Large ensemble simulations for water resources planning

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Introduction

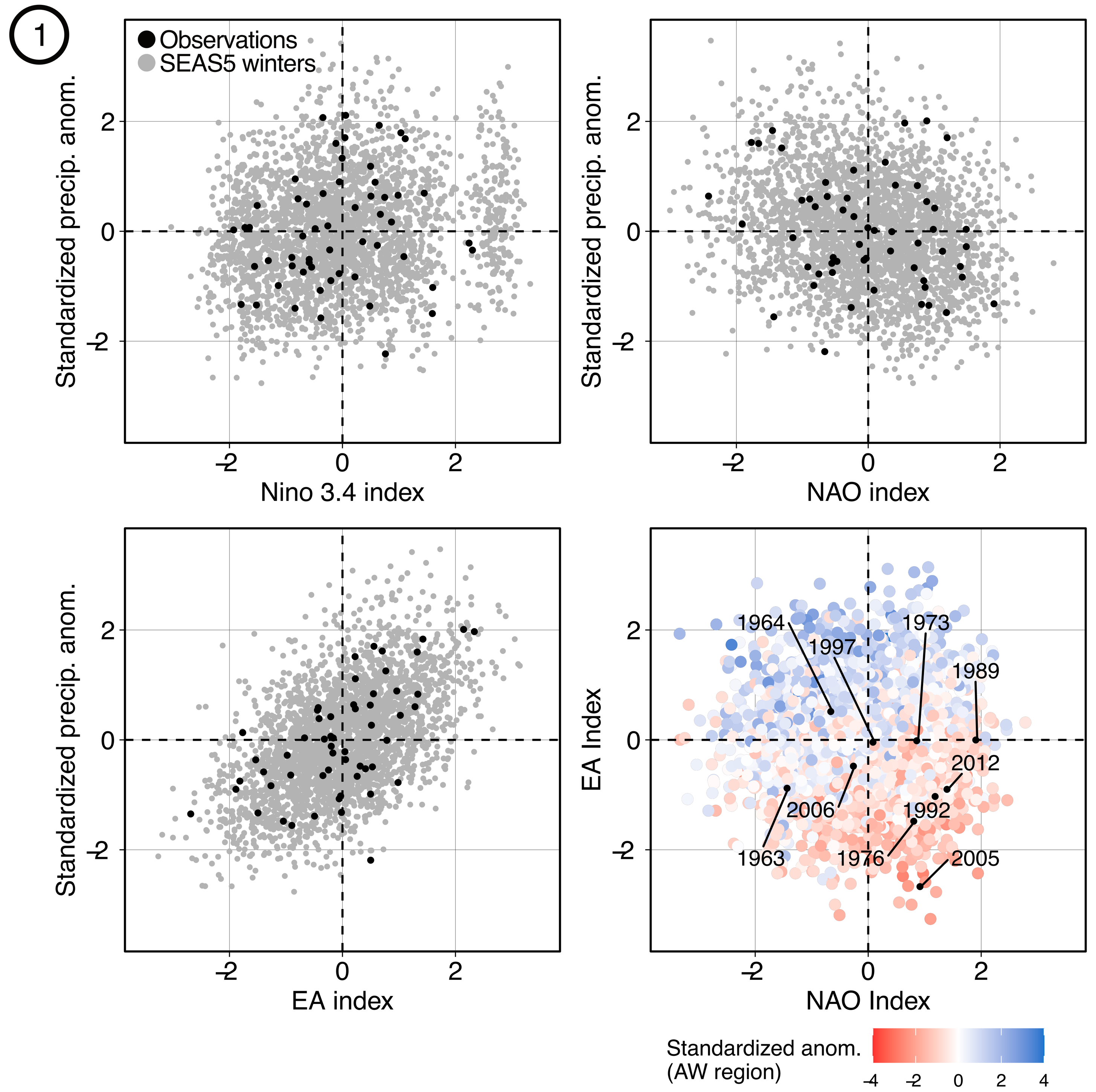
Droughts threaten water supply and incur environmental and social impacts. Planning against plausible worst cases is of interest for water resources managers. The East Anglia region is the driest region in the UK and susceptible to current and future droughts. Large ensemble simulations (e.g. seasonal hindcasts or single model initial condition large ensembles) can mitigate the challenge of short observational records and better consider internal climate variability.

