IM3 INTEGRATED MULTISECTOR MULTISCALE MODELING

INFERRING WATER SCARCITY VULNERABILITIES

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

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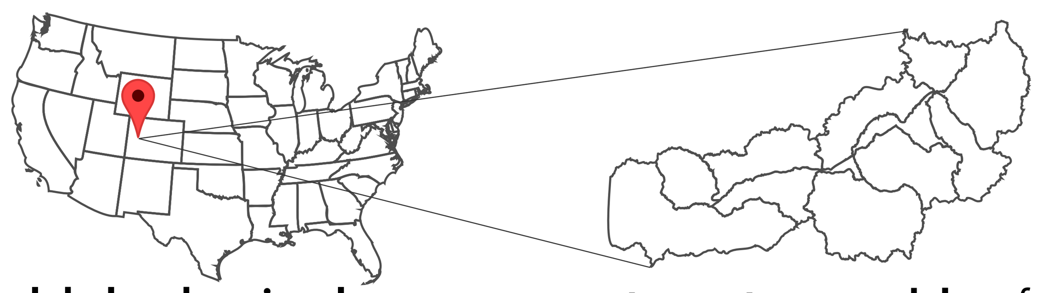
MODELING ACROSS SCALES

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:



global and regional modelers *focusing on hydro-climatological processes* and **water-systems modelers** *focusing on the environmental, infrastructural, and institutional features at the local basin level*

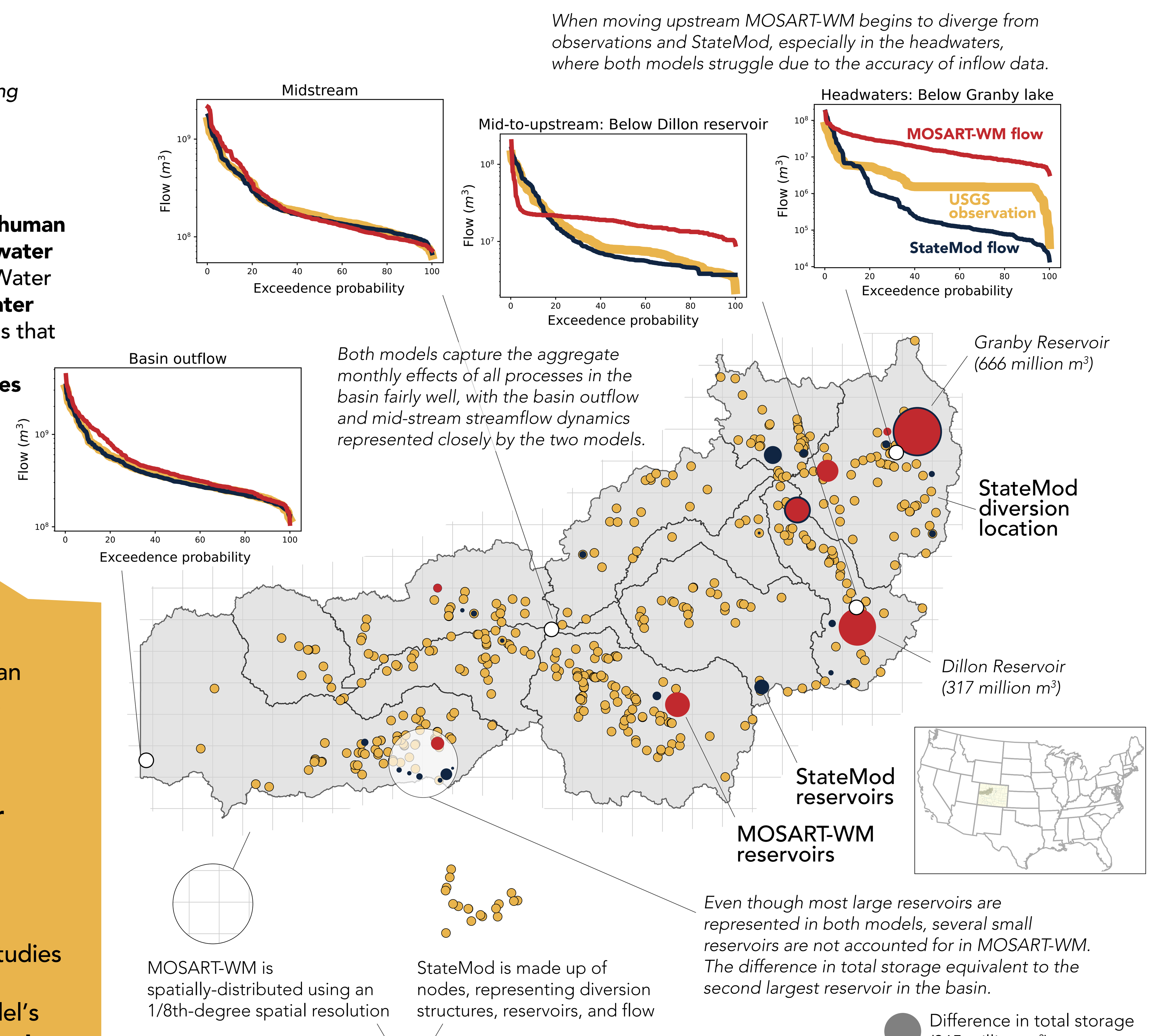
Both communities are interested in addressing similar societal and scientific questions: **how changes in the availability and allocation of water affect its human uses**, and **how human uses impact the spatial and temporal distribution of water resources**. But they approach these questions from different 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

