IM3 INTEGRATED MULTISECTOR MULTISCALE MODELING

statemodify: a Python framework to assess drought vulnerabilities across systems, sectors, and users in the Colorado River Basin

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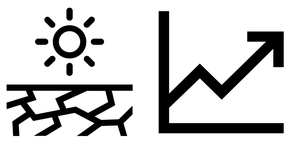
MSD LIVE

The Colorado River Basin is experiencing an unprecedented water shortage crisis and future conditions in the region are highly uncertain.



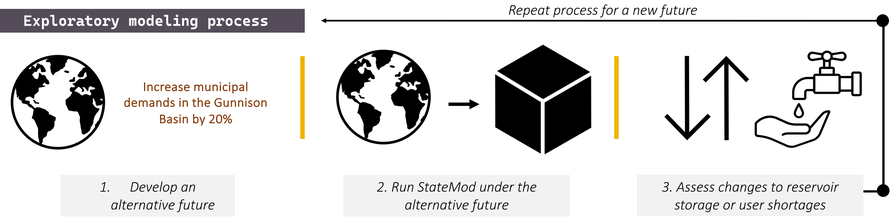
Aridification and over-allocation of the Colorado River are key drivers of the current crisis

The complexity of balancing the demands of agriculture and a growing population combined with a diminishing water supply makes water systems planning and management a growing challenge in the region. However, a wide range of uncertainties from changes in the hydroclimate to potential changes to infrastructure, policies, and system efficiencies make it difficult to understand exactly how the future will unfold.

Water systems planning and management models paired with exploratory modeling can help uncover vulnerabilities in the basin.

Because future conditions in the region are not known for certain, we utilize **exploratory modeling**, which involves running the State of Colorado's water supply and allocation model, StateMod, under a wide range of plausible futures. These futures are developed by adjusting historical demands and water rights across users, changing reservoir storage and evaporation rates, and generating new streamflow scenarios across Colorado's five West Slope Basins.

Exploratory modeling process



Open-source frameworks can make exploratory modeling accessible to a wider group of researchers.

Because StateMod is so finely resolved, it is a powerful model that can provide a detailed representation of the users, water rights, and water accounting throughout the West Slope. However, this means that the development and use of many future scenarios is essential to adequately characterize the behavior of the system, which requires nontrivial computational resources. Additionally, exploratory modeling with StateMod requires familiarity with Fortran and Linux. We develop ***statemodify*** as a framework to **increase the usability and flexibility of StateMod** for exploratory modeling and thus to **empower a larger group of diverse researchers to utilize StateMod** and contribute their expertise to help more robustly manage the basin.

Key Features

statemodify

Python-based functions are developed to adjust StateMod Fortran input files to create alternative futures (see map). Manipulations include applying multipliers to historic demands, reservoir storage, and evaporation rates. Water right priorities and decrees can be adjusted for individual users. A Hidden Markov Model-based synthetic streamflow generator can be used to create spatially correlated streamflow traces across StateMod nodes in the five West Slope Basins.

1 *Accessibility*

jupyter python™

*Users run StateMod simulations and analyses through Python-based **Jupyter Notebooks***

2 *Analysis Tools*

*Notebooks provide code for **extracting data** and **visualizing output***

3 *Compressibility*

*Reduced output storage volume using **.parquet file formatting***

4 *Scalability*

*Deployable as a Docker container that can be linked to external **HPC or cloud resources***

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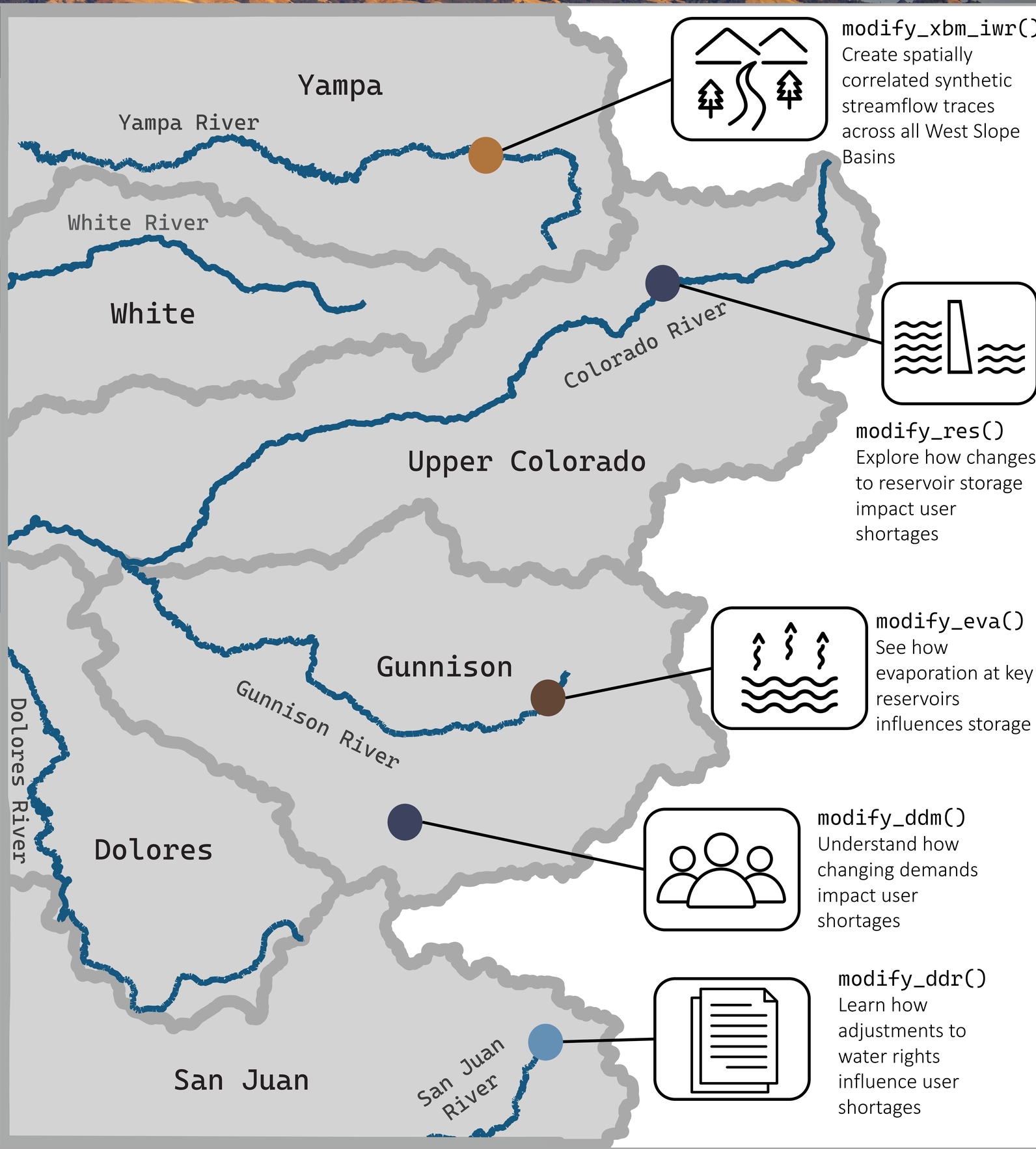

modify_xbm_iwr()
Create spatially correlated synthetic streamflow traces across all West Slope Basins

modify_res()
Explore how changes to reservoir storage impact user shortages

modify_eva()
See how evaporation at key reservoirs influences storage

modify_ddm()
Understand how changing demands impact user shortages

modify_ddr()
Learn how adjustments to water rights influence user shortages