Integrating High-resolution Wetland and Depression Water Storage Data in Major Basin Hydrologic Modeling

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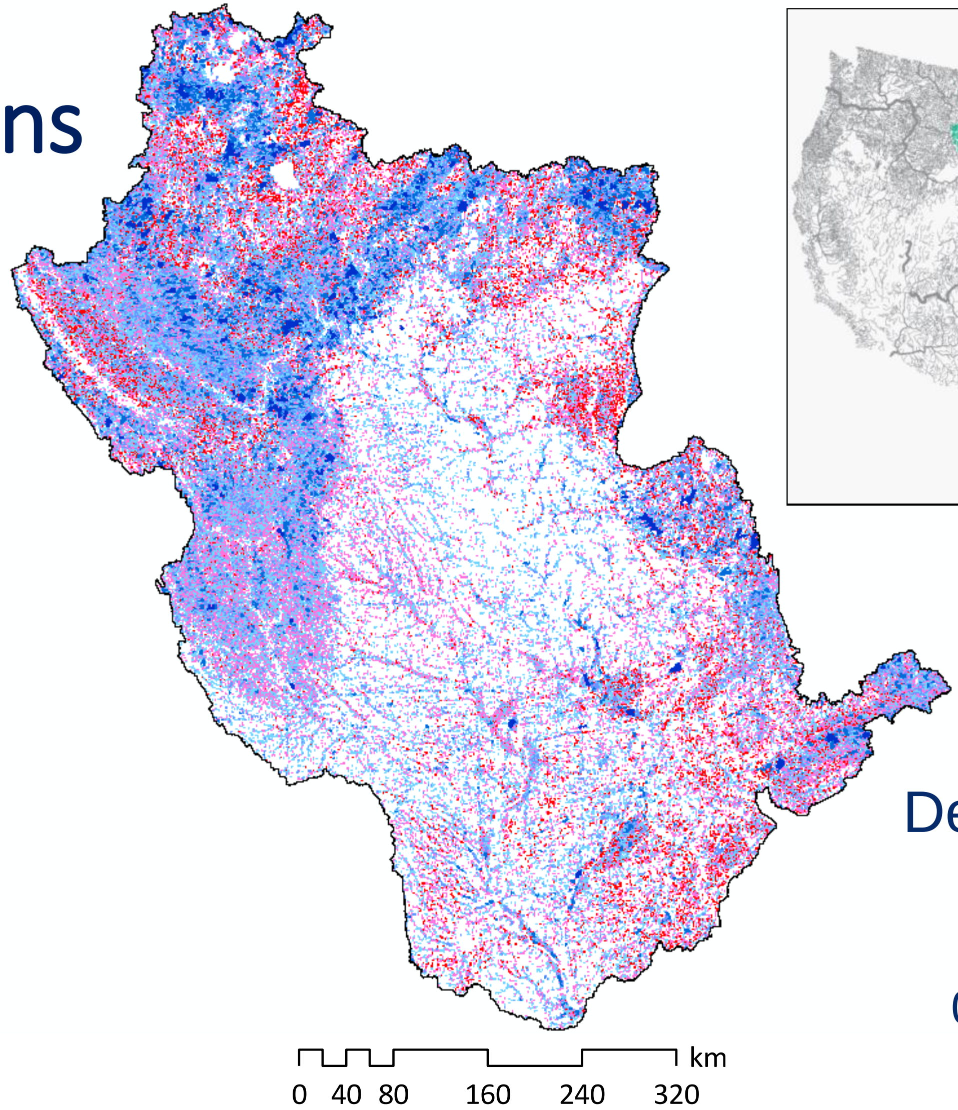
Abstract

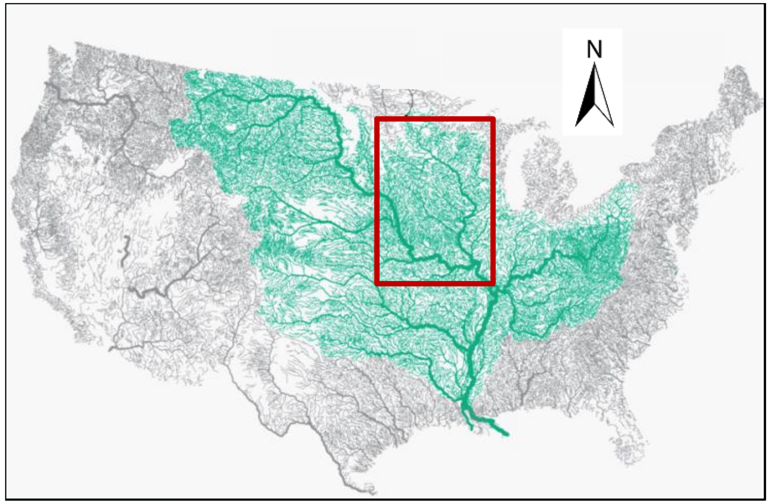
The increasing availability of surface water inundation data has encouraged modelers and managers to include small yet abundant surface water storage systems (e.g., wetlands and other landscape depressions) in process-based models. Yet, these model applications have been largely limited to small- to meso- watershed scales, with drainage areas ranging from a few hectares to several thousand square kilometers. The conventional practice of overlooking these surface water storage systems in basin-scale (e.g., >10,000 m^2) hydrologic modeling may be missing the total picture of flood and drought hazards. To fill this gap, we developed a 30-m resolution topography-based wetland and depression storage (maximum surface area and storage volume) database for the Upper Mississippi, Ohio, and Missouri River Basins [?] encompassing the 2.35 million km^2 upstream domain of the Mississippi River system. Further, we integrated this depression dataset into a process-based model to simulate sub-catchment and river reach-scale hydrologic fluxes (surface runoff, soil wetness, evapotranspiration) and flows (streamflow). Compared with a "no depression" conventional model constructed for the Missouri and Upper Mississippi River Basins, our exploratory analyses demonstrate that a depression-integrated model (i) significantly alters the spatial patterns and magnitudes of water yields, (ii) improves streamflow simulation accuracy, and (iii) provides realistic spatial distributions of landscape wetness conditions. These emerging findings provide us with new insights into the effects of small surface water storage and stimulates a reassessment of current practices for basin-scale hydrologic modeling and water management.

