Emerging river flow and hydrological drought trends in Great Britain

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HS2.4.3 Hydrological extremes: from droughts to floods

18/04/24

Photo: Jamie Hannaford at Ladybower Reservoir

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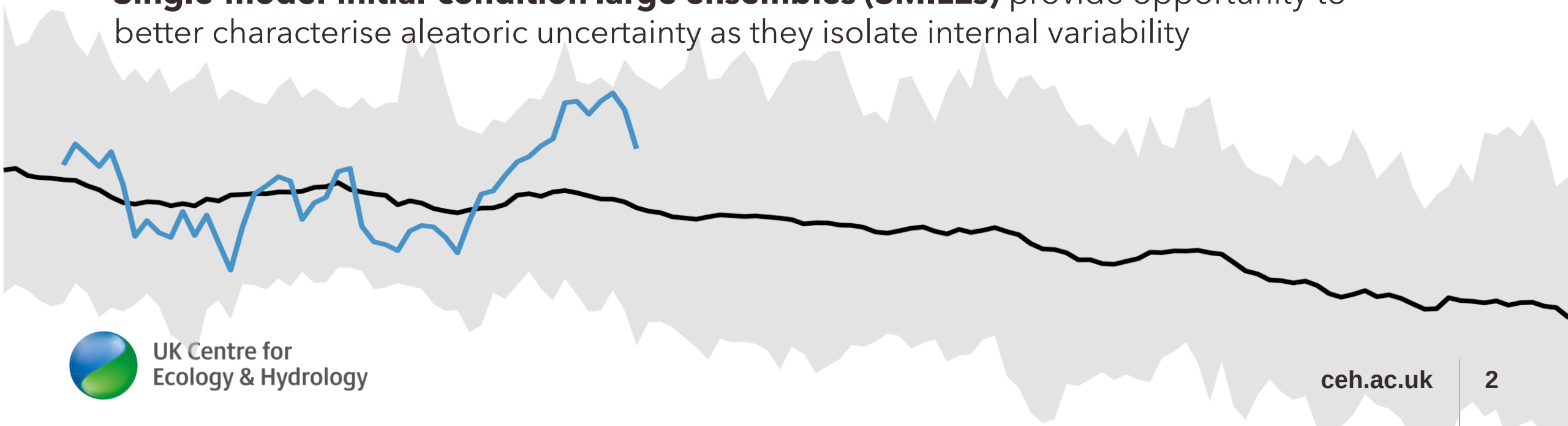
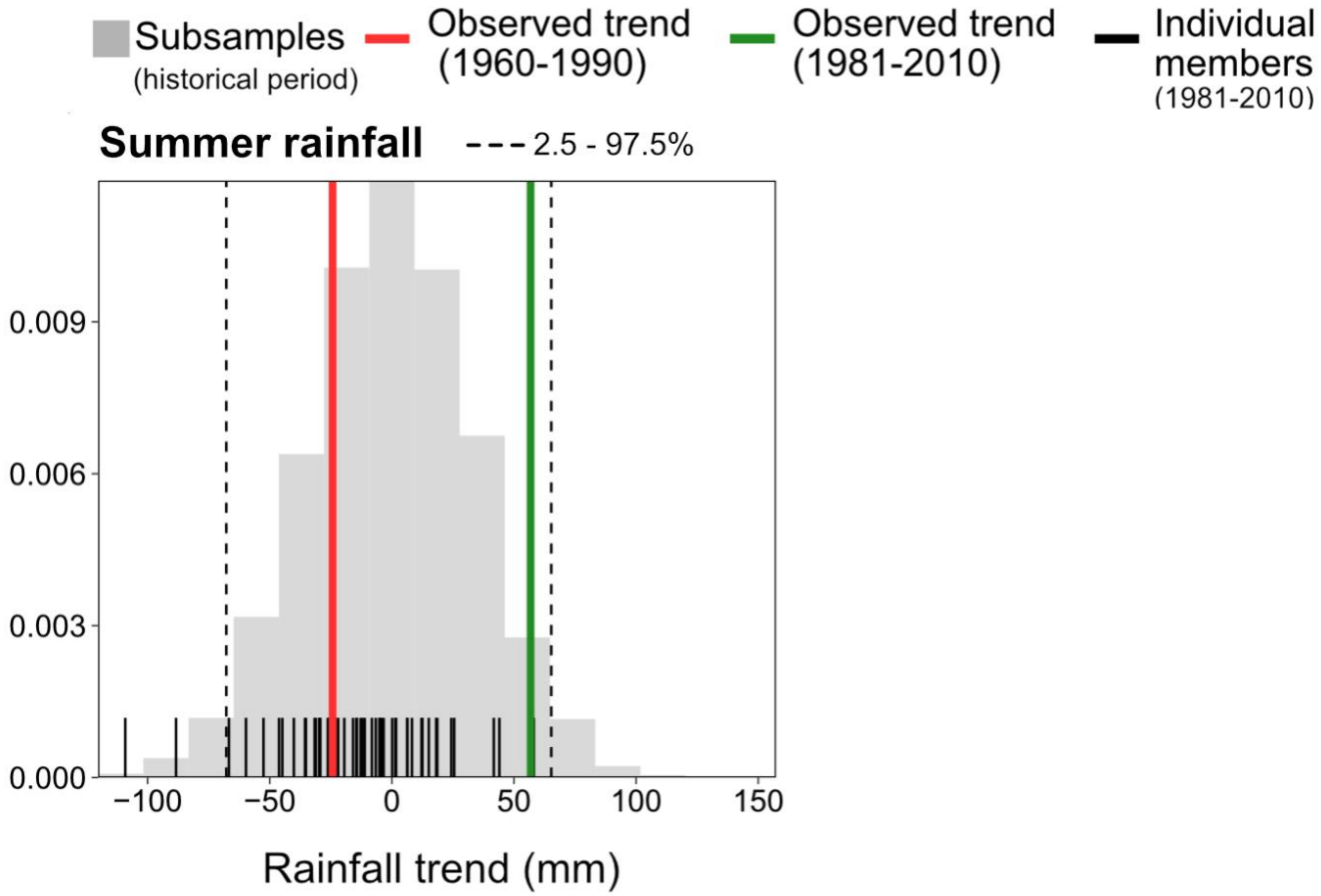
Motivation

