April 2005 Snowpack Outlook for Colorado

By Shaleen Jain, NOAA Climate Diagnostics Center and University of Colorado at Boulder

Despite a dry February, the seasonal snowpack continues well above average the Rio Grande and San Juan/Animas River basins. Marked improvements occurred in the Gunnison River Basin snowpack – 84% in early February to 133% in early March. By contrast, the Yampa, Colorado Headwaters, and Platte basin snowpacks continue to be below average.

With April 1 approaching, there is strong interest in estimates of the April 1 snowpack, long the benchmark for planning and decisions for water-related resource management in Colorado.

Climatologically, March can deliver significant moisture in Colorado, particularly in the South Platte basin. Tropical Pacific sea surface temperatures ("SSTs") are the best known predictor of above average spring precipitation in Colorado, with warm temperatures correlated with above average March/April/May precipitation. Current tropical Pacific SSTs in the so called "NINO3" region indicate near neutral, or average, conditions. These average SSTs do provide some useful information to guide estimates of Colorado's expected water supply for this year.

Analysis of the 1968-2005 basin average snowpack for the eight major river basins in Colorado allows us to examine the range of likely April 1 outcomes consistent with the current levels of snowpack (as reported by Mike Gillespie at NRCS in early March). Figure 1 shows the expectations for April snowpack based on two cases: (1) likely snowpack estimates using only the observations in early March (red boxplots) and (2) likely snowpack estimates based on both the March observations and the inclusion of tropical Pacific climate information (green boxplots). March 1 observations are shown by filled circles. The bottom of each box shows the lower 33rd percentile, the middle line in the box shows the 50th percentile (median), and the top of the box indicates the upper 67th percentile of all the years used in each analysis. The dashed lines (the "whiskers") report the 10th and 90th percentile of the calculated spread.

Using the March observations only (red), the boxplots of April 1 snowpack show that the northern basins (North Platte, South Platte, and Yampa) will

