INTEGRATED MULTISECTOR MULTISCALE MODELING

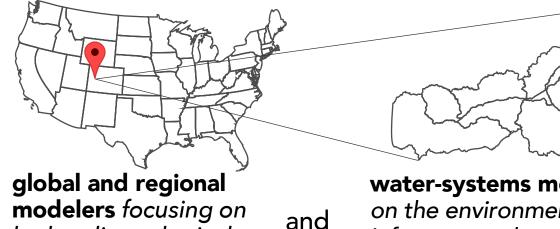
INFERRING WATER SCARCITY VULNERABILITIES

MODELING ACROSS SCALES

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Water resources model development and simulation have seen rapid growth in recent decades, aiding evaluations and planning around water scarcity and allocation.

A divide has emerged between:



modelers focusing on hydro-climatological processes

water-systems modelers focusing on the environmental, infrastructural, and institutional features at the local basin level

Both communities are interested in addressing similar societal and scientific questions: how changes in the availability and allocation of water affect its human uses, and how human uses impact the spatial and temporal distribution of water **resources**. But they approach these questions from different vantage points. Water systems models emphasize the representation of elements pertaining to water management and use and require downscaled inputs of the climatic conditions that shape water availability in their watersheds. Large-scale hydrologic models emphasize the representation of regional and global hydroclimatic processes and use simplified representations of the human systems elements.

An example of this representational difference can be seen in the Upper Colorado Basin within the state of Colorado and how it is represented by two state-of-the-art models from the two communities: a **regional-scale** model (MOSART-WM) and a basin-scale water systems model (StateMod).

Main Findings

Results show that while the regional-scale model (MOSART-WM) can capture the aggregate effect of all water operations in the basin, it underestimates the sub-basin scale variability in specific user's vulnerabilities.

The basin-scale water systems model (StateMod) suggests a larger variance of scarcity across the basin's water users due to its more detailed accounting of local water allocation infrastructure and institutional processes.

We highlight the potentially **significant limitations** of large-scale studies in seeking to evaluate water scarcity and actionable adaptation

strategies, as well as ways in which basin-scale water systems model's information can be used to better inform water allocation and shortage when used in tandem with larger-scale hydrological modeling studies.

When moving upstream MOSART-WM begins to diverge from Using MOSART-WM outputs observations and StateMod, especially in the headwaters, Using StateMod outputs where both models struggle due to the accuracy of inflow data. Midstream Headwaters: Below Granby lake Mid-to-upstream: Below Dillon reservoir **MOSART-WM flow** (m³) 100 🔗 StateMod flov 20 40 Exceedence probability Exceedence probability 40 60 Exceedence probability Granby Reservoir Both models capture the aggregate Frequency o **Basin outflow** Frequency of (666 million m³) occurence (%) monthly effects of all processes in the occurence (%) basin fairly well, with the basin outflow and mid-stream streamflow dynamics Percentage of model nodes/grid cells classified as vulnerable to water scarcity if different combinations of shortage represented closely by the two models. magnitude (% of demand) and frequency (% of time) are used, using outputs from the two models. Left: the percentage of StateMod user nodes that experience each metric combination. Right: the percentage of StateMod MOSART-WM basin grid cells that experience each metric combination. diversion location **REGIONAL-SCALE MODEL UNDERREPRESENTS SUB-BASIN VARIABILITY** Dillon Reservoir The comparison of percentage of nodes and grid cells that would be classified as (317 million m³) vulnerable to water scarcity suggests that looking at the basin as a whole (i.e., all aggregated shortages as a percentage of all aggregated demands), MOSART-WM estimates larger and longer shortages than StateMod. However, when looking at the StateMod variance across grid cells and nodes, we observe much larger variability among the reservoirs basin users described by StateMod. **MOSART-WM** reservoirs This is attributed to main differences in the two models: **the lack of detailed allocation** and operation processes that describe how prior appropriation in the basin Even though most large reservoirs are consistently allocates available water to senior users first, and the **spatially distributed** represented in both models, several small reservoirs are not accounted for in MOSART-WM. **nature** of MOSART-WM which evenly allocates available water to sets of users The difference in total storage equivalent to the MOSART-WM is StateMod is made up of associated with specific reservoirs. second largest reservoir in the basin. spatially-distributed using an nodes, representing diversion 1/8th-degree spatial resolution structures, reservoirs, and flow This research was supported by Difference in total storage the U.S. Department of Energy, (365 million m³) Office of Science, as part of MSD MOSART-WM's representation allows it to better capture regional and global research in MultiSector Dynamics, Pacific Dillon Reservoir hydroclimatic processes, whereas StateMod's fine nodal representation enables Earth and Environmental System Northwest (317 million m³) Modeling Program.

Exceedence probability

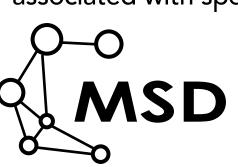


detailed accounting of infrastructure and institutions, such as prior approriation



Do converging model representations of water systems lead to convergent insights?

AGREEMENT IN AGGREGATE BASIN ACCOUNTING, DIFFERENCES IN REPRESENTING INFRASTRUCTURE & INSTITUTIONS





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How does model structure influence the perception of vulnerability in the basin?

