could bring an increased probability of a dry April-June 2007 to western Colorado, eastern Utah, northern New Mexico, and a slight shift toward wet conditions for eastern Colorado, southwestern Utah and the northwestern corner of Arizona (not shown, see On the Web box). The IRI multi-model world precipitation forecast also indicates a slightly increased risk for below average precipitation in Utah, Wyoming, and western Colorado and for the May- July 2007 forecast period (not shown, see On the Web box).

CPC does not expect any El Niño or La Niña impacts on the climate of the United States during the May-July 2007 season; although models suggest that a weak La Niña could develop by summer, the certainty in these projections is too weak to put much confidence in this for U.S. climate impacts later in the year. An updated May 2007 precipitation forecast will be available on April 30th, on the CPC web page.

Notes

The seasonal precipitation outlooks in Figures 12a-d predict the likelihood (chance) of precipitation corresponding to the above-average, near-average, and below-average categories. The numbers on the maps refer not to amount of precipitation, but rather to the probability in percent that precipitation will be in one of these three categories.

The NOAA-CPC outlooks are a 3-category forecast based largely on the status of El Niño and recent trends. As a starting point, the 1971-2000 climate record for each 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). 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 above-average (A) or below-average (B)--with a corresponding adjustment to the opposite category. The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high.

Thus, areas with dark brown shading in the precipitation outlook 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. Green shading indicate areas with a greater chance of above average precipitation.

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

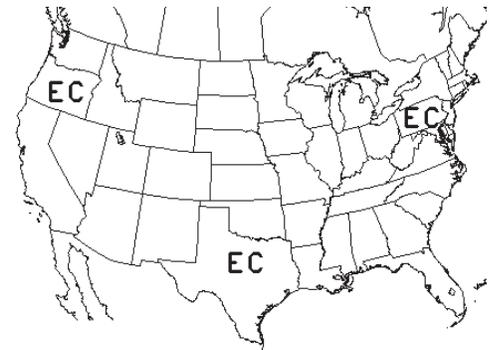


Figure 12a. Long-lead national precipitation forecast for May 2007. (released April 19, 2007)

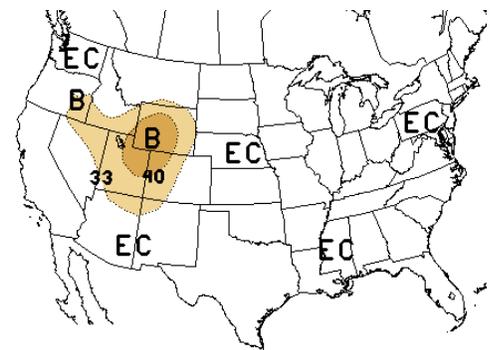


Figure 12b. Long-lead national precipitation forecast for May – July 2007. (released April 19, 2007)

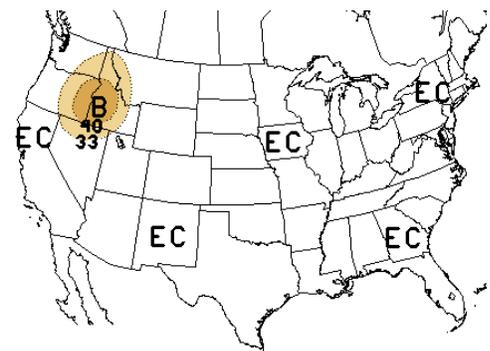


Figure 12c. Long-lead national precipitation forecast for June – August 2007. (released April 19, 2007)

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

On the Web

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



Seasonal Drought Outlook through July 2007

The Seasonal Drought Outlook issued April 19th, depicts general, large-scale trends from that date through the end of July 2007 (3.5 months), and is developed by experts based on their subjective judgement of various forecasts (Figure 13). The Outlook indicates that significant drought relief is unlikely across the Southwest, **Utah** and the Great Basin, western **Colorado**, and southwestern **Wyoming** as the snow season comes to a close and snowpack remains well below normal. Although some precipitation is expected near the start of the forecast period, overall drought conditions will not improve significantly across most of the region. Varying degrees of improvement may occur for the western Dakotas, western Nebraska, and parts of **Wyoming**, although CPC says that complete eradication of the long-running drought is unlikely in the outlook period.