- Despite perception of a wet country, the UK is not immune to hydrological droughts Robust detection of a climate change driven trend in observations is complicated by **1) short records**, **2) internal climate variability** and **3) human influences on catchments**
- Hydrological drought risk largely under-sampled from multi-model ensembles given high variability
- **Single-model-initial-condition large ensembles (SMILEs)** provide opportunity to better characterise aleatoric uncertainty as they isolate internal variability



Internal variability and hydrological trends

- CRCM5-LE 12km 50-member RCM SMILE
- Bias-adjusted using power transformation (Leander and Buishand 2007)
- UNSEEN technique to resample detrended data 10,000 times and 30-year trend calculated for each subsample (Thompson et al. 2017; Jian et al. 2023)
- GR6J simulations of river flows for 190 UK catchments



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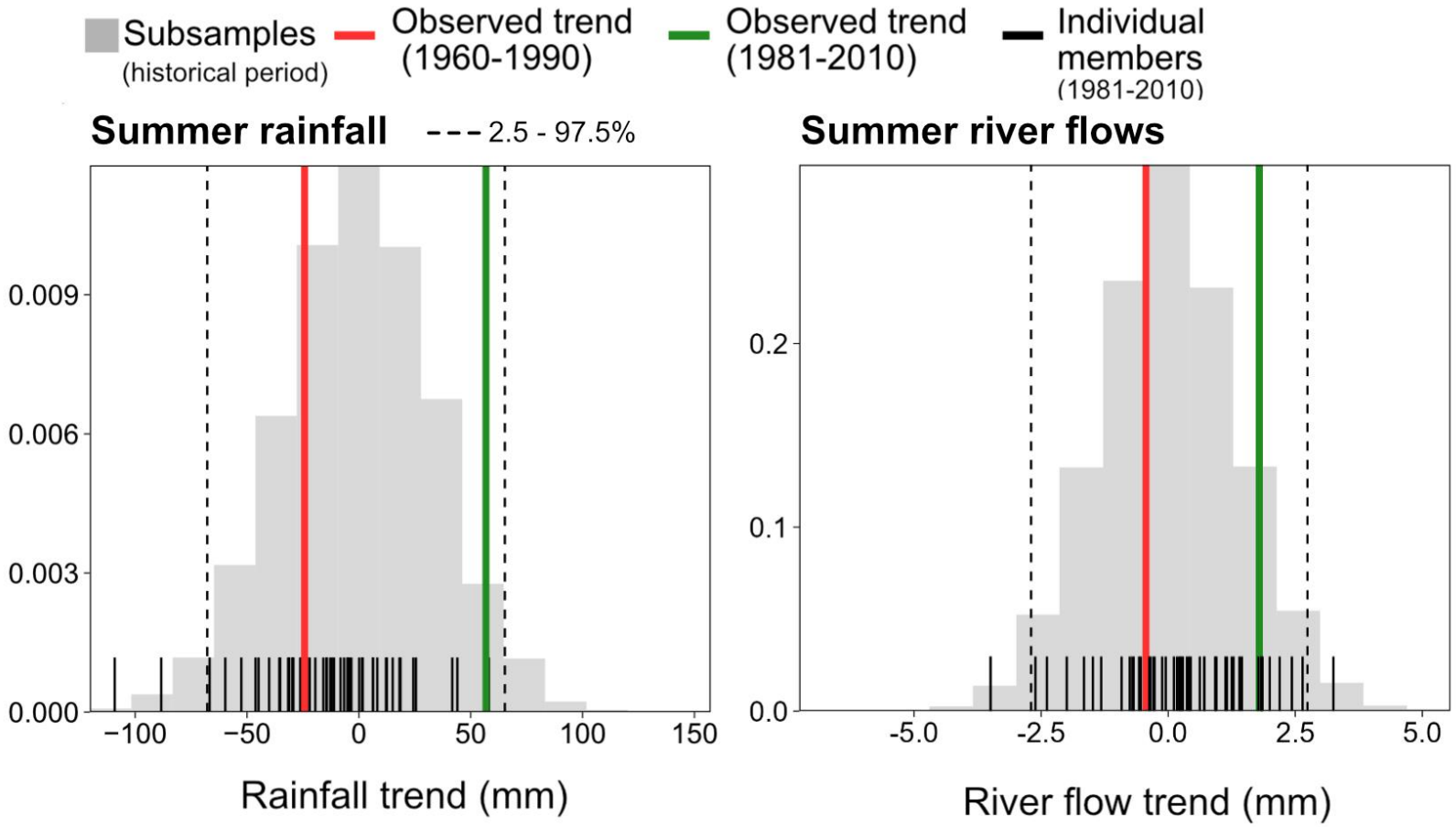
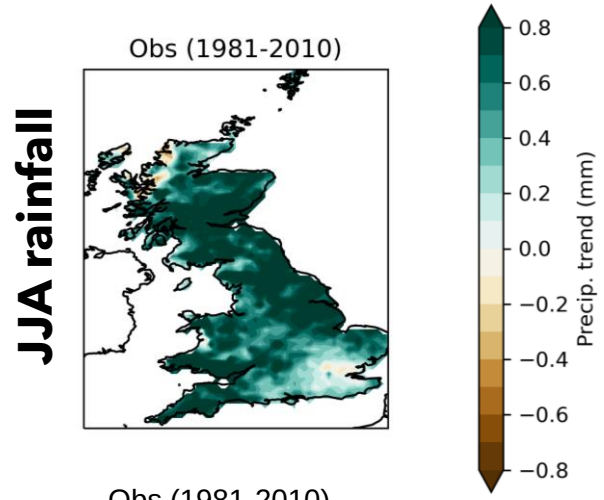
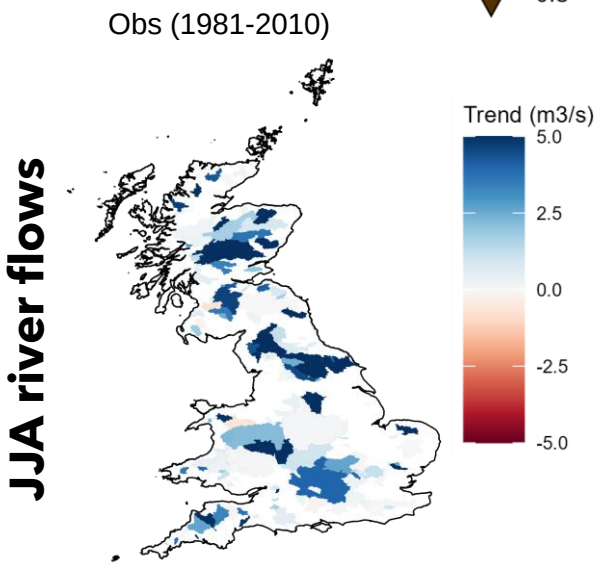