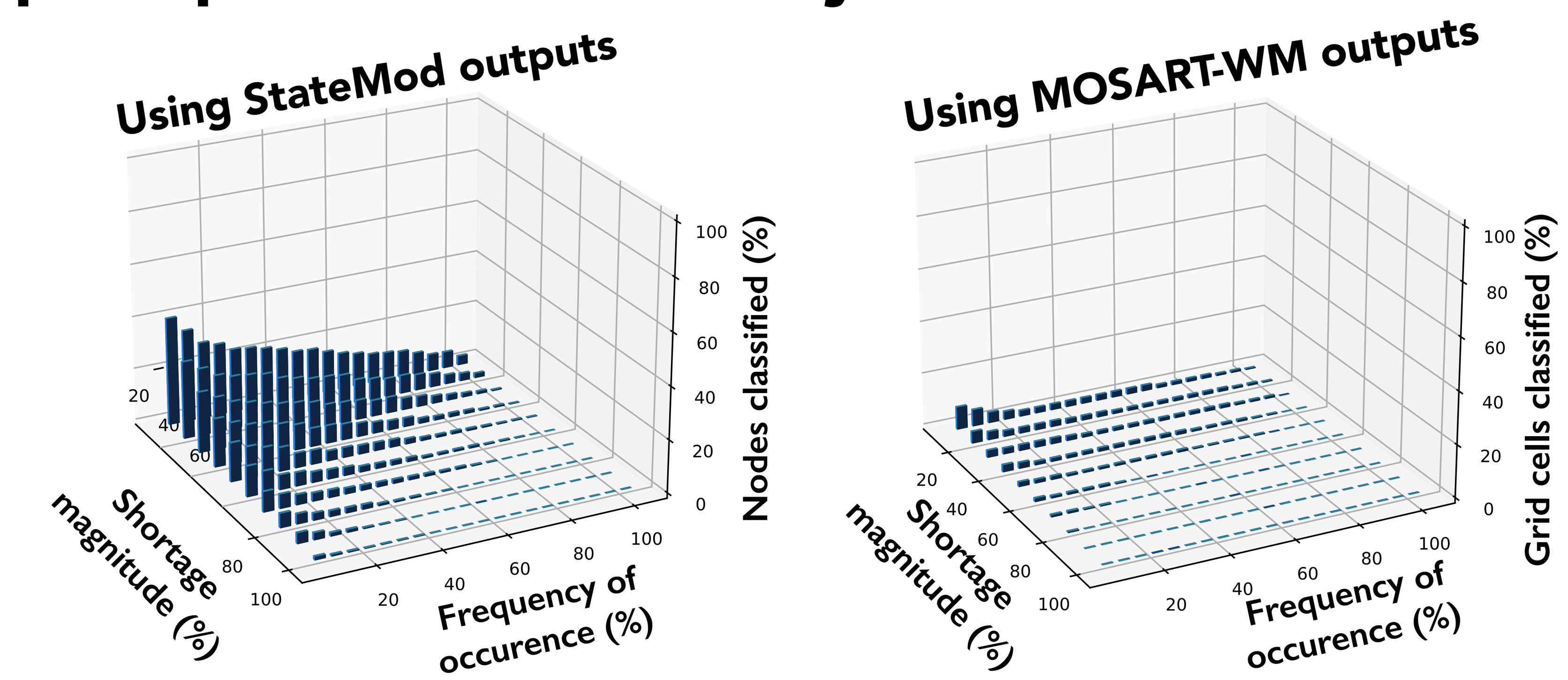
- Results show that while the regional-scale model (MOSART-WM) can capture the aggregate effect of all water operations in the basin, it **underestimates the sub-basin scale variability in specific user's vulnerabilities**.
- The basin-scale water systems model (StateMod) suggests a **larger variance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

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



MOSART-WM's representation allows it to better capture regional and global hydroclimatic processes, whereas StateMod's fine nodal representation enables detailed accounting of infrastructure and institutions, such as prior aprroriation

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



Percentage of model nodes/grid cells classified as vulnerable to water scarcity if different combinations of shortage 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 MOSART-WM basin grid cells that experience each metric combination.

REGIONAL-SCALE MODEL UNDERREPRESENTS SUB-BASIN VARIABILITY

The comparison of percentage of nodes and grid cells that would be classified as **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 variance across grid cells and nodes, we observe much larger variability among the basin users described by StateMod.

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 consistently allocates available water to senior users first, and the **spatially distributed nature** of MOSART-WM which evenly allocates available water to sets of users associated with specific reservoirs.

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