Hydrological Modelling for the Resilient Agriculture-Water-Community Systems Initiative

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Introduction

Statement: Water availability is strongly shaped by the interaction between hydrologic processes and human activities. However, current research often examines these components separately, limiting our understanding of how surface water reductions, groundwater pumping, land-use change, and agricultural practices collectively influence basin-scale water resources.

Impact: The lack of integrated analysis makes it difficult to predict system-wide responses, leading to uncertainties in water management, reduced resilience under different stressors, and challenges for communities that depend on reliable water supplies.

Need: A comprehensive, integrated model based on existing coupled model framework for the basin is needed to capture the dynamic interactions between human and natural systems. Developing coupled surface water–groundwater models for different watersheds in the Western US and evaluating key drivers of water availability will support the RAWCS initiative and help design resilient agricultural and community water systems.

Objectives

- Develop regional SWAT+MODFLOW models to simulate surface–groundwater interactions in the study basins.
- Evaluate how reduced surface water, increased pumping, land-use change, and agricultural practices affect basin water balance.
- Calibrate and optimize the coupled models using regional datasets, metaheuristic methods, and in High-Performance Computing (HPC)resources.
- Share the models and findings to support collaboration and advance RAWCS water-resilience efforts.

Study Area

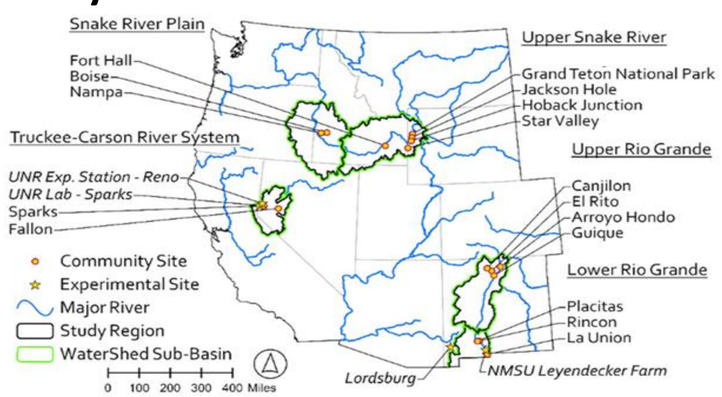

Figure 1. Study Area

Data Sources

Data	Source	Resolution
DEM	USGS 3D Elevation Program 10 m	Resampled 30 m
Soil	USDA Soil Survey Geographic Database (SSURGO)	Polygon
Landuse	MRLC National Land Cover Database (NLCD)	30m
Flow	USGS	Daily
Forcing Data	NASA North American Land Data Assimilation System (NLDAS) – Phase 3	Daily

Methods

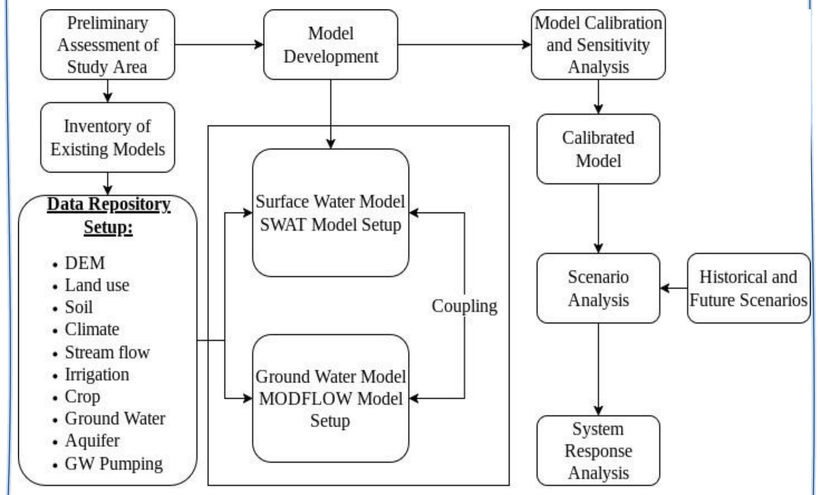

Figure 2. General Methods of the Study

Results

- Automated reusable scripts for data collection, analysis and model development
- Built a SWAT+ model for the Upper Snake Basin
- Compiled the SWAT+ model on Linux for use HPC)environments.
- Configured and optimized the modeling environment for calibration using Isolated-Speciation-based Particle Swarm Optimization (ISPSO) within an HPC setting.

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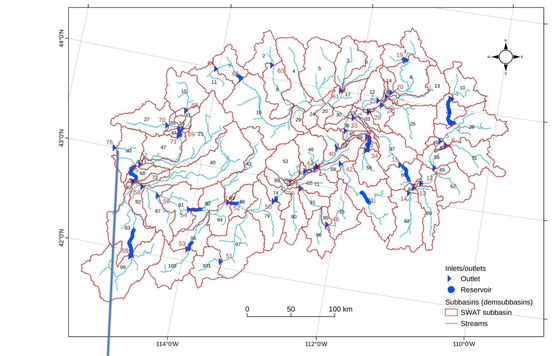

Figure 3. Upper Snake SWAT+ model

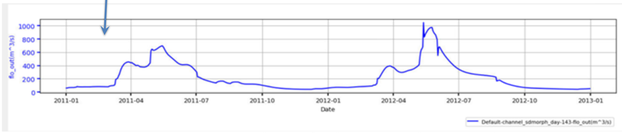

Figure 4. Simulated Flow at the Outlet
(Calibration in Progress Using ISPSO)

Future Work

- Set up the groundwater model using MODFLOW, including boundary conditions, aquifer properties, and calibration inputs.
- Implement and validate the coupling between SWAT+ and MODFLOW.
- Evaluate how reduced surface water, increased pumping, land-use change, and agricultural practices impact basin-scale water balance.

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