Storylines of internal variability

Discrete storylines to explore effect of internal variability





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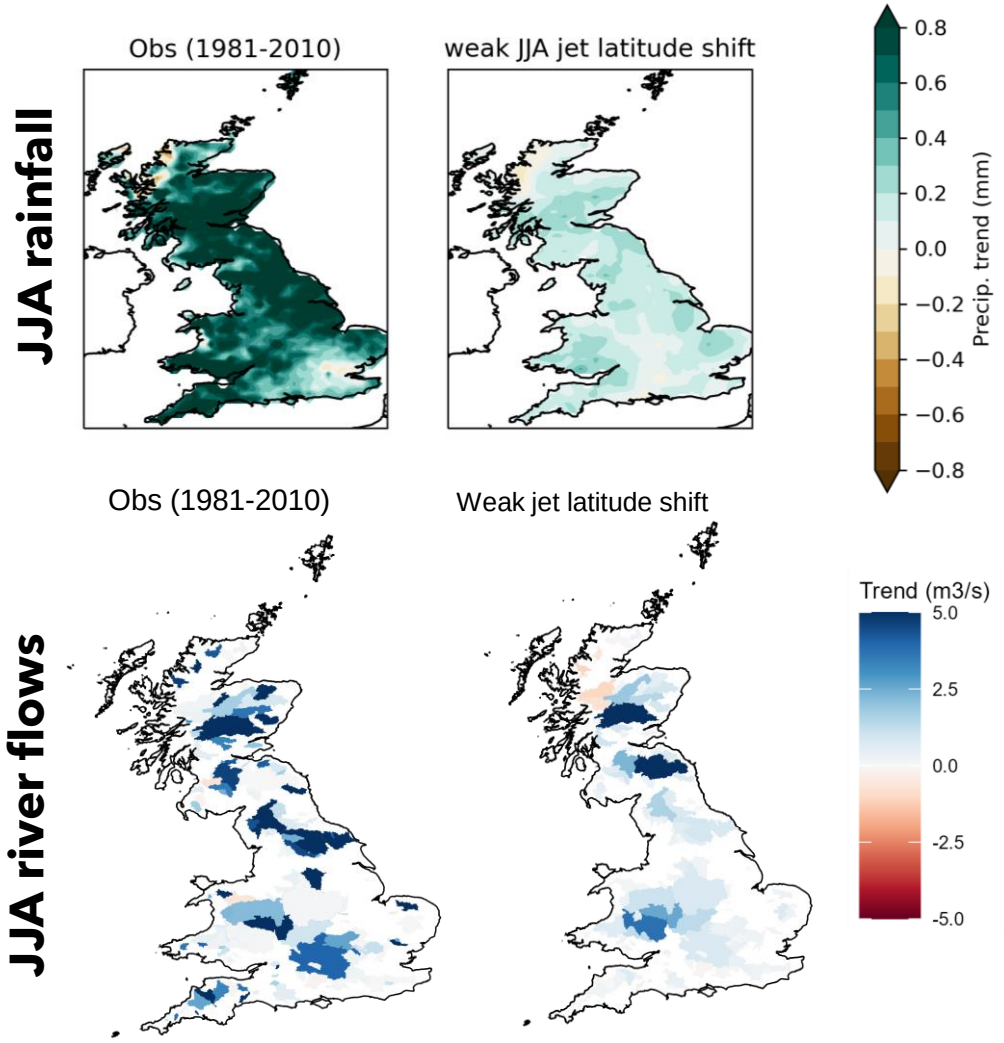
Example – Trends over historical period conditioned on trend in jet stream position

- Partition SMILE by conditioning on specific jet stream changes following linear regression framework in Zappa and Shepherd (2017)



Zappa and Shepherd (2017); Harvey et al. (2023)

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Example – Trends over historical period conditioned on trend in jet stream position