NOAA/CPC is soliciting comments on a proposed change in the scheduled release time for this product. Currently the U.S. Drought Outlook is issued on the third Thursday of each month at 8:30 a.m. eastern time with a valid period of 3 1/2 months after issuance. This proposal would change the scheduled release date to the first day of the month at 8:30 a.m. eastern time with a

valid time covering the three calendar months starting the day of issuance. This new schedule issuance time would allow better use of the updated monthly precipitation and temperature outlooks issued on the last day of the previous month. For additional information please contact Douglas LeCompte at: Douglas.Lecompte@noaa.gov; You may provide comments via a form on the Drought Outlook page, or by email to LeCompte.

Notes

The delineated areas in the Seasonal Drought Outlook produced by the NOAA Climate Prediction Center (Figure 13) are defined subjectively and are based on expert assessment of numerous indicators, 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: <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.

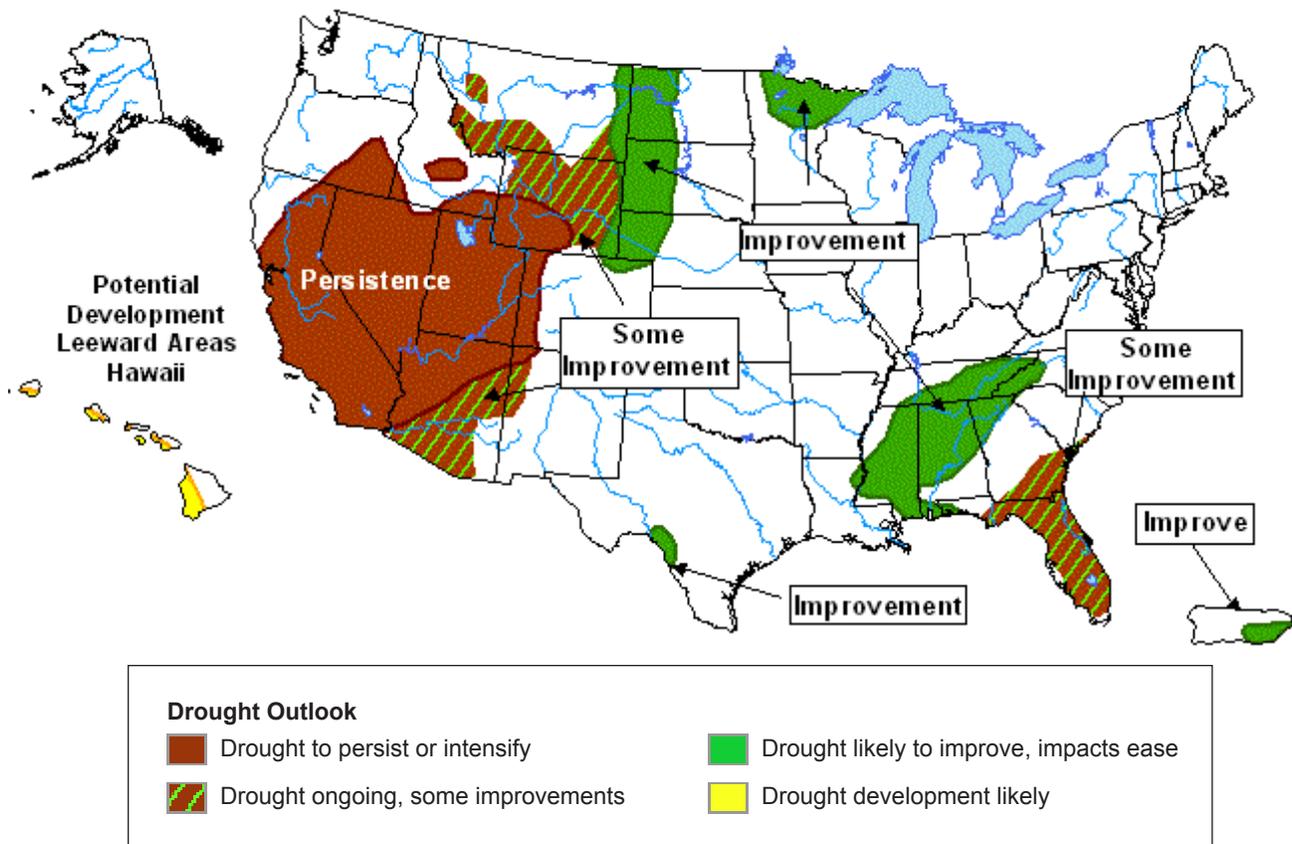


Figure 13. Seasonal Drought Outlook valid April 19 through July 2007.

On the Web

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



El Niño Status and Forecast through April 2007

The El Niño event of the past winter came to a quick end by March 2007, and the Pacific is now in ENSO-neutral conditions, meaning around average sea surface temperatures (SSTs, Figure 14a). However, both the NOAA Climate Prediction Center (CPC) and the International Center for Climate and Society (IRI) suggest that a La Niña may be on the way. Most of the statistical and coupled model forecasts indicate additional anomalous surface cooling during the next several months, and some models indicate a transition to La Niña during May-July 2007 (Fig. 14b). This forecast is consistent with the observed trends