

---

**AWRA 2011 ANNUAL WATER RESOURCES CONFERENCE**  
**Albuquerque, New Mexico**

November 7-10, 2011

Copyright © 2011 AWRA

---

**INCORPORATING CLIMATE VARIABILITY, CHANGE, AND MODEL UNCERTAINTY IN SCENARIOS FOR CALIFORNIA WATER PLANNING**

Armin Munevar\*

**ABSTRACT:** Climate change projections derived from global climate models are becoming more widely used in basin-scale water planning and management. These model projections consistently indicate accelerated warming throughout the 21st century, but the degree of warming varies considerably between models and emission scenarios. For most of California, even greater uncertainty exists in projections of precipitation with some models indicating directionally inconsistent trends. Selection of appropriate representative scenarios of future climate variability and change is important for regional and basin-scale studies. Use of the multi-model ensemble has been shown to be superior to any individual model projection largely through reduction in the "noise"; and multi-decadal variability inherent in individual projections. While these findings suggest that as many projections of the ensemble as is possible should be considered, for many applications it is impractical to simulate the impacts of tens to a hundred of climate projections on water resources involving hydrological, biological, estuarine, and fisheries studies for a broad suite of water management alternatives. This paper presents a hybrid technique for climate scenario selection that reflects the full range of uncertainty in climate projections through the use of sub-ensembles. The technique allows for the selection of statistically-representative climate scenarios, derived from over 100 downscaled climate projections, which maintain superiority over individual scenarios while reducing the number of projections needed for complex water management studies.

This technique is being applied in planning studies for the Bay Delta Conservation Plan (BDCP), a program attempting to provide long-term water supply reliability and ecosystem restoration in the Bay-Delta. Climate and sea level rise scenarios are combined with hydrologic and water quality modeling suggest a significant changes to water availability and salinity regimes within the Delta. Water management in the Central Valley must consider changes to the "system" which is impacted by upstream changes from climate, hydrology, and river water quality conditions; and downstream changes in ocean and estuary responses. The management of this system under a range of climate futures is being analyzed in the BDCP and is providing insights into adaptive management of the program to balance water supply and ecosystem needs.

---

\* Global Technology Leader, CH2M HILL, 402 W. Broadway, Suite 1450, San Diego, CA 92101 USA, Phone: 619-687-0120, Email: armin.munevar@ch2m.com