Future climate change effects on regional hydrology in the Boise River Basin

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LEAF

Introduction

- The western U.S. is already experiencing effects of climate change on water resources (i.e. drought in CA, earlier spring runoff)
- Here, we aim to develop a working spatially-explicit model that adequately represents historical hydrology, then run the model into the future with climate change scenarios
- While other hydrologic models may be more robust, the Envision framework used here allows us to also work with local land management agencies to incorporate potential land use change and how that, coupled with climate change, may further affect regional hydrology.

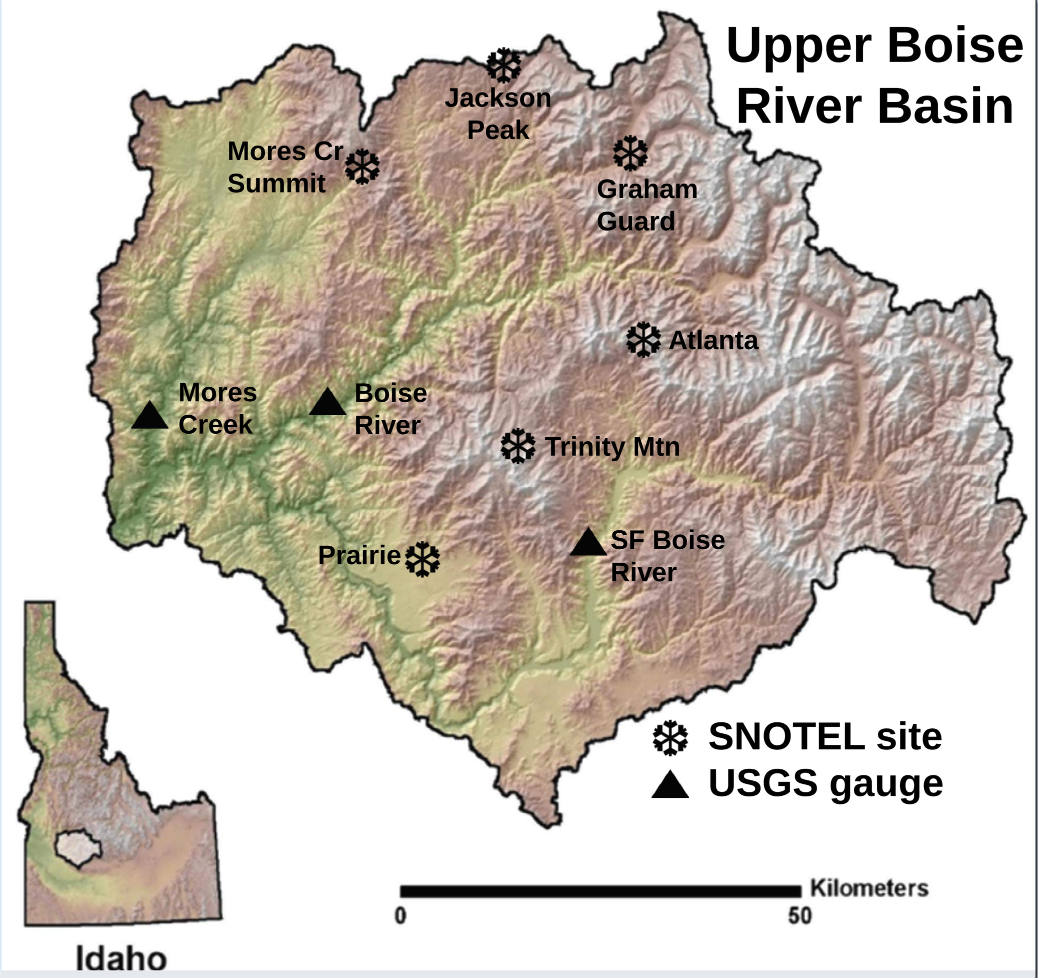
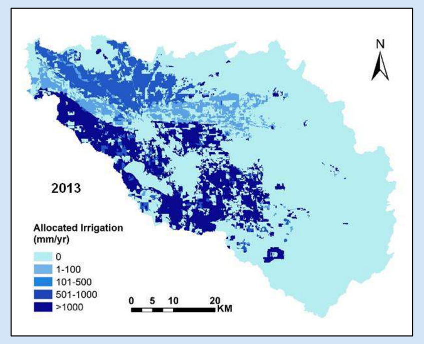


Fig 1) Study area overview: ~7000km^2, primarily managed by the Forest Service, and provides water for Treasure Valley region

Connections to EPSCoR projects



Bangshuai Han - Simulating the intensively managed Treasure Valley: coupling biophysical and social systems to evaluate potential water scarcity. My work will serve as the upper boundary condition as he begins running simulations into the future.