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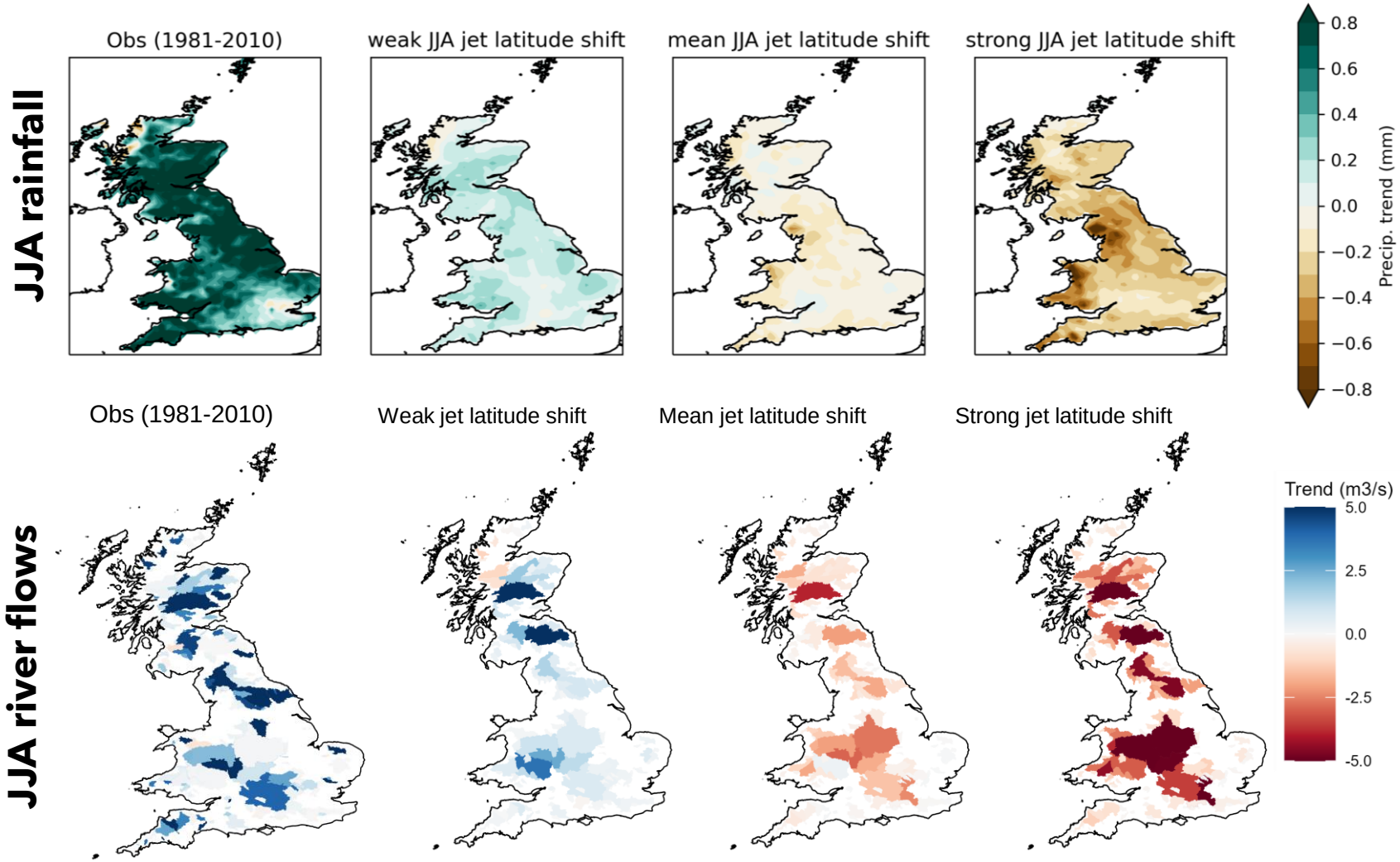
- **What if we saw a 30-year period with a different jet stream state?**



