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The impact of global reservoir expansion on the present-day climate

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By now, humans have constructed more than 45 000 large reservoirs across the globe, increasing the global lake area with 8%. These reservoirs have large impacts on freshwater processes and resources by impounding continental runoff and altering river flows. So far, the impact of reservoirs on the climate remains largely unknown, as they are typically not represented in current Earth System Models (ESMs). This is remarkable, as two-way interactions between reservoirs and climate are likely to alter hydrological extremes and impact future water availability.

Here we present the implementation of the role of reservoirs in the Community Terrestrial Systems Model (CTSM), a land surface model, by accounting for the increase in open water surfaces due to reservoir construction throughout the 20th century. To this end, we allow lake area to expand in the model, while ensuring that the surface energy and mass balances remain closed. We use reservoir and lake extent from the state-of-the-art Global Reservoir and Dams (GRanD) and HydroLAKES data sets.

By conducting both land-only and coupled simulations with CTSM and the Community Earth System Model (CESM), we assess the added value of accounting for reservoir expansion in the land surface model performance and investigate their impacts on the mean climate and extremes. Globally, the effect of reservoirs on temperatures and the surface energy balance is small, but responses can be substantial locally, in particular for grid cells where reservoirs make up a large fraction. Our results show that reservoirs reduce temperature extremes and moderate the seasonal temperature cycle, by up to -1.5 K (for reservoirs covering > 15% of the grid cell).

This study is an important step towards incorporating human water management in ESMs.