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# Quantifying human impact on hydrological drought using an Earth System Model

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Predicting the human impact on the present and future hydrological cycle remains a significant scientific challenge. Anthropogenic impact includes water management practices like diverting water for irrigation, abstraction of groundwater, and reservoirs. Hydrological extremes, in particular, are heavily affected by water management practices, due to the existing stress on the system during droughts and floods. Therefore, to prepare adaptation plans for hydrological extremes in the future, it is essential to account for water management and other human influences in Earth System Models.

In this study we have implemented water management practices in the state-of-the-art GFDL land model, which includes terrestrial water, energy, and carbon balances. Both irrigation practices and reservoirs have been added in the land surface model component of the model. Irrigation amounts are determined from the soil water balance, the evaporative demand of the vegetation and fractional coverage of croplands. The resulting water demand is fulfilled by abstractions from surface water and groundwater. Reservoir outflow is dynamically coupled to the downstream water demand and available reservoir storage.

Retrospective model simulations over the contiguous United States indicate a strong human influence on hydrological drought. A water management attribution analysis shows a significant impact on the water availability, mostly in the Midwest of the United States and California. Implementation of reservoirs alters the flow regime, thereby decreasing the short-term drought impact, however, in the case of multi-year drought, impacts are delayed due to the dependency on the reservoir outflow. Irrigation, on the other hand, decreases the water availability in rivers due to increased evapotranspiration leading to a higher drought impact. The average increase in evapotranspiration amounted up to 2 mm/day for cropland areas in California and Texas.

Overall, the results show the importance of including water management in global scale models. This new modelling framework can be used to understand how humans will impact future water availability, water scarcity, and drought. Next steps will include coupled model simulations to investigate the human impact on feedbacks in land-atmosphere interactions.