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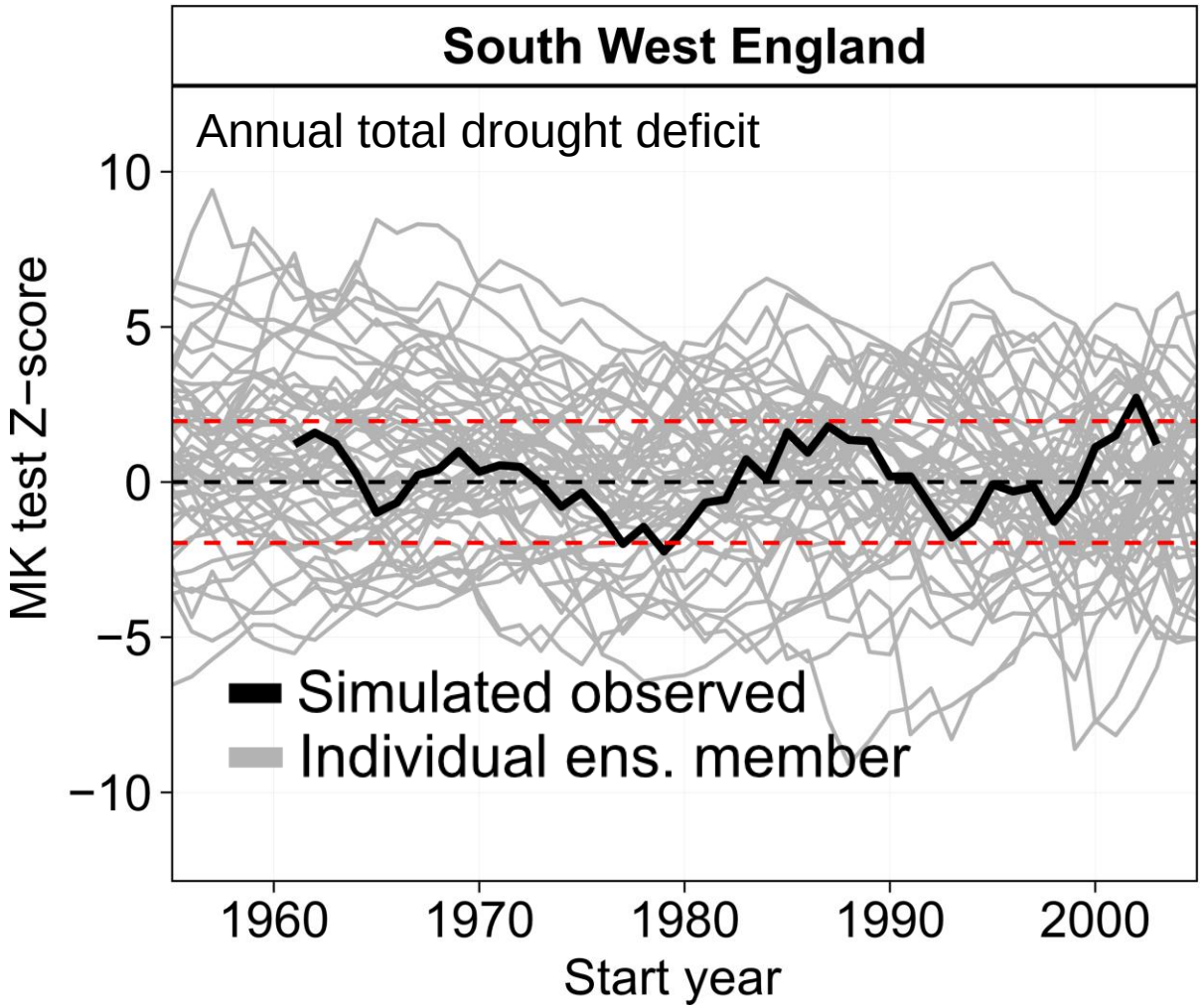
