Reconstruction of Sierra Nevada Hydrology over the Last Millennium

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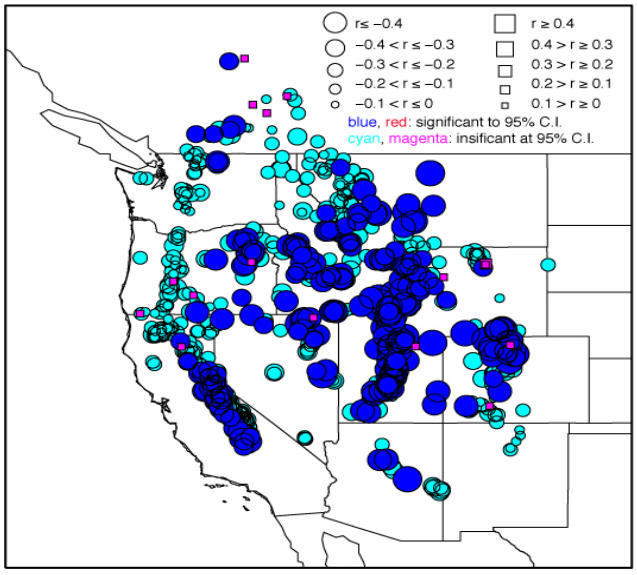
It is crucial that we understand the hydrologic response of the Sierra Nevada Mountains—a primary source of fresh water for Southern California—to projected climate change over the next few decades to centuries. This study aims to contribute to this understanding by reconstructing hydrologic conditions of the Sierra Nevada over the last millennium.

Climate change and growing demand for fresh water in Southern California over the 21st century leaves this region highly vulnerable to severe drought and the resulting environmental damage and socioeconomic disruption. Much of Southern California's freshwater supply relies on the accumulation snow pack and the release of snowmelt from the Sierra Nevada Mountains, processes which may already be impacted by the effects of a warming climate. Furthermore, studies of past climate indicate that at certain periods over the last millennium, the entire western United States was witness to droughts of greater duration and severity than any in recorded history. This study aims to contribute to the understanding of hydrologic response of the Sierra Nevada to projected climate change over the next few decades by reconstructing hydrologic conditions of these mountains over the last millennium through the collection and analysis of a suite of sediment cores from Swamp Lake, located in an isolated catchment at the northwest corner of Yosemite National Park.

Two primary goals of this project are to: 1) create a time series of hydrologic variability in the western Sierra Nevada through analysis of Swamp Lake sediment morphology and geochemistry and, 2) determine the quality with which climate information is recorded in the sedimentary archive through a comparison of the uppermost sedimentary layers with the instrumental record of the last several decades.

Having collected sediment cores during field expeditions in 2006 and 2007, we have focused our efforts thus far on analyzing properties of the most recent sediment, that which was deposited within the period of instrumental record. By comparing results with instrumental observations, we can assess the ability of these analyses to reveal information about Sierra Nevada hydrology over the past millennium. High-resolution images of core surfaces were complied at the Limnological Research Center (LRC) at the University of Minnesota, Minneapolis and analyzed to create a time series of varve thick-



Correlation of National Water and Climate Center SNOTEL station April 1 Snow Water Equivalent values from 1949-2006 with Swamp Lake sediment δD over the sample time period.

ness and light/dark (grey scale) intensity. Through further investigation of these images and comparison of results with existing hydrologic reconstructions from across the western United States we will attempt to determine the relationship between the thickness of seasonal varve components and sediment grey scale values to the hydrology of the area.

A record of hydrogen isotope ratios (δD) from a specific organic compound, probably from terrestrial and aquatic plants around the perimeter of the lake, was measured over the 20th century as sampled from the upper core sediments in order to compare δD with know variability from the instrumental climate record. Comparison of the preliminary δD series April 1 Snow Water Equivalent records reveal significant negative correlations, indicating the years with low snowfall deposit sediments enriched in deuterium, as expected under our hypothesis. These results suggest, therefore that lipid δD from the lake sediments may reflect snowfall amount and periods of aridity sustained over multiple years. δD measurements of plant and lake water sample from the Swamp Lake watershed provide further constraint when assigning climatological mechanisms to observed 20th century δD variability. We have begun to measure δD from Medieval aged sediments, deposited between 900 and 1400 AD, from the same suite of cores. We find significant decadal scale δD variability over this time, and using the linkages established through the 20th century measurements, we can reconstruct precipitation and aridity patterns over these centuries. Overall, this work should provide a longer hydrologic record of wet and dry and warmer and cooler episodes in the region.

The results of this study will help construct a climatologic framework within which the Sierra Nevada Mountains, the major source of California's water supply, has operated over the last millennium. This framework can then be projected onto the coming decades in order to anticipate how California's hydrology may vary in the future and to provide insight into how it will respond to climate change. Such information is crucial in the face of an already warming climate and continually growing demand.

Professional Presentations

Roach, Lydia, Daniel Cayan, Christopher Charles and R. Scott Anderson, Modern Swamp Lake Cores: Lake Sediment D/H Ratios, A potential Tracer for Decadal Scale Hydroclimate Variability in the Sierra Nevada. American Geophysical Union PACLIM conference, Pacific Grove, CA, April 2009.

Roach, Lydia, Daniel Cayan, Christopher Charles and R. Scott Anderson, Modern Swamp Lake Cores: D/H Ratios from Sierra Nevada Varved Lake Sediments Record Decadal Scale Hydroclimate Variability During the Medieval Period. American Geophysical Union conference, San Francisco, CA December 2009.

Collaborative Efforts

Field work in Yosemite National Park (YNP) was permitted by the National Park Service. Logistical support was provided by Jan Van Wagtendonk of the USGS and by Jim Roach, Josh Bacchi, and Sam Seimens of YNP. Considerable support, including coring and raft equipment was provided by Scott Anderson of Northern Arizona University. Core Processing facilities and storage was provided at the University of Minnesota LRC Core Facility. Hydrogen isotope analysis is carried out in direct collaboration with Alex Sessions at the California Institute of Technology; all sample processing and δD measurements are made in his lab.

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