Improving Stream Temperature Predictions for River Water Decision Support Systems: A Preliminary Physically-Based Temperature Model for the Upper Sacramento River, California

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Abstract. Stream temperature is a critical indicator of habitat quality for endangered salmonid species and affects re-licensing of major water projects and dam operations worth billions of dollars. The Central Valley Project (CVP) in California currently relies upon a monthly mean temperature standard for fisheries related decisions. Improving the spatial and temporal resolution of stream temperature forecasts allows for evaluation of habitat impacts at appropriate scales, anticipation of extreme water temperature events, and mitigation of adverse impacts to salmon through targeted water releases.
In this study, we present a preliminary high-resolution stream temperature model (sub-hourly time step, 1km spatial resolution) developed for the Upper Sacramento River, spanning from Keswick Dam at the upstream end to Red Bluff Diversion Dam approximately 100km downstream. The model uses a heat budget approach to calculate the rate of heat transfer to/from the river, considering shortwave, longwave, evaporative, and conductive heat fluxes. Inputs for the heat budget formulation are atmospheric variables provided by the Weather Research and Forecasting (WRF) model, including: air temperature, relative humidity, atmospheric pressure, wind speed, and cloud cover. Water temperature is calculated using a 1-dimensional advection-diffusion ("bulk flow") equation in a Lagrangian framework.
Modeled temperatures for a test period (August-October, 2004) provided a substantially better estimate of the temperature dynamics than the current DSS standard monthly mean. Modeled values closely approximate both the magnitude and the phase of measured water temperatures for much of the test period. The spatiotemporal scale of our model also allows for the examination of critical temperature dynamics that would not otherwise be detected using monthly mean temperature standard. Specifically, our current model output reveals important longitudinal patterns in diel temperature variation that are unique to regulated rivers, and may be critical to salmon physiology.
Ultimately, end users will be able to access the model over the internet, run various scenarios of water discharge and temperature under forecasted weather conditions to make informed decisions about water releases and subsequent impacts on fish and habitat.

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