in atmospheric and oceanic conditions. However, the spread of the most recent statistical and coupled model forecasts (ENSO-neutral to La Niña) indicates considerable uncertainty as to when La Niña might develop and how strong it might be. IRI indicates a 50% chance of a La Niña developing by mid-2007 (Aug-Oct) but only about a 5% chance of El Niño conditions.

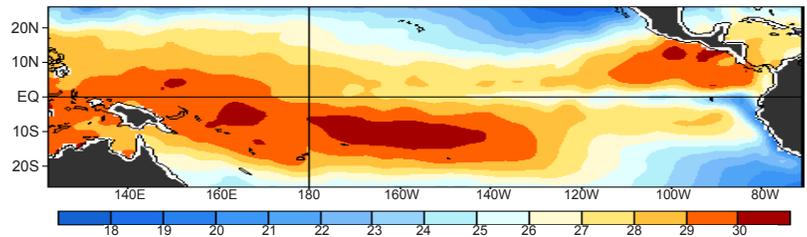
No significant ENSO impacts are anticipated on the climate of the U.S. during the May-July 2007 season. The CPC ENSO Diagnostic Discussion will be updated on May 10th.

Notes

Two NOAA graphics in Figure 14a show the observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. Data are from the TOGA/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 in the Niño 3.4 region for nine overlapping 3-month periods from September 2005 to July 2006. "Niño 3.4" refers to the region of the equatorial Pacific from 120°W to 170°W and 5°N to 5°S, which is used as an index for defining ENSO sea surface temperature anomalies. Abbreviations represent groups of three months (e.g. SON = Sept-Nov). Note that the expected skills of the models, based on historical performance, vary among the models, and skill generally decreases with lead-time. Forecasts skill also varies over the year because of seasonal differences in predictability of the system, for example, forecasts made between June and December are generally better than between February and May. Differences among forecasts reflect both differences in model design and actual uncertainty in the forecast of the possible future SST scenario.

Observed Sea Surface Temperature (C°)



Observed Sea Surface Temperature Anomalies (C°)

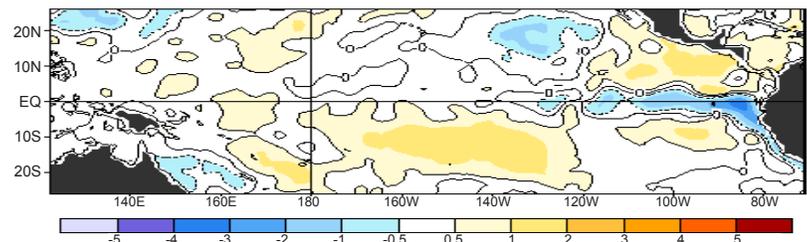


Figure 14a. Observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. The Niño 3.4 region encompasses the area between 120°W-170°W and 5°N-5°S. The graphics represent the 7-day average centered on April 11, 2007.

Model Forecasts of ENSO from April 2007

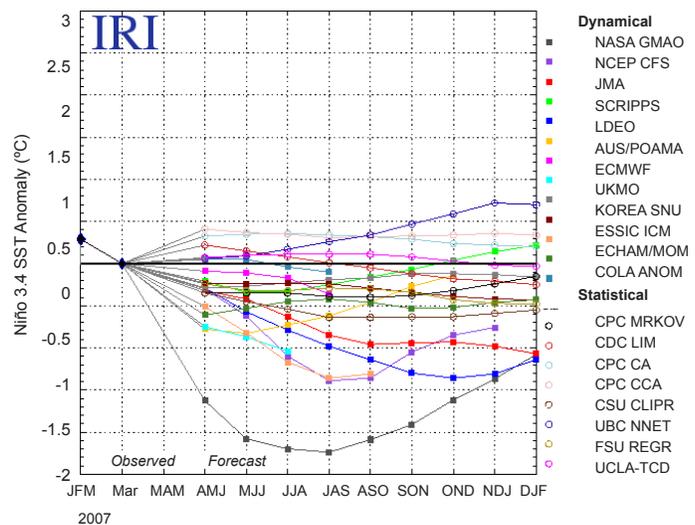


Figure 14b. Forecasts made by dynamical and statistical models for sea surface temperatures (SST) in the Niño 3.4 region for nine overlapping 3-month periods from April 2007 through February 2008 (released April 19, 2007). Forecast graphic is from the International Research Institute (IRI) for Climate and Society.

On the Web

- For a technical discussion of current El Niño conditions, visit: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ens0_advisory/.
- For updated graphics of SST and SST anomalies, visit this site and click on "Weekly SST Anomalies": <http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/ens0.shtml#current>.
- For more information about El Niño, including the most recent forecasts, visit: <http://iri.columbia.edu/climate/ENSO/>.



Spring and Summer Streamflow Forecasts for the 2007 runoff Season

The month of March brought below average snowfall to most of the Intermountain West region, with the exception of eastern **Wyoming**. According to the NRCS, most basins now are projected to have 25–70% of average streamflows for the spring and summer runoff season (Figure 15). The lowest projected streamflows are in **Utah**, where over half of the state is projected to have streamflows that are below 50% of average. The NRCS attributes this to very low precipitation all winter long; two central **Utah** basins had the lowest April 1 SWE since 1977, and the SWE for southwestern Utah set a new record low. The only basins in the IMW projected to have near average streamflows are in the Upper South Platte and Arkansas River basins in eastern **Colorado** and the Tongue River basin in north-central **Wyoming**. However, these projections are lower than those made last month due to below average precipitation in March. In both **Colorado** and **Wyoming**, most of the state is projected to have between 50% and 89% of average streamflows.

For more information on inflow projections to particular reservoirs in the region, see page 9-10. Refer to the **Colorado**, **Wyoming**, and **Utah** state water availability pages 12-15, for more information on streamflow forecasts, snowpack, and precipitation by state.

Notes

This page provides the NRCS spring and summer streamflow forecasts for the entire Intermountain West region. The official NOAA streamflow forecasts are developed by individual river basin forecast centers. (See On the Web box below for links to the official NOAA forecasts.)

Forecasts of natural runoff are based principally on measurements of precipitation, snow water equivalent, and antecedent runoff, influenced by precipitation in the fall before winter snowfall (Figure 15). Forecasts become more accurate as more of the data affecting runoff are measured (i.e. accuracy increases from January to May). In addition, these forecasts assume that climatic factors during the remainder of the snow accumulation and melt season will have an average affect on runoff. Early season forecasts are, therefore, subject to a greater change than those made on later dates.

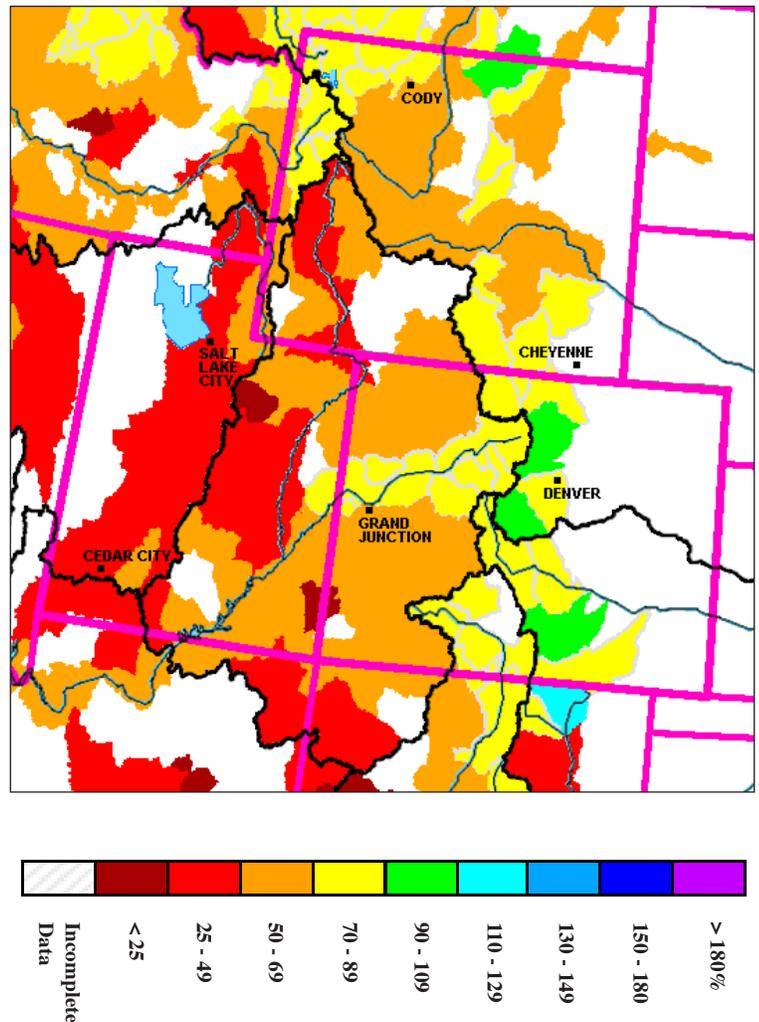


Figure 15. NRCS outlook for natural streamflows for spring and summer in the Intermountain West region as a percent of average streamflows. (data through April 1, 2007 courtesy of Natural Resources Conservation Service)

On the Web

- For more information about NRCS water supply forecasts based on snow accumulation and access to the graph on this page, visit: <http://www.wcc.nrcs.usda.gov/wsf/>.
- The official NOAA streamflow forecasts are available through the following websites of individual River Forecast Centers:
 - Colorado Basin (includes Great Basin): <http://www.cbrfc.noaa.gov/>
 - Missouri Basin (includes South Platte and North Platte): <http://www.crh.noaa.gov/mbrfc/>
 - West Gulf (includes Rio Grande): <http://www.srh.noaa.gov/wgrfc/>
 - Arkansas Basin: <http://www.srh.noaa.gov/abrfc/>



The Colorado Climate Center

By Nolan Doesken, Colorado State Climatologist

Doesken was recently appointed as the Colorado State Climatologist in July 2006 and has been at the Colorado Climate Center since 1977. He succeeds Dr. Roger Pielke (2000-2006), and Dr. Thomas McKee (1974-2000).

The Colorado Climate Center (CCC) is an academic center dedicated to monitoring and tracking climatic conditions throughout Colorado. Part of Colorado State University's Department of Atmospheric Science in the College of Engineering, the CCC also serves as an information resource to business, government, industry, education, researchers and the general public. The CCC is home to the Colorado State Climatologist position. This article highlights primary activities and responsibilities, featuring climate monitoring, data archival, applied research, climate services, and education and outreach. A version of this article was originally featured in the February/March 2007 Colorado Water Newsletter, a Colorado State University Water Center newsletter and publication of the Colorado Water Resources Research Institute (CWRRI) (see On the Web box).

