

**American Water Resources Association**  
**2009 SPRING SPECIALTY CONFERENCE**  
***Managing Water Resources Development in a Changing Climate***  
**May 4-6, 2009**  
**Anchorage, AK**

**Monday, May 4**

**10:30 AM – 12:00 Noon**

**Session 1: Regional Watershed Responses I**

**1. Integrated Watershed Scale Response to Climate Change in Selected Basins Across the United States - Steve Markstrom, U.S. Geological Survey, Lakewood, CO (co-author: Lauren E. Hay)**

General circulation model (GCM) simulations of future climate predict a wide range of possible scenarios. To determine the sensitivity and uncertainty of long-term climate change on the freshwater resources of the United States 17, basins from different hydroclimatic regions have been selected as study sites for the U.S. Geological Survey project "Integrated watershed scale response to climate change in selected basins across the United States". Selected GCM scenarios were evaluated at these sites for their hydrologic responses using the Precipitation Runoff Modeling System (PRMS) and Ground-water/Surface-Water Flow (GSFLOW) models. PRMS and/or GSFLOW models of the 17 basins were developed, calibrated, and evaluated. Monthly precipitation and temperature output were obtained for six GCMs for current and future conditions. Climate change scenarios were generated for PRMS and GSFLOW by modifying precipitation and temperature inputs with the mean monthly climate change fields derived by calculating the change in climate from current to future conditions simulated by each GCM. The hydrologic sensitivity and uncertainty to simulated climate change will be estimated by comparison of the of current condition simulation to the climate change simulation ensemble for each basin. The simulations are evaluated according to: (1) environmental flow components, (2) annual water balance storage and flux, (3) timing and volume of evapotranspiration, (4) timing and volume of snowmelt, and (5) timing and volume of ground-water recharge/discharge. Although this study will not be completed until summer 2009, some noteworthy results have been obtained. This work will continue to focus on the effect of climate change on: (1) the components of the freshwater hydrologic cycle; (2) the seasonal impacts of climate change on the components of streamflow; (3) management and policy issues; and (4) ecological impacts on wildlife habitat and downstream water quality.

**2. Watershed-Scale Response to Climate Change: Feather River Basin, California - Kathryn Koczo, U.S. Geological Survey, San Diego, CA**

The Feather River basin is at the headwaters of the California State Water Project (SWP), which distributes water throughout California for domestic use, irrigation, and hydropower production. The reservoir at the basin's outlet, Lake Oroville, holds 8% of California's reservoir capacity, and plays an important role in flood management, water quality, and fisheries, affecting areas downstream at least as far south as the Sacramento/San Joaquin River Delta. The climate is Mediterranean, with warm dry summers and cool wet winters. Spring snowmelt is relied upon to meet SWP's summer water demands. Precipitation Runoff Modeling System (PRMS) was constructed to simulate runoff-generating processes of the Feather River Basin. PRMS is a deterministic, distributed-parameter, watershed model developed to evaluate effects of various combinations of precipitation, temperature, and land use on streamflow and basin hydrology. The Feather PRMS is used by California Department of Water Resources for watershed management and reservoir operations. The Feather River basin is one of 14 evaluated in the USGS's Global Change (GCC) study titled, "An integrated watershed scale response to climate change in selected basins across the United States". The goal of the GCC is to evaluate effects of climate-change on hydrology across the nation. The GCC study employs six General Circulation Models (GCM) and four GCM scenarios to simulate climate to year 2100 and develop inputs for PRMS. For the Feather River basin, results from GCMs indicate a gradual increase in temperature, and indicate multi-decadal cycles of predominantly wet and dry periods. Large uncertainties are associated with these projections. Results from GCM simulations were input into the Feather PRMS. The watershed response to simulated climate change in this basin includes: a reduction of annual snowpack accumulation; a reduction of snowmelt available to meet summer water demands; an increase of winter streamflow, which may contribute to flooding and threats to levees downstream; and, an earlier depletion of soil moisture and drying of native vegetation, which may lead to an increase in the threat

of wildfires. These PRMS simulations have implications for watershed management and reservoir operations.