Data

SEAS5 hindcasts

The SEAS5 hindcast is used to provide a large sample of winters (DJF). In total, there are 2850 winters in the hindcast dataset across 25 ensemble members and three lead times (Sep, Oct and Nov). The credibility of the hindcasts are confirmed by fidelity tests in Thompson et al. (2017) and Kelder et al. (2022) over eastern England. The North Atlantic Oscillation (NAO), East Atlantic pattern (EA) and ENSO are key drivers of rainfall in eastern England (**Figure 1**).

1



Downward counterfactuals storylines

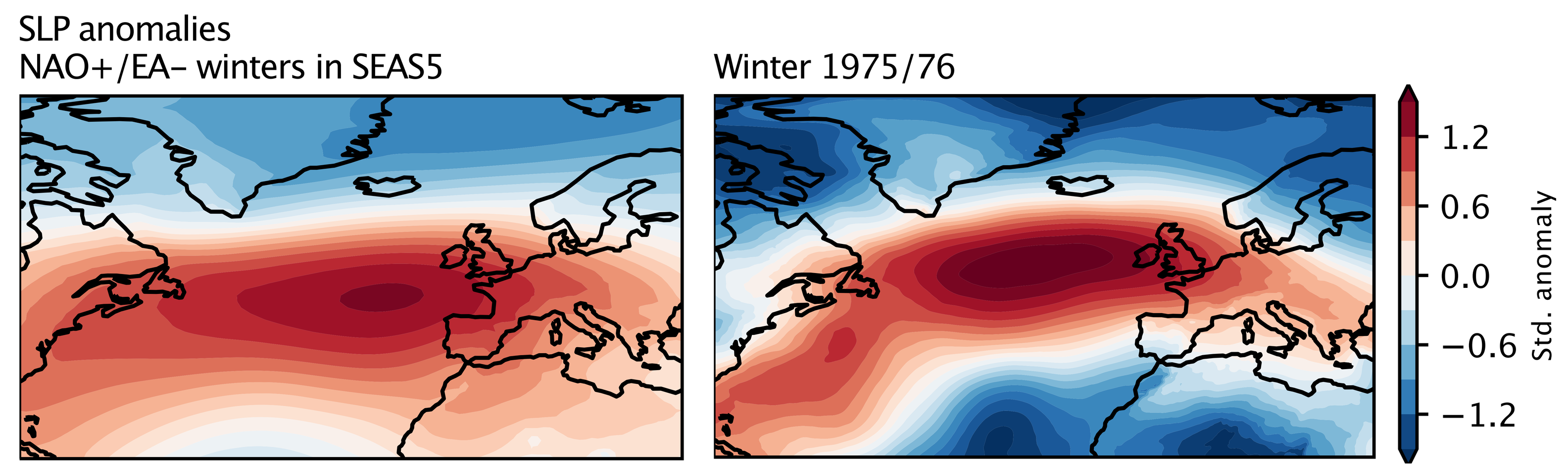
1975-76 drought

The winter half year 1975/76 (Oct to Mar) saw <50% of long term average rainfall and was associated with strong La Nina conditions. The observed winter 1975/76 exhibited NAO+/EA- atmospheric circulation patterns. We use the large sample of plausible winters in the SEAS5 hindcast dataset to sample for La Niña winters with similar NAO+/EA- atmospheric circulation patterns (**Figure 2**).

What if the dry winter 1975/76 was even drier than observed?

GR6J hydrological model simulations with observed winter 1975/76 replaced with La Niña winters with NAO+/EA- in the hindcasts show that drought could have been significantly worse across catchments in the Anglian Water region, especially for slow-responding groundwater-dominated catchments (such as Wensum and Nar) vulnerable to long-term precipitation deficits (**Figure 3**).

2



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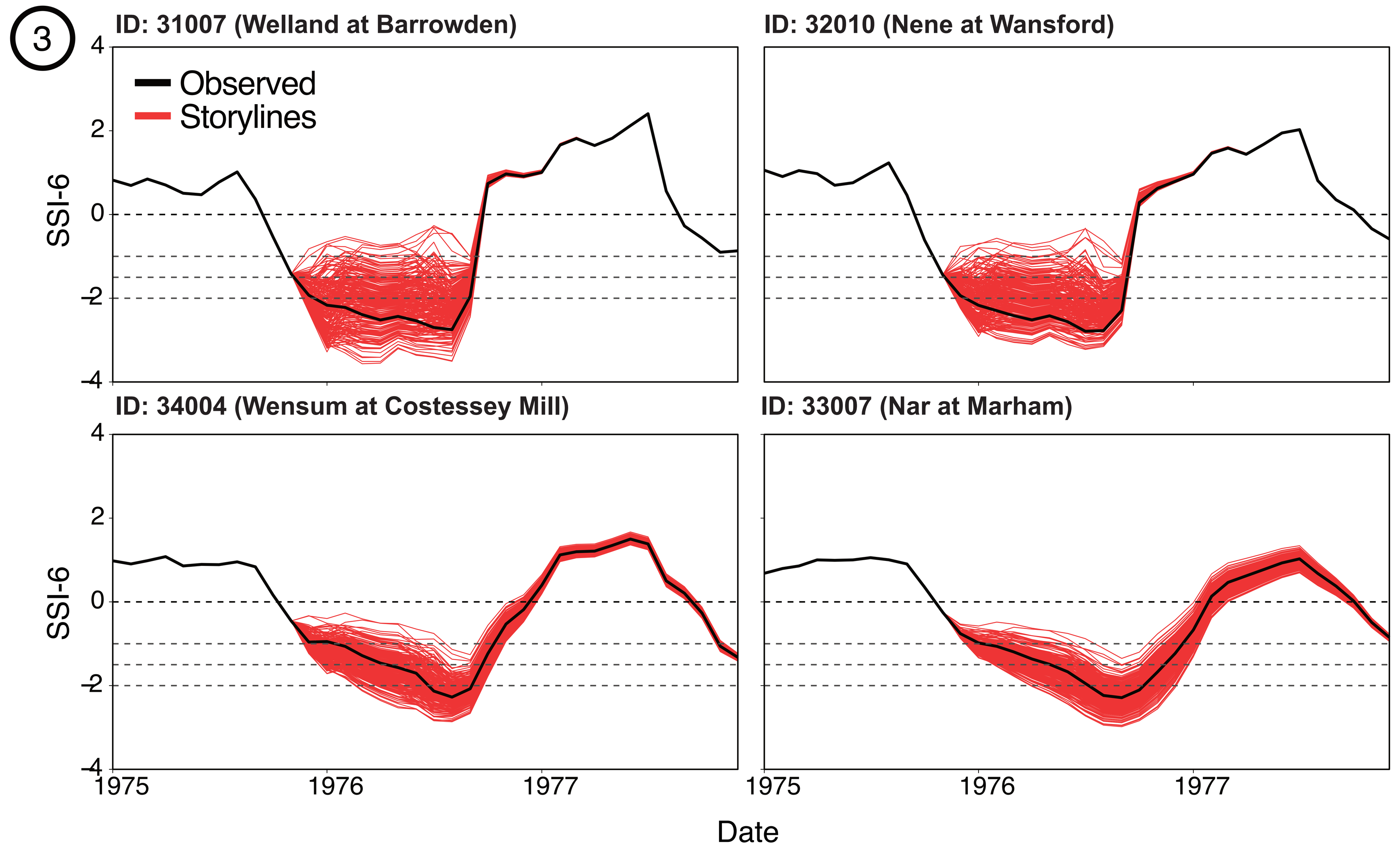


Hydrological outlooks

