ARRA modeling project:

A projection of the impact of anthropogenic climate change on the San Joaquin watershed for the mid-21st century period

As a part of the ARRA modeling project, the impact of the anthropogenic climate change on the hydrologic fields in the San Joaquin River watershed during the mid-21st century has been generated by dynamically downscaling the global climate change scenario generated by NCAR CCSM3 on the bases of the IPCC SRES-A1B emissions storyline. The regional climate model, the Weather Research and Forecast (WRF) model version 3.0.1 was run over a nested Western United States (WUS) – Californian (CA) domain.

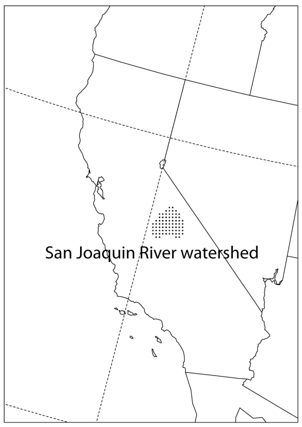

Figure 1. The CA domain and the location of the San Joaquin River watershed.

The WUS domain covers the eastern Pacific Ocean and the WUS region (not shown) at a 36-km resolution. The inner CA domain (Figure 1) covers the California region with a 12-km horizontal resolution and is one-way nested within the WUS domain.

The physics schemes used in the climate change simulation includes the Kain-Frisch convection, YSU PBL, NOAH land surface, WSM3 microphysics, Dudhia shortwave, and RRTM longwave schemes.

The climate change signals in surface hydrologic fields for the mid-21st century period have been calculated as the difference between the 10-year means representing the present-day (1990-1999) and mid-21st century.

The three key watershed-mean temperature fields, the mean (T_bar), minimum (T_min), and maximum (T_max) daily temperatures both increase in response to the increased greenhouse gas concentrations provided in the SRES-A1B scenarios (Figure 2). The temperature rise ranges from 1.2C to 3.8C with larger increases in the December-August (winter-spring-summer) period.

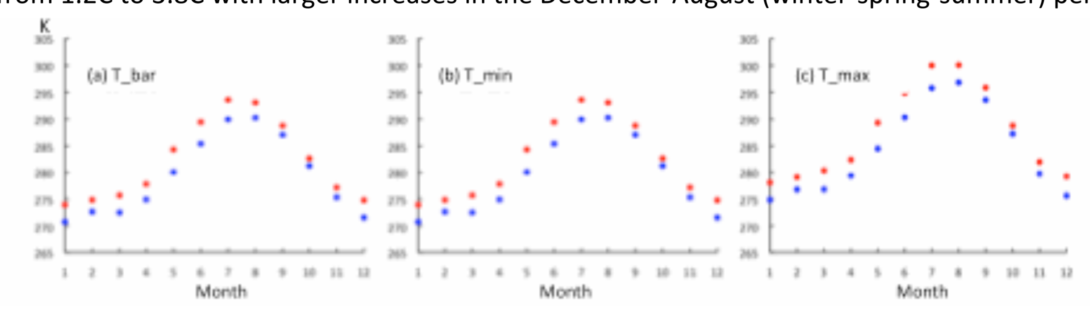

Figure 2 . The impact of anthropogenic climate change corresponding to the IPCC SRES-A1B emissions profile on the watershed-mean temperature fields between the present-day and mid-21st century periods.

All three temperature fields show similar increases according to season, however, by different amounts. The increase in the daily maximum temperature is generally larger than that in the daily minimum temperature, especially during summer when dry condition persists. The amount of warming in mountainous regions depends on a number of parameters such as the changes in precipitation characteristics, SWE, and soil moisture content. Further analysis will be performed to understand the changes in the three temperature fields.

The watershed-mean precipitation change in the San Joaquin River watershed is characterized by large increases in January and October (Figure 3). The most notable decrease in precipitation is projected for March, May, and September. The precipitation decrease in March will have especially adverse impact on warm season water supply.

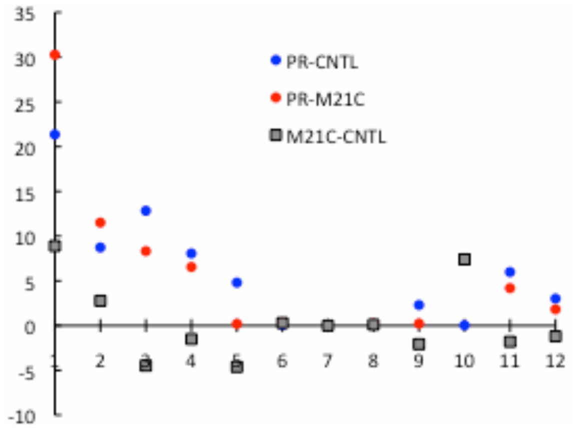

Figure 3. The monthly-mean precipitation in the present-day (blue), mid-21st century (red), and their differences (gray square) averaged over the San Joaquin River region in the regional climate change projection study.

The low-tropospheric warming in response to the anthropogenic emissions strongly affects cold season SWE in the basin (Figure 4). Throughout the cold season, October – March, the basin-mean SWE averages about 50% of the amounts in the present-day simulation. The effect of early snowmelt appears clearly in the SWE values during the spring (April – June) as the spring SWE in terms of the percentage of the present-day values decreases rapidly from 35% in April to less than 10% in June. This is among the well-known impacts of low tropospheric warming on the water supply in California in previous studies. The relatively large value in the SWE in October is due to the increase in October precipitation (Figure 3). It is practically insignificant because of small SWE values in October in both present-day and mid-21st century periods.

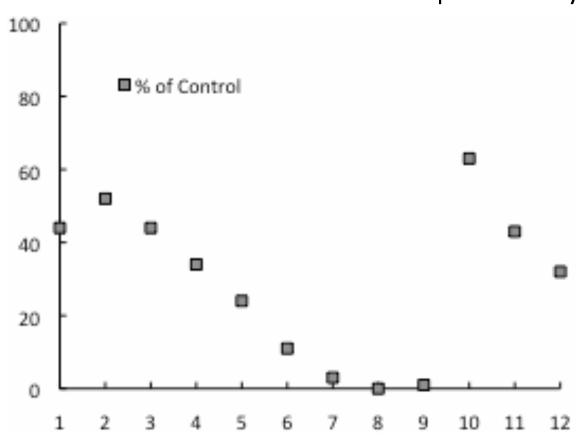

Figure 4. The watershed-mean SWE during the mid-21st century period as a percentage of the present-day amount.

The analysis of the projected climate change signal above shows that the warm season water supply from the San Joaquin River watershed will be reduced substantially, primarily due to the decrease in snowpack. This result agrees closely with previous studies. Similar to the previous regional climate change studies, results obtained in this study suffers from uncertainties mainly due to climate model errors that have not been quantified and uncertainties in future emissions. In addition, the climate projection data needs to be processed in the form suitable to drive a hierarchy of models (e.g., surface hydrology models, reservoir operation and water distribution models) used for calculating regional water resources. Future research plan is being designed to address these concerns. Leveraging the capabilities and end-user relationship built in this study, the next phase climate change study will emphasize: (1) model evaluation and the development of bias correction in constructing forcing data to drive models for assessing water resources and other regional concerns (e.g., ecosystems, Sacramento Delta, agriculture, energy generation and demand) using the regional climate model evaluation system (RCMES), (2) develop value-added products based on remote sensing, assimilation, and climate modeling (e.g., seasonal ensemble forecasts) to provide data needed by regional water agencies, and (3) generation of ensemble climate projections for California water agencies using the IPCC AR5 GCM scenarios.