Andrea Leonard – Modeling impacts of climate change and management decisions on agricultural water use and production. In order to capture agricultural water usage, we must know how much and when water arrives in the basin.

Methods

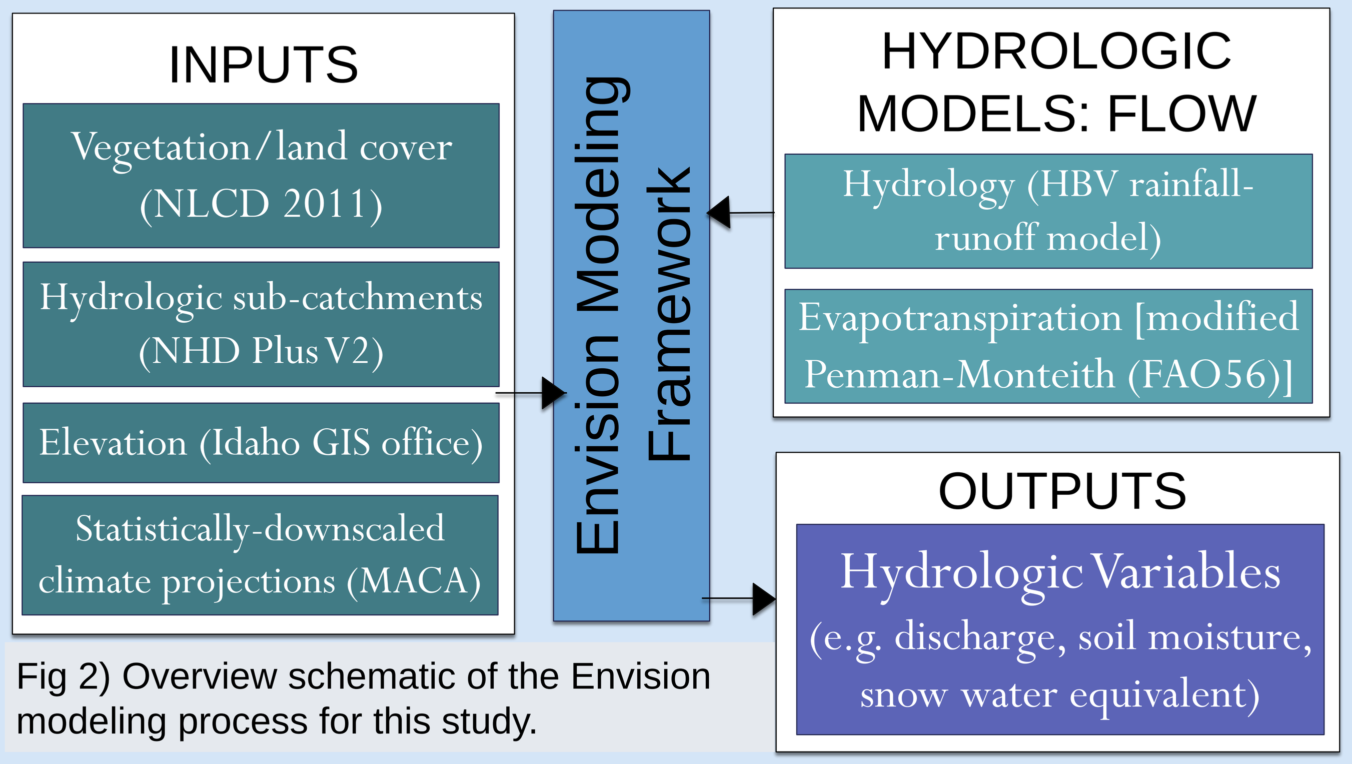


Fig 2) Overview schematic of the Envision modeling process for this study.

Envision is a flexible agent-based modeling framework. Central to its structure is its ability to model the interaction between agents and how policies applied affect how the landscape changes *(Bolte et al., 2007)*. For this study, we assume a static land cover and employ the use of the Flow plug-in submodel to project how hydrologic variables (discharge, snow water equivalent, etc.) may change under different climate change scenarios.