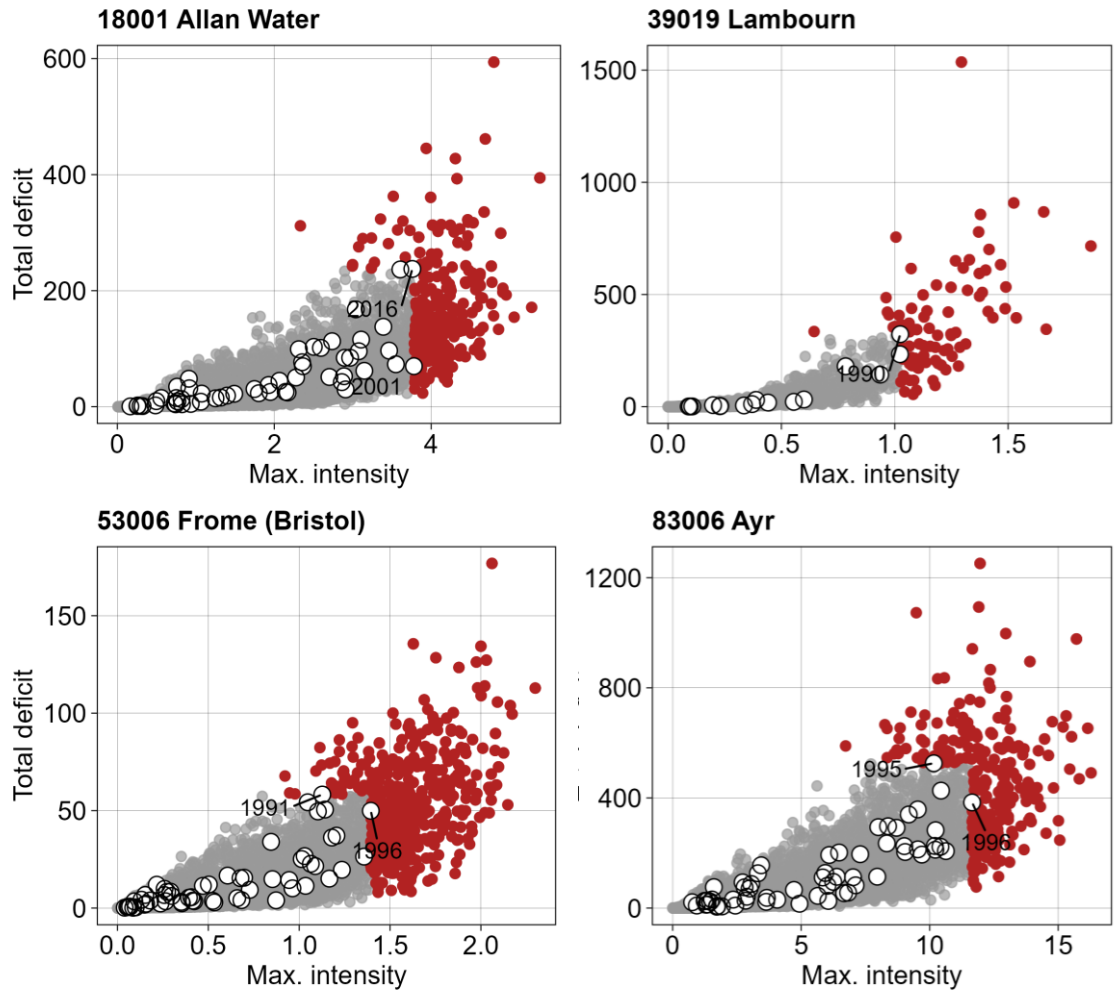
Record-shattering droughts