Small surface waters in the world's major basins

- Small surface water storage systems perform sink-lag-source functions

- Hydrologic models typically don't account for small water bodies (i.e., wetlands and surface depressions) and processes therein





Depression Volume
(x 10^6 m^3)

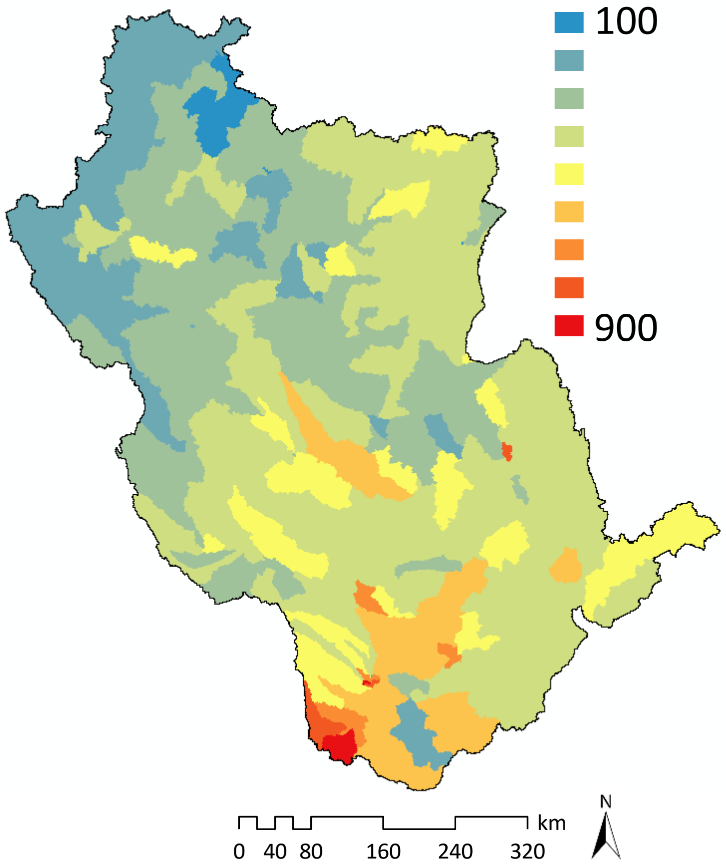
0.001 100

Small surface waters alter magnitude and distribution of basin water yield

- *Significantly* different water yield with the depression-integrated model
- Increased physical realism in model predictions
- Depression size is *not* the only driver of downstream hydrological influence

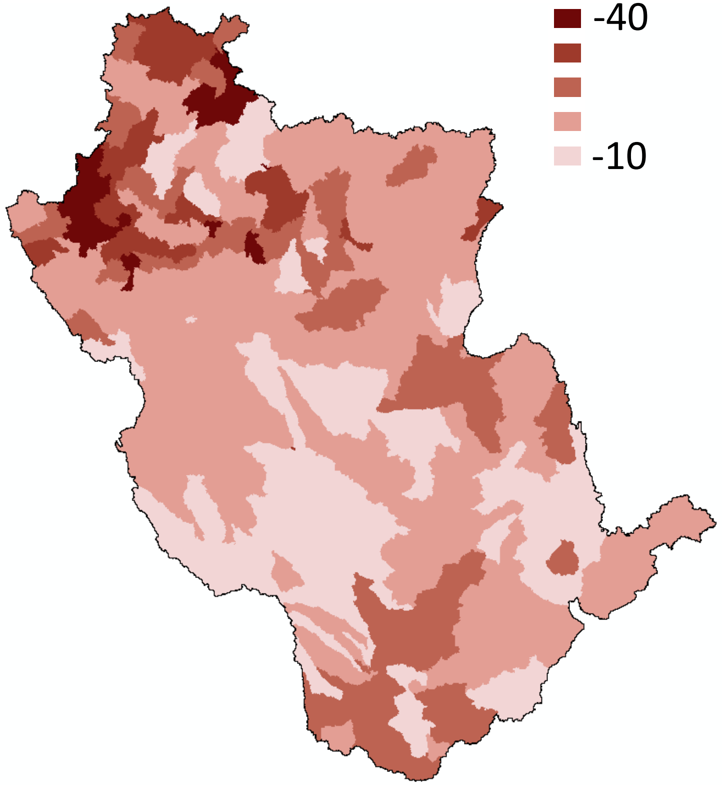
Conventional model

Average water yield (mm/year)



Depression-integrated model

% Reduction in water yield



Depression-integrated hydrologic modeling: Broader impact

- Conventional hydrologic models disregarding small surface waters may be overpredicting floods and underpredicting droughts
- Knowing where small surface waters impart significant hydrologic effects can inform management decisions in response to climate and land use change

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