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Nonlinear Scaling of Climate Change Impacts in Headwater Catchments: Contribution to Watershed Function Scientific Focus Area

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My role on the Watershed Function Scientific Focus Area (SFA) team is to (1) develop and maintain the hyper-resolution, watershed-scale, physically-based model that nearly every SFA team uses either directly or through comparison to their observations as a tool in their own research; (2) examine how processes scale at different resolutions in order to develop the most appropriate tools for each question; and (3) study the impact of climate changes to water supplies in the East River and whether these impacts are robust across different modeling frameworks.

In 2017, I completed over 50 sensitivity simulations to constrain the parameters that determine flow in the watershed. In the paper for this work a new methodology is presented for downscaling or upscaling hydraulic conductivity parameters in complex mountainous terrain where formal calibration is impossible due to computational limitations. Beyond the need for this work to define the best parameters for the hyper- resolution model used by the team, this work directly contributes to Question 4 of 6 laid out in the SFA 2017 Annual Report: "When and where does fine-scale representation of processes significantly improve prediction of watershed nutrient dynamics, and how can those processes be tractably represented in mechanistic watershed models?" This paper also has implications to the wider research community where continued pushes for higher-resolution, physically-based models at successively larger scales (from full watersheds up to continental scales) require methods to constrain the few parameter sets for subsurface processes.

The parameter work served as the foundation for a climate sensitivity study also completed in Fall 2017. In this work I compare sensitivity to temperature and precipitation across different modeling resolutions to determine how robust climate impact predictions are to different models. The main conclusions from this study are (1) even large increases in precipitation are not enough to compensate for the loss of snowpack, streamflow, and groundwater in a warmer climate and (2) coarse resolution models under-predict reductions to water availability, suggesting that we may need to be more conservative in planning for water scarcity in the Southwest US.

The "Grand Challenge" driving the SFA according to the Annual Report is: "How do mountainous watersheds retain and release water, nutrients, carbon, and metals? How will … [climate] perturbations impact downstream water availability and biogeochemical cycling at decadal to episodic timescales". The hyper-resolution model is a foundation for answering this grand challenge, providing high resolution data in space and time to constrain and contextualize observations across the watershed for the entire team. Beyond my own research, I support other team members in using the models I maintain by gathering forcing datasets for them, answering modeling questions, and improving the README and other files to help people use these modeling tools.