UNSEEN approach applied to droughts - see also ***Chan et al. (2023) Journal of Hydrology***





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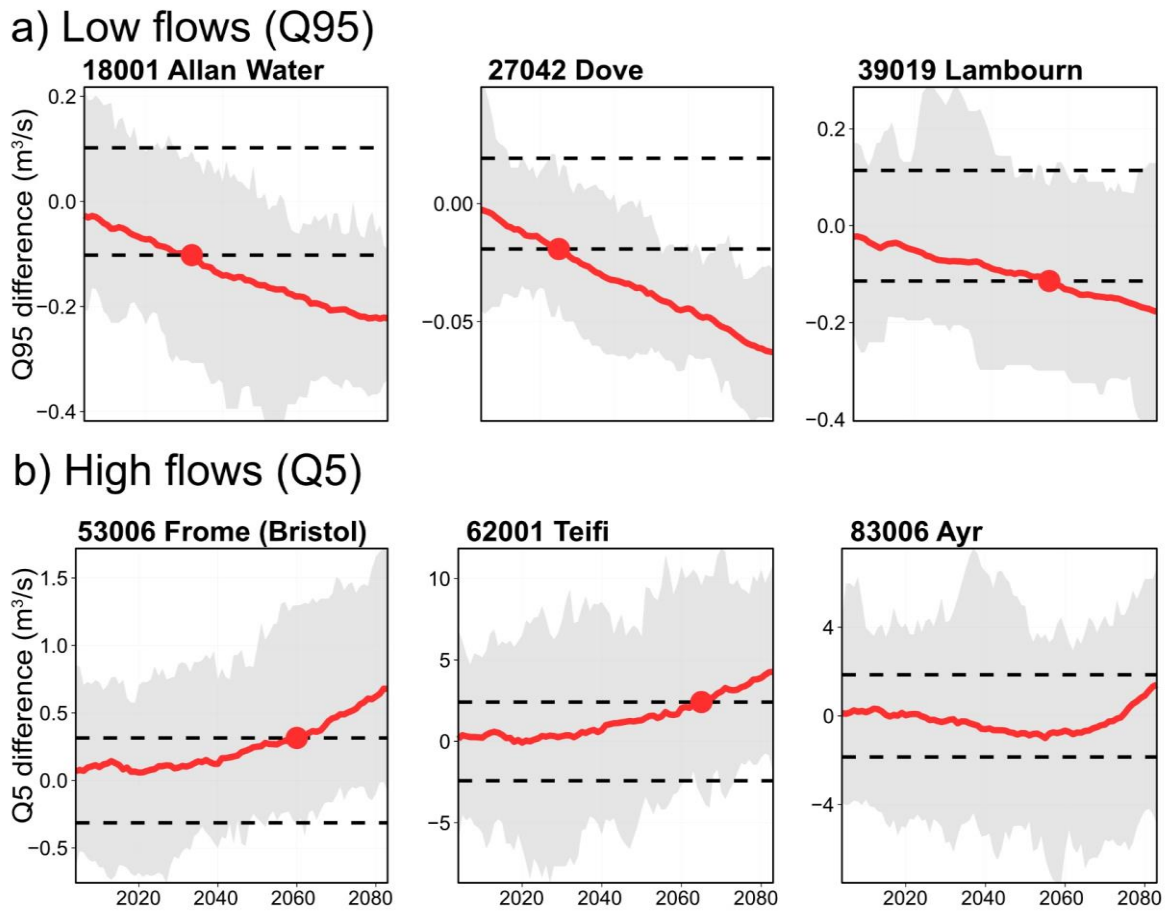
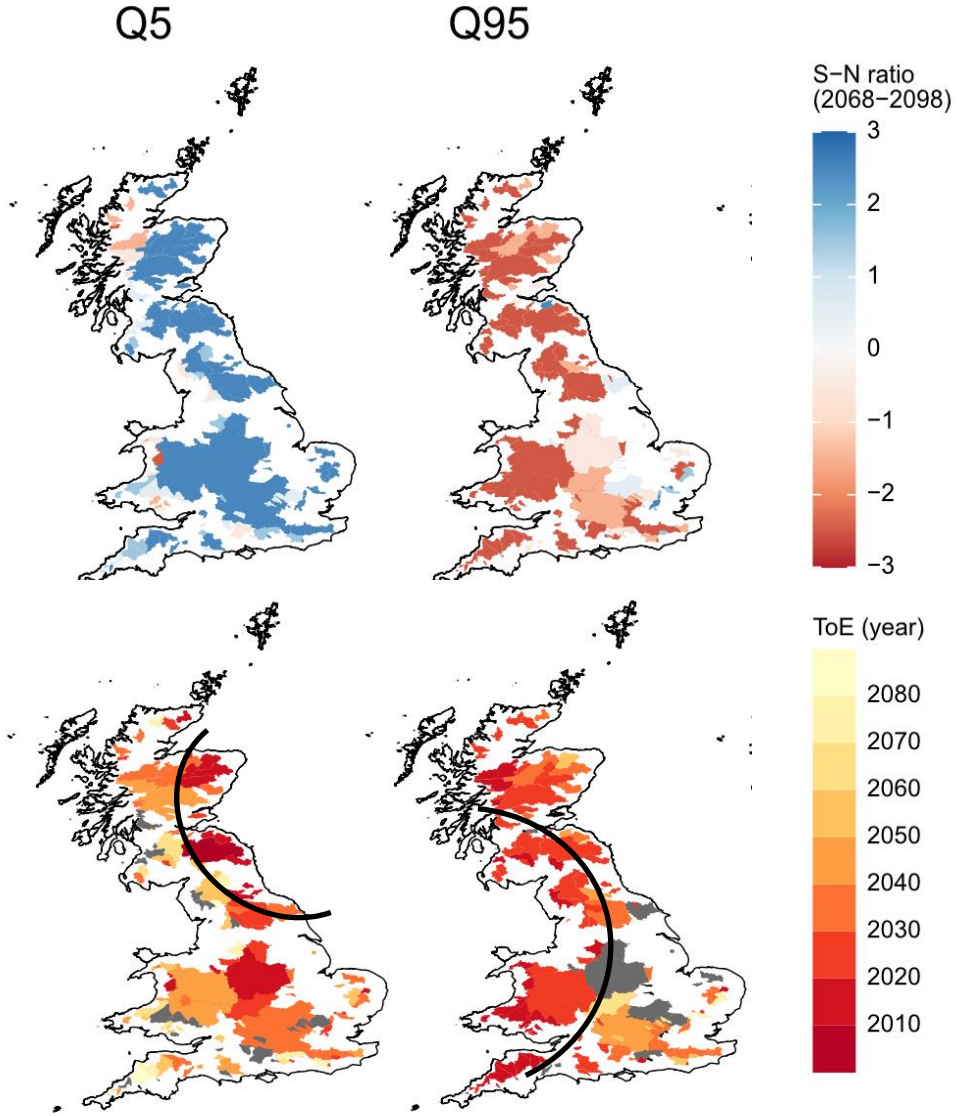
Future emergence of hydrological extremes





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Summary

- Hydrological simulations driven by SMILEs presents emerging opportunities to better characterise the effect of internal variability on river flows
- Wide range of plausible trends in rainfall and river flows show that observed trends fall within the range of internal variability
- Storylines of hydro-climate changes can be made by partitioning SMILEs to explore alternative, equally plausible outcomes – *Proof of concept to be applied to existing SMILEs and the new CANARI LE*
- Time of Emergence (ToE) for catchments across the UK highlights hotspots of increasing high flows for northeastern UK and decreasing low flows for western UK

Thank you!

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Photo: Jamie Hannaford at Ladybower Reservoir