

Human Induced Changes in the Hydrological Cycle of the Western United States

Tim Barnett, David Pierce, Hugo Hidalgo, Tapash Das, and Daniel Cayan
Scripps Institution of Oceanography
La Jolla, California

Celine Bonfils, Benjamin Santer, Bala Govindasamy, and Art Mirin
Lawrence Livermore National Laboratory
Livermore, California

Michael Dettinger and Daniel Cayan
U.S. Geological Survey
La Jolla, California

Andrew Wood
University of Washington
Seattle, Washington

Numerous studies have documented marked change in components of the hydrological cycle of the western United States over the last 50 or so years. The snow pack has decreased and been observed to melt earlier in the calendar year. Main spring river runoff has also been coming earlier in the year over the entire region, while air temperatures, especially in Spring, have increased. Previous studies have speculated that such changes are due to global warming. However, strong interannual variability and marked decadal fluctuations in weather patterns greatly affect the region, and previous studies have not performed a formal detection and attribution analysis of these changes, nor attempted to quantify the comparative effect of natural and anthropogenic forcing

In this study we have conducted a rigorous, multi-variate detection and attribution analysis with a variety of climate, regional and hydrological models to determine the causes of the recent changes in the western snowpack, large river flow and surface air temperature. Natural variability of the western climate system has been ruled out as the major cause of the changes. Similarly, changes in solar variability and volcanic impacts are also ruled out by the analysis.

We find that the observed changes in the hydrological components mentioned above can be explained well by anthropogenic forcing (green house gases and aerosols) alone. This is the first time, to our knowledge, that regional changes in the hydrological cycle have been attributed rigorously to human induced forcing. Further, since the climate models used here simulated the last 50 years of observations well, we might do well to place stock in model predictions of future changes in the West. The current simulations suggest that within the next few decades, the western United States will face a 'climate crisis' wherein its sustainability will be severely stressed.

CLIMATE SCIENCE AND ANNUAL PREDICTION