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Climate change appears to alter the proportion of rainfall that becomes streamflow in Australia

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Abstract: The impact of climate change on streamflow is predominantly estimated by adjusting climatic variables (e.g., precipitation and temperature) for a given streamflow model. Catchment processes in most streamflow models are assumed to remain unaffected by climate change, resulting in roughly the same partitioning of a given annual rainfall depth into hydrological components (i.e., streamflow, evapotranspiration and infiltration). Droughts in Australia have triggered a shift in how rainfall is partitioned into hydrological components (Saft et al., 2015), resulting in large and unexpected reductions in streamflow. The processes responsible for the shifts in rainfall-partitioning are unresolved (Fowler et al., 2022). Thus, existing physical and conceptual-based streamflow models cannot replicate the shifts in rainfall-partitioning.

Climate change is predicted to produce conditions similar if not worse than previous droughts, potentially causing widespread and permanent reductions in streamflow. To understand how climate change, in the form of anthropogenic CO_2 concentrations, could alter annual rainfall-partitioning we developed and applied 24 data-based streamflow models capable of replicating a wide range of annual rainfall-partitioning to 533 Australian catchments from the CAMELS-AUSv2 dataset (Fowler et al., 2024).

For 112 out of 533 CAMELS-AUSv2 catchments, streamflow models including CO_2 as a variable outperformed those without CO_2. Water-limited catchments which previously experienced drought induced shifts in rainfall-partitioning (Peterson et al., 2021) were more likely to include CO_2 as a driving variable in the best model. Of the types of rainfall-partitioning changes tested, a uniform reduction in streamflow and a reduction in streamflow proportional to annual rainfall were the most common. However, challenges remain when quantifying the direct effect of CO_2 on streamflow. For catchments where a model with CO_2 outperforms a model without CO_2, we estimate the median Australia-wide impact of CO_2 during 2012-2021 resulted in a 30 % reduction in streamflow. However, this average does contain some unrealistic values caused by either confounding factors or assumptions regarding the methodology.

Current climate change projections suggest there will be less rainfall for many parts of Australia leading to less streamflow. However, our findings indicate these predictions will likely underestimate the reductions in streamflow. For water-limited catchments, CO_2 induced shifts in rainfall-partitioning are likely to produce additional reductions in streamflow, compounding the already reduced streamflow from changes in rainfall. Given most streamflow projections do not account for CO_2 induced shifts in rainfall-partitioning, unexpected decreases in streamflow are likely to become more widespread, threatening both ecosystems and water resources.

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