### **3. Watershed-Scale Response to Climate Change - Mark Mastin, U.S. Geological Survey, Tacoma, WA**

A U.S. Geological Survey global change study "An integrated watershed-scale response to global change in selected basins across the United States" was started in 2008. The goal of the study is to provide a foundation for hydrologically-based climate-change studies across the nation. Fourteen watersheds in different hydroclimatic regimes for which the Precipitation Runoff Modeling System (PRMS) had been previously calibrated and verified were selected as study sites. PRMS is a deterministic, distributed-parameter, watershed model developed to evaluate the impacts of various combinations of precipitation, temperature, and land use on streamflow and basin hydrology. One of the fourteen basins and the subject for this presentation is the Yakima River Basin, located in south-central Washington State. Results from six general circulation models (GCMs) that each simulate three GCM scenarios were used to develop an ensemble of climate-change scenarios for 2001-2099 for input into PRMS. All GCM simulations project an overall increase in temperature and slight increases in precipitation. Using these projections, streamflows were simulated for 2001-2099 and compared with baseline streamflow conditions measured from 1988 through 2000. Projected streamflow changes are small in annual volume, but significant in the changes in the monthly distribution of streamflow. Much of the Yakima River Basin lies in a rain-to-snow transition zone (63 percent of the basin is between altitudes of 2,000 ft. - 4,500 ft.). As winter temperatures increase, the altitude of the snow line moves up and the percentage of winter precipitation that falls as rain increases for the basin. In addition, these GCM scenario simulations project less snow available to melt in the summer, leading to lower summer runoff. These projected snowpack changes can be seen by comparing the spatial distribution of the April 1 simulated snow-water equivalent values for baseline conditions with the three GCM scenarios at 2030, 2060, and 2090. The watershed response to climate change has important implications for water managers planning long-term deliveries to the billion-dollar agricultural industry in the Yakima River Basin that relies mostly on surface water for irrigation.

### **4. Simulated Watershed Scale Snowmelt and Ground-water Recharge Trends from 1960- to 2099 for Basins Draining to Long Island Sound: Hydrologic Response to Climate Change - David Bjerklie, U.S. Geological Survey, East Hartford, CT (co-authors: Thomas J. Trombley, Lauren E. Hay, Steven L. Markstrom)**

A watershed model (PRMS) was developed for the Connecticut River Basin and watersheds to Long Island Sound. The model is a large-scale application of the precipitation runoff modeling system (PRMS); the study region covers approximately 16,000 mi<sup>2</sup> and extends from a moderate coastal climate in the south (Long Island Sound), to a mountainous northern New England climate dominated by snowmelt in the north (White Mountains of New Hampshire). The model was used to evaluate: 1) the application of the PRMS model on a large spatial scale spanning a gradient of climatic zones; 2) recent and projected trends in snowmelt and ground-water recharge resulting from past and predicted climate change from 1960 to 2099. Six General Circulation Models (GCMs) incorporating four climate-change scenarios were used to develop an ensemble of climate-change-related meteorological input to PRMS. GCM simulations of future climate indicate an overall increase in temperature and precipitation for the region; however, there are large uncertainties associated with these projections. The results of the PRMS model demonstrate that large spatial and temporal scale models can reproduce historical trends and characteristics of climate-driven hydrologic variables. The simulations indicate that there will be a general decline in snow and snowmelt-derived runoff throughout the study region in the future. Additionally, the simulations indicate that projected ground-water recharge and baseflow trends vary across the region. Some areas, particularly in the north, will receive greater recharge and other areas, particularly in the south, will receive less recharge and thus lower baseflow. The study did not address potential land-cover changes. Urban growth and increasing demands for off-stream water-use, combined with the effects of climate change will potentially affect future flow regimes and biologic diversity of aquatic communities in the region. Future work needs to address the combined effects of climate and land-cover changes on streamflow regimes.