Calibration & Validation

To calibrate the model, we used spatially and temporally resolved historical climate data (Abatzoglou & Brown, 2012) with random parameter estimation for each run. The model was run for 1000 simulations over a period of 12 years that included both very wet and dry years (1995-2006). To assess how well each parameter set performed, an objective function was employed:

$$Obj = \frac{2}{3}(E_G - 0.1 * |VE_G|) + \frac{1}{3}E_{SWEavg}$$

where E_G is the Nash-Sutcliffe efficient of each gauge or SNOTEL avg and VE_G is the volume error

Fig 3) Hydrograph for observed & simulated values over calibration and validation periods

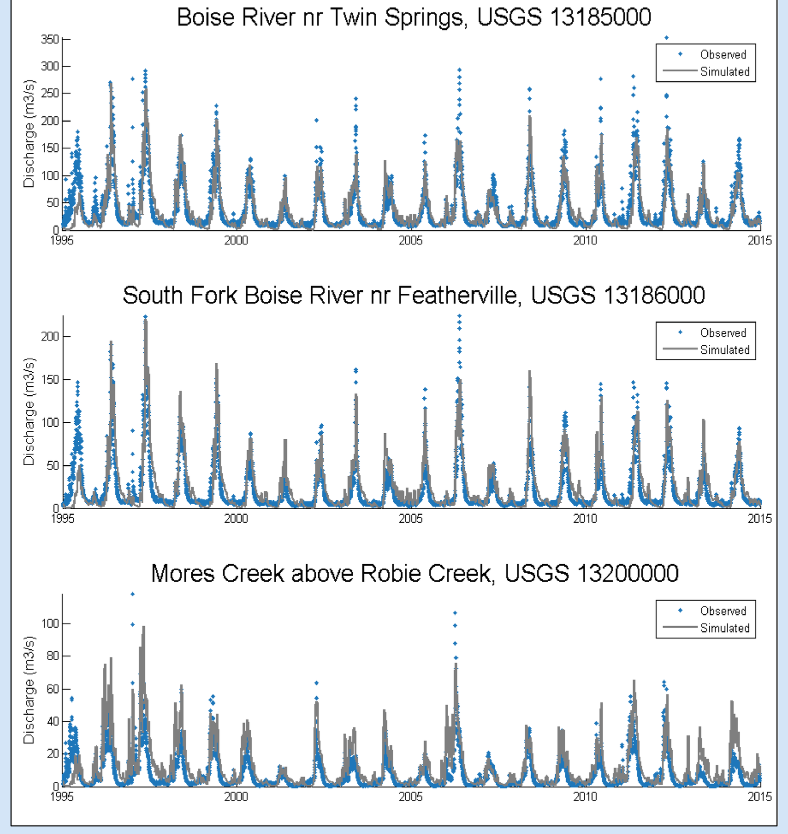
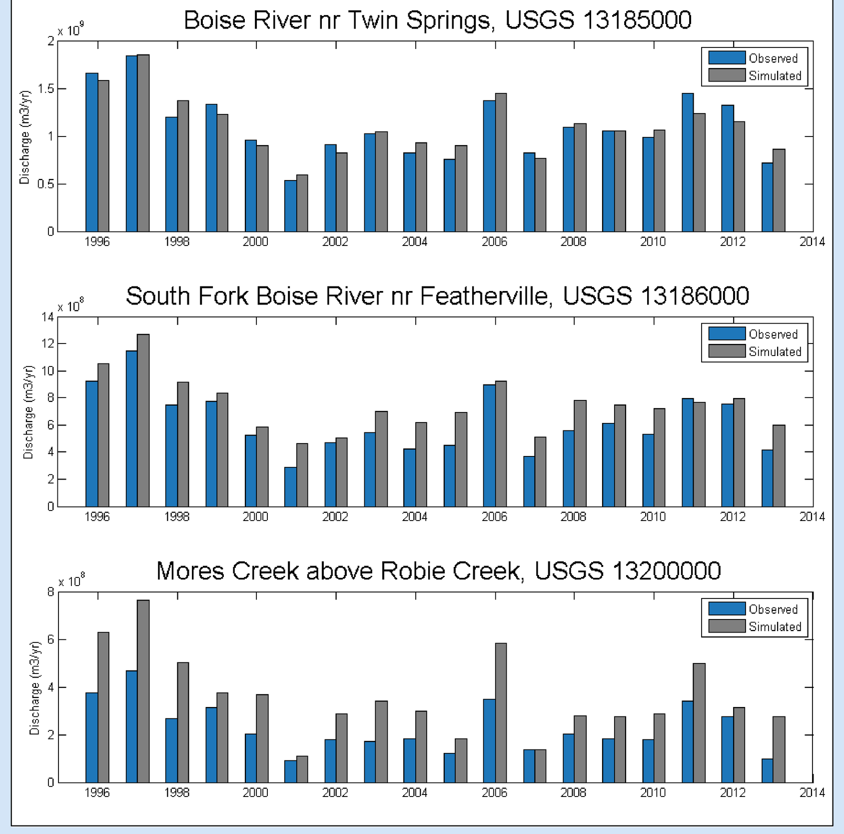


