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Emerging river flow and hydrological drought trends in Great Britain

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Hydrological drought frequency and severity is projected to increase for the UK. However, there is not yet robust observational evidence for decreasing river flows and increasing hydrological drought severity. This lack of evidence may stem from short observational records, human influences on river flows and internal climate variability. As a result, river flow trends in the past and in the near-term may be different to the trend induced by long-term climate change. This lack of congruency poses significant challenges for decision-makers faced with uncertain future projections on the one hand and an apparent lack of observed changes on the other: underscoring the need for approaches that bridge this gap. Single-Model-Initial-Condition-Large Ensembles (SMILEs) provide an ideal opportunity to reconcile past observations and future projections as they isolate the effect of internal climate variability. Here, we use the 50-member CRCM5 12km SMILE to drive GR6J catchment hydrological models for 190 catchments across Great Britain. Results show that observed trends in precipitation and river flows are within the spread of the large ensemble, which includes both robust wetting and drying trends over the historical period that could have arisen from internal climate variability. We further estimate the time of emergence for each catchment, i.e. the decade at which river flow changes exceed natural climate variability. Winter river flows increase with warming and are estimated to exceed natural climate variability before the 2050s for many catchments, with implications for flood risk. Summer river flows are estimated to reduce with warming, including hotspots in southwest Britain with an early time of emergence, exacerbating existing pressures on water resources. Autumn flows for catchments in southeast England are estimated to decrease but are not estimated to exceed natural climate variability until late 21st century. Establishing water management and adaptation strategies is crucial well in advance of catchments reaching their time of emergence (i.e. before a statistically significant trend is detectable). These results highlight the potential to use SMILEs to explore plausible alternative realisations and explore storylines of low-likelihood, high-impact hydrological extremes.