A New Approach to Predicting the Effect of Climate Extremes on California's Water Supply

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Introduction

Given the high demands on freshwater for use in the domestic, agricultural, and industrial sectors of California, understanding the partitioning between the two primary sources of water (Sierra Nevada snowmelt and Central Valley groundwater) are imperative to ensure water resource resilience in the future. Record-breaking durations of droughts have led to unsustainable rates of groundwater pumping, leading to issues such as land subsidence and increased concentrations of contamination in aquifer reservoirs. Additionally, new data shows unprecedented record-breaking wet and dry year extremes that will likely continue into the future with unknown consequences on standard water management practices. State-of-the-practice approaches utilize models that are empirical and rely on highly calibrated observations for hydrologic predictions, thus lacking the physics to understand fluctuations based on future climate scenarios and extremes for which there is no historical precedent. Furthermore, standard water management practices also neglect the complex dynamics occurring between Sierra Nevada runoff and infiltration into the Central Valley, that is, the treatment of surface and subsurface water as part of an integrated hydrologic system. Understanding this partitioning at large scales and from a mechanistic standpoint is imperative to manage water resources on a state level in the future.

Approach

With recent developments in high performance computing and remote sensing, this work enables California water decisions to transition from state-of-the-practice empirical approaches to more mechanistic ones capable of predicting watershed dynamics under different climate scenarios. Large-scale quantification of groundwater storage will be isolated from NASA's GRACE satellite with the use of high-resolution hydrologic modeling. Although a large-scale terrestrial water balance is possible via GRACE, it lacks the ability to separate groundwater from surface water. To isolate groundwater, a high-resolution integrated hydrologic model will explicitly simulate individual components of the watershed from bedrock to the lower atmosphere. This explicit simulation of water with a physically based approach will propagate less uncertainty than previous GRACE approaches, which relied on rough estimates such as point and other satellite data. An un-managed watershed region straddling the Sierra Nevada and Central Valley will be used as a test-bed to demonstrate this novel pairing of methods, and allows for the impacts of climate change to be isolated from water management schemes. By using historically alternating wet and dry periods during the GRACE dataset in this rare natural experiment, the impact on groundwater storage during climatic extremes will be quantified. Other future perturbations will be simulated to assess the impact of water supply within other basins across the state.

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