Fig 4) Observed & simulated annual discharge volumes – Mores Creek had large volume errors



The parameter sets with an objective function in the 99th percentile were ran over the validation period and the best performing set was chosen for the model (Fig 3,4).

To assess future climate change effects, we used statistically-downscaled climate forcings for 2010-2100 for RCP 4.5 and 8.5 using the CNRM-CM5 GCM model, which has been shown to have historically represented climate trends in the PNW adequately (Rupp et al., 2013).

Results

As we move later in the century, a few key trends stood out in our modeled simulations

SNOW: Less precipitation is falling as snow, and overall snowpack levels are lower at all elevations (Fig 5), with greater variability and change at the low-elevation site. Additionally, we see max SWE occurring earlier in the season.

DISCHARGE: Interestingly, our model indicates an increase in average yearly discharge. We see more discharge occurring earlier in the season and less during the historical peak-flow time periods, with the signal amplified as we move later in the century (Fig 6).

Fig 5) Modeled & historical snow water equivalent for three time periods for a low-, mid-, and high-elevation SNOTEL site using both climate scenarios

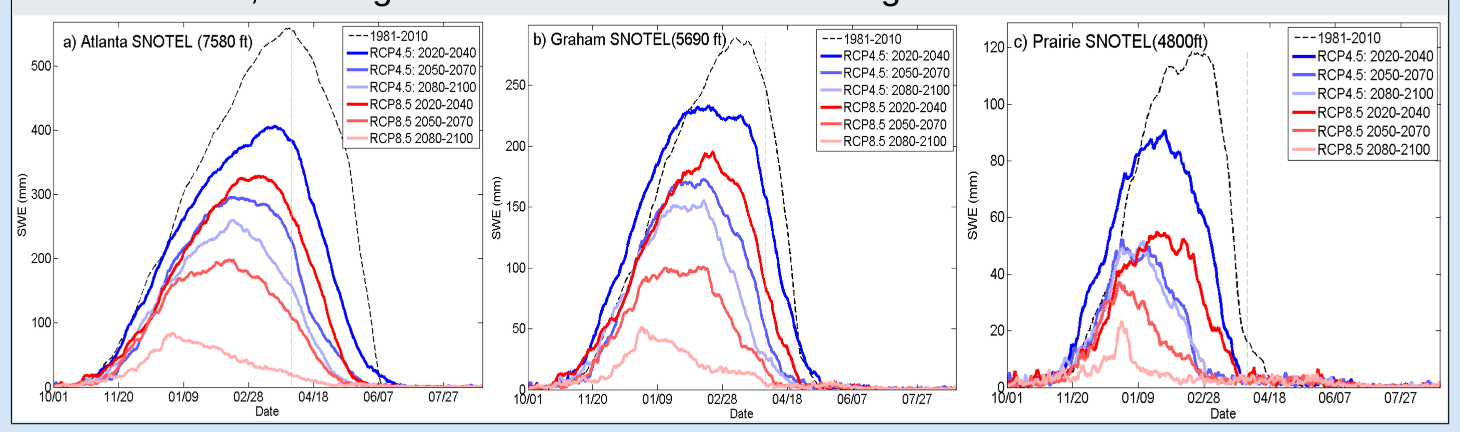
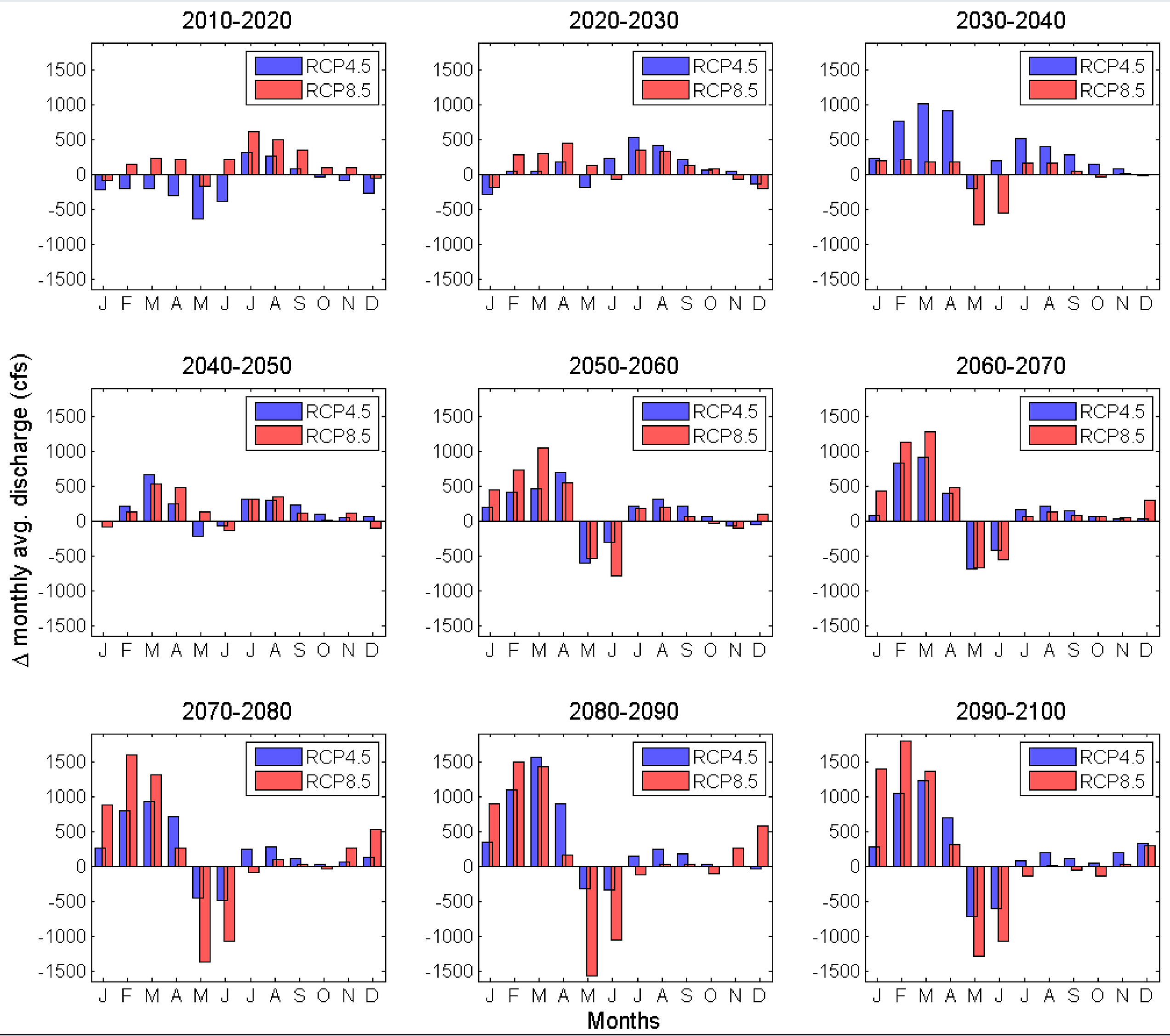


Fig 6) Modeled decadal deviations from historical averages (1990-2010) in the timing and magnitude of discharge from the Boise River gauge



Future work

- Because land use and land cover are critically important in how water moves through a landscape, we will work with stakeholders to create plausible scenarios of landscape change to input in the model
- Mores Creek did not achieve a very high efficiency (max 0.47) and this subbasin will be calibrated separately, as it may be a key player for future flood control
- Run model for a different GCM or suite of GCMs

References

Abatzoglou J.T. and Brown T.J. (2012). A comparison of statistical downscaling methods suited for wildfire applications. *International Journal of Climatology*.

Bolte, J.P., Hulse, D.W., Gregory, S.V., and Smith, C. (2007). Modeling biocomplexity – actors, landscapes, and alternative futures. *Environmental Modellng & Software*.

Rupp, D.E., Abatzoglou, J.T., Hegewisch, K.C., and Mote, P.W. (2013). Evaluation of CMIP5 20th century climate simulations for the Pacific Northwest USA. *Journal of Geophysical Research: Atmospheres*.