Spatio-Temporal Patterns of Open Surface Water in the Central Valley of California 2000-2011: Drought, Land Cover, and Waterbirds

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The Central Valley is a nexus for water resources in California containing the Sacramento and San Joaquin watersheds which together provide drinking water to approximately two-thirds of Californians. Improved understanding of the distribution of water is needed to maximize efficiency of water management for urban, agricultural, and ecosystem services and to calibrate water optimization models. We used a supervised classification approach of Landsat satellite imagery to (1) quantify the distribution of open surface water across the Central Valley of California 2000 – 2011, (2) summarize spatial and temporal variation of open surface water July - December during this time series, and (3) assess the factors that might influence the distribution of open surface water, including drought conditions and land cover type. We also applied the classified imagery to identify available habitat for waterbirds. Our analyses indicated that between 2000 and 2011 open surface water has declined across the Central Valley during the months of July – October. Drought had a significant effect on open surface water throughout the Central Valley. The negative impact of a drought was experienced immediately in the southern Central Valley; however, there was a 1 to 3-year time-lag effect in the northern Central Valley. Generally, the highest proportion of open surface water was in lakes, rivers, and streams as well as flooded agriculture, yet the relative proportions varied spatially and across months. Our data supported previous assumptions about the timing and availability of flooded post-harvest rice fields in the northern Central Valley for waterbirds, and highlighted the need to consider flooded agriculture as available habitat for waterbirds in the southern Central Valley. Tracking water distribution using satellite imagery enables an empirically-based assessment of the impacts of changing water policy, land-use, climate, and management on water resources.

Keywords: water; Central Valley; trend; drought; land cover; satellite imagery; waterbirds
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Quasi-Decadal Oscillation in the CMIP5 and CMIP3 Climate Model Simulations: California Case

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The ongoing three drought years in California are reminding us of two other historical long drought periods: 1987-1992 and 1928-1934. This kind of interannual variability is corresponding to the dominating 7-15 yr quasi-decadal oscillation in precipitation and streamflow in California. When using global climate model projections to assess the climate change impact on water resources planning in California, it is natural to ask if global climate models are able to reproduce the observed interannual variability like 7-15 yr quasi-decadal oscillation.

Further spectral analysis to tree ring retrieved precipitation and historical precipitation record proves the existence of 7-15 yr quasi-decadal oscillation in California. But while implementing spectral analysis to all the CMIP5 and CMIP3 global climate model historical simulations using wavelet analysis approach, it was found that only two models in CMIP3 , CGCM 2.3.2a of MRI and NCAP PCM1.0, and only two models in CMIP5, MIROC5 and CESM1-WACCM, have statistically significant 7-15 yr quasi-decadal oscillations in California.

More interesting, the existence of 7-15 yr quasi-decadal oscillation in the global climate model simulation is also sensitive to initial conditions. 12-13 yr quasi-decadal oscillation occurs in one ensemble run of CGCM 2.3.2a of MRI but does not exist in the other four ensemble runs.

Keywords: drought, interannual variability, global climate model simulation
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2014 Delta Drought Modeling

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In late winter through spring, Delta modeling was performed using historical information and forecasts that represented very dry conditions. These forecasts aided decision-making about if, when, and where emergency barriers might be installed.

In early February, the outlook was grim; 2014 was potentially the driest year in the historical record. Concerns about having enough water for upstream releases, meeting water quality objectives in the Delta, flows for fish, and being able to export enough water for health and safety needs led to a series of modeling studies which also evaluated impacts to farmers/marinas, to salmon migration, and smelt survival. If installed too early, barriers could negatively impact fish migration and spawning. If installed later, there might not be enough water to meet water quality or ecosystem needs later in the summer. As precipitation occurred during the spring, reservoir storages improved, and the urgency of installing the barriers began to diminish.

Consequently, the objective of studies shifted towards evaluating water savings due to installation of the barriers. The water savings could be used as storage and then released later for ecosystem needs, exports, or other diversions. Using a minimum water cost compliance tool in conjunction with DSM2, water savings were determined for meeting D-1641 Water Quality Objectives with and without the barriers and with relaxing or moving the Emmaton Objective. The biggest water savings occurred from relaxing the Emmaton objective (~612 cfs), whereas installation of the three barriers (Sutter Slough, Steamboat Slough, and False River) resulted in a water savings of about 275 cfs if the Emmaton objective was relaxed. So, although significant benefits of the barriers to water quality could be demonstrated given a fixed amount of available water, the water savings from installing the barriers given a fixed water quality objective was not considered large.

Keywords: Drought, Modeling, DSM2, Delta, Barriers, Ecosystem, Water Quality, Water cost
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Drought Decisions in a Highly Impacted California River; Using Umbrella Species to Inform Water Management

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Virtually all large California rivers are regulated by dams that provide power, water and flood protection to the world's eighth largest economy. This has created conflict between economic needs and protection of key ecological processes. This year, one of the most severe droughts in recorded California history pushed this issue to the forefront of scientific and political discussion. Reservoir storage in the American River, a key California water artery, was at an all-time low, resulting in drastically reduced river discharge, with embryos of native Chinook salmon incubating in gravels of the lower river. Resource agencies, along with local stakeholders, developed a decision–tree management process to identify and implement impact mitigation for key ecological processes using Chinook salmon as an umbrella species. We developed Chinook salmon conceptual life cycle models that included fry emergence and outmigration timing, identifying processes and environmental conditions needed to support key lifestages. We monitored physical and biological parameters and identified several options for flow manipulation to benefit target life stages, which were presented to resource managers.

We estimated that up to 12% of the 2013-14 Chinook salmon brood-year was stranded in dewatered or disconnected incubation or rearing habitat within the lower river. Intergravel temperatures and dissolved oxygen reached stressful levels after several weeks. Emerged fry, stranded in off-channel pools, demonstrated stressed behavior including aggression and very low condition factors. Considering critically low water availability, a 2-day pulse flow was identified as the most feasible management action to mimic a spring freshet. The objective of the flow pulse was to reconnect migration corridors for stranded fry within the gravel and juveniles in off-channel habitats and ameliorate poor water quality parameters. Results from this exercise provide a framework for future water management decisions, as human demands increase and the climate continues to trend toward greater precipitation extremes.

Keywords: flow management, regulated rivers, salmon, life cycle modeling
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Benefits of an Advanced Quantitative Precipitation Information System - San Francisco Bay Area Case Study

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Advancements in monitoring and prediction of precipitation and severe storms can provide significant benefits for water resource managers, allowing them to mitigate flood damage risks, capture additional water supplies and offset drought impacts, and enhance ecosystem services.

A case study for the San Francisco Bay area provides the context for quantification of the benefits of an Advanced Quantitative Precipitation Information (AQPI) system. The AQPI builds off more than a decade of NOAA research and applications of advanced precipitation sensors, data assimilation, numerical models of storms and storm runoff, and systems integration for real-time operations. An AQPI would dovetail with the current National Weather Service forecast operations to provide higher resolution monitoring of rainfall events and longer lead time forecasts.

A regional resource accounting approach has been developed to quantify the incremental benefits assignable to the AQPI system; these benefits total to $35 M/yr. Compared to AQPI system implementation and O&M costs over a 10 year operations period, a benefit – cost (B/C) ratio is computed which ranges between 2.8 to 4. It is important to acknowledge that many of the benefits are dependent on appropriate and adequate response by the hazards and water resources management agencies and citizens.

Keywords: Advanced precipitation forecasts, benefit-cost analysis, San Francisco Bay case study
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