Climate Monitoring

The CCC is responsible for tracking daily weather conditions and interpreting the seasonal, annual, and interannual observed patterns and variations that climate provides. Climate monitoring for Colorado involves multiple approaches due to the vast local differences in climate that is characteristic of mountainous regions. The first approach involves the National Weather Service's Cooperative (COOP) Network, which has over 200 stations in Colorado reporting temperatures and precipitation on a daily basis. Data from some of these stations date back more than a century and provide the longest continuous data records for tracking climate variations and change. CSU's main campus weather station, part of the COOP network, is operated by the Center and is Colorado's premier historic weather station with complete records dating back to the 1880's (Figure 16a).

The second monitoring approach incorporates observations from other organizations, like the Natural Resource Conservation Service's snow surveys and SNOTEL stations. Information on snow depth, snow water equivalent and, in some places, soil moisture provides essential data for climate and water supply monitoring.

Finally, since the early 1990s, the CCC has assisted several other CSU and federal groups in maintaining a specialized automated weather-observing network to serve Colorado agriculture users. The Colorado Agricultural Meteorological Network (CoAgMet) now provides detailed hourly weather data from 60 stations across the state representing most agricultural areas. Observations include temperature, humidity, wind speed and direction, precipitation, solar energy and soil temperatures. Computations of evapotranspiration from CoAgMet have become the primary

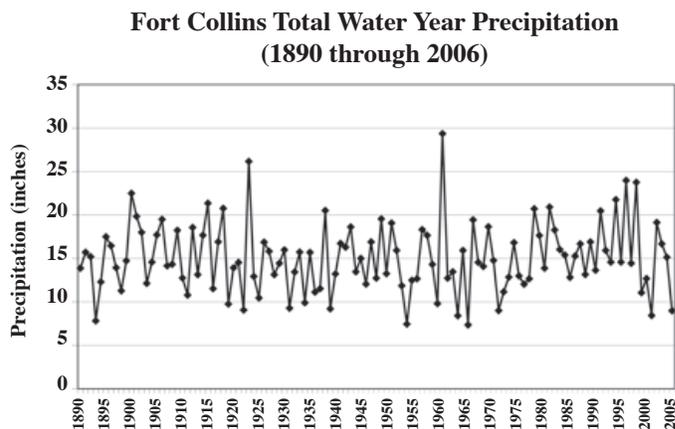


Figure 16a. Water year time series of Fort Collins precipitation amounts in inches; 1890 through 2006.

data source for much of the state for tracking water use by crops. All current and historic data from this network are available online free of charge (<http://ccc.atmos.colostate.edu/%7Ecoagmet/>).

Data Archival

The CCC also serves as an archive of historical climate data collected in Colorado including original climate data and published summaries dating back to the 1800s. Digital databases are also maintained. For efficiency, much of the data management is coordinated nationally by the National Climatic Data Center in Asheville, North Carolina, and by regional climate centers in Nebraska and Nevada. This data is available from the Center upon request.

Climate Research

Since its beginning, the CCC has been actively involved in research. Former State Climatologist McKee spearheaded drought research and developed the "Standardized Precipitation Index," a drought-monitoring index that is now used worldwide. The CCC also works closely with the National Weather Service in research to improve accuracy of weather station observations. The CCC is currently leading a nationwide test and evaluation of automated snow measurement systems. Years of research on mountain and valley weather patterns have led to greater understanding of mountain climatology. The CCC is also involved in research on energy, crop production, and engineering applications of climate information.



Climate Services

Uses of climate information including: exploring the potential for introducing new crops, causes for fluctuations in crop and livestock production, recreational opportunities, commercial and residential construction, transportation, verifying insurance claims, human and animal health, where and when to schedule conferences and outdoor events, dam and spillway design and floodplain management, drought and water supply -- the list is nearly endless. The ultimate goal of the CCC is to provide climate data, information, and expertise to a wide range of user groups, so climate services are provided in a variety of ways. CCC's web site is now the primary means for answering questions and sharing data and information, and phone calls and walk-in visitors are welcome as well (see On the Web box).

Education and Outreach

Recent years have seen a huge upswing in education and outreach opportunities for the CCC. Tours of the historic Fort Collins Weather Station bring hundreds of visitors to campus each year and many talks and presentations are provided on the topic of Colorado's amazingly variable climate (Figure 16b). The most visible education and outreach activity of the CCC today is



Figure 16b. The Center provides education and outreach services to the academic community, water managers and even public school systems. Here, State Climatologist Nolan Doesken explains a weather station to elementary school students.

CoCoRaHS -- the Community Collaborative Rain, Hail and Snow Network. Thousands of citizens of all ages help monitor the weather and water resources in Colorado by setting up backyard rain gauges across the state. This program is providing educational opportunities for a large number of individuals while also contributing an incredibly valuable data resource for studying weather patterns and local rainfall variations in Colorado. The project is so popular that it has spread to many other states and may be a nationwide program by 2010 (Figure 16c). The CCC also participates in many statewide meetings and organizations. For example, the CCC was actively involved in the development of Colorado's Drought Response Plan and has attended nearly every meeting of the Colorado Water Availability Task Force since it was established in 1981.

Supplemented by multiple sources of funding including the state of Colorado, CSU, and other grants and contracts, the CCC continues to be a hub for state-wide climate monitoring, research, and educational and outreach resource available to a range of user groups including climate researchers, farmers, and interested citizens. Visit their website or contact Colorado State Climatologist, Nolan Doesken at nolan@atmos.colostate.edu for additional information, resources and services.

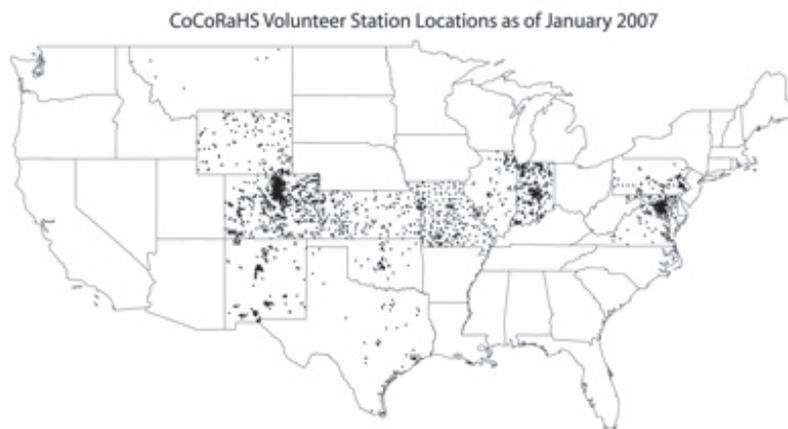


Figure 16c. The state of Colorado hosts one of the largest CoCoRaHS climate monitoring volunteer networks across the nation. Members of the public assist researchers in compiling a database of various climate parameters.

¹ See March 2006 Intermountain West Climate Summary for a focus page on CoCoRaHS.

On the Web

- The Colorado Climate Center homepage is available at <http://ccc.atmos.colostate.edu/>.
- Information about the Colorado Climate Center's Colorado Climate magazine is available at: <http://ccc.atmos.colostate.edu/magazine.php>. (Past issues are available, but the publication is currently suspended.)
- For information about the CoCoRaHS monitoring assistance programs, visit www.cocorahs.org and click on "Join CoCoRaHS."
- For CoAgMet current & historic climate information beneficial for agriculture users, visit: <http://ccc.atmos.colostate.edu/Ecoagmet>.
- The Colorado Water Newsletter based out of the Colorado State University Water Center and Colorado Water Resources Research Institute (CWRRI) is available online at: <http://cwrri.colostate.edu/pubs/newsletter/newsletter.htm>.