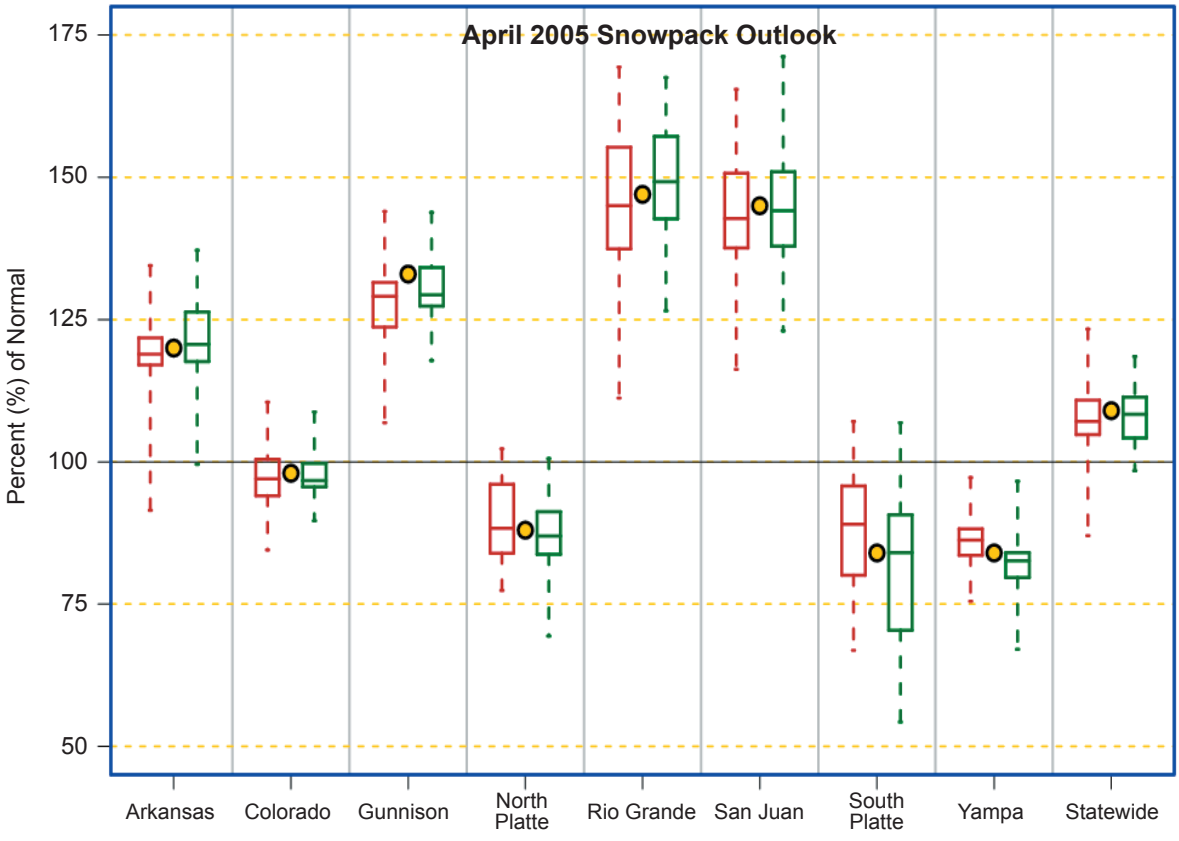

Figure 1: This graphic shows the predicted snowpacks as a percent of normal for each of the eight major river basins in Colorado and the whole state for April 1, 2005. Black circles filled with yellow represent the current snowpack, as of March 1, 2005. Snowpack predictions were calculated using only current conditions (red boxes) and current conditions, plus El Niño status (green boxes). The boxes show the lower tercile, median, and upper tercile probabilities (33rd, 50th and 67th percentiles respectively), and the "whiskers" report the 10th and 90th percentile of the calculated spread.

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likely (33rd to 67th percentiles) stay below 100%. The Colorado Headwaters have been just under 100%, and will most likely remain in that territory. The southern basins appear likely to be in the 115-150% range. Note that the whiskers (10th to 90th percentiles) for all basins show a wide range of possible outcomes.

Using the March observations conditioned by the near-neutral tropical Pacific SSTs for the January/February period (green), the boxplots of April 1 snowpack do not appear to be markedly different from either the March snowpack measurements (black circles) or the April 1 estimates from observations alone (red boxplots). One noteworthy aspect for a number of basins is that the SST-conditioned estimates of April 1 snowpack show a general tightening of the likely (33rd to 67th percentile) outcomes. (South Platte and Arkansas appear to be exceptions). Tighter boxplots indicate that the SSTs downgrade the potential of unusually wet or dry March precipitation, thus narrowing the likely 33rd to 66th percentile values for April 1. The observational analysis presented here does not explicitly consider the losses in snowpack due to meteorological conditions causing early melt, wind-driven redistribution and losses, and losses to sublimation.

Shaleen Jain is a research scientist at the NOAA Climate Diagnostic Center and his work focuses on statistical based streamflow forecasts. His other research interests include Hydroclimatology, Climate-related Hydrologic Risk, Dendrohydrology, Integrative Hydrologic Science, Statistical Analysis of Environmental Data, and Climate Information for Water Applications.

New Research Spotlight

Increased Variability in Annual Streamflows in Four North American River Basins

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Article by Jessica Lowrey, NOAA-CIRES Climate Diagnostic Center and the University of Colorado at Boulder

Climate researchers at NOAA's Climate Diagnostic Center (CDC) have found that annual streamflows in four western North American rivers have behaved more synchronized in recent decades, with larger amplitude swings between low and high flows. A recent paper by Jain and colleagues to appear in the Journal of Climate explores the question of reliability of runoff and synchroneity of annual stream flows in the Fraser, Colombia, Upper Colorado and Sacramento-San Joaquin River Basins.

Water managers and reservoir operators in western North America depend on water stored in the winter snowpack to provide water supplies for both cities and agriculture throughout the whole year. To ensure sufficient water supplies each year, these managers often use historical streamflow and runoff regimes, along with estimates of current snowpack to determine how to operate dams and canals to prevent either shortages or floods. A long-term change in the reliability of spring runoff could pose challenges for water managers in the future. Furthermore, if all three river basins in the U.S. experience either anomalously high or low flows in the same year, it could be more difficult for the U.S. Government to provide adequate drought relief or flood mitigation in each basin.

All four of the river basins in this study are snowmelt dominated, meaning the annual runoff is highly correlated to snowpack. The question becomes what climate states control snowpack growth; and whether these have lead-time predictability, for example seasons ahead. Climate researchers want to understand the causal mechanism of these states because the Pacific Ocean affects winter precipitation amounts in North America. To do this, researchers monitor both the Pacific sea surface temperature and the atmospheric pressure above the Pacific Ocean, and determine if there are pre-cursor patterns in these variables that correspond to patterns of winter snowfall and annual streamflows in the western U.S. For example, ENSO has been long-known to affect western North American climate. Jain and colleagues hypothesize that a mean warming of tropical oceans, as has occurred post 1970, may also be affecting the four western North American river basins.

Jain and his colleagues at CDC want to go beyond understanding the correlation between climate and streamflow to understanding how changes in the ocean-atmospheric circulation patterns cause changes in weather events. In addition, they want to predict how long term changes in the climate affect weather and streamflows in western North America so they can help water managers make better operational and long-term planning decisions for the future.

This paper was published in the March 2005 edition of the Journal of Climate. Jain, S., M. Hoerling, and J. Eischeid, 2005: "Decreasing Reliability and Increasing Synchroneity of Western North American Stream Flow." *Journal of Climate*: **18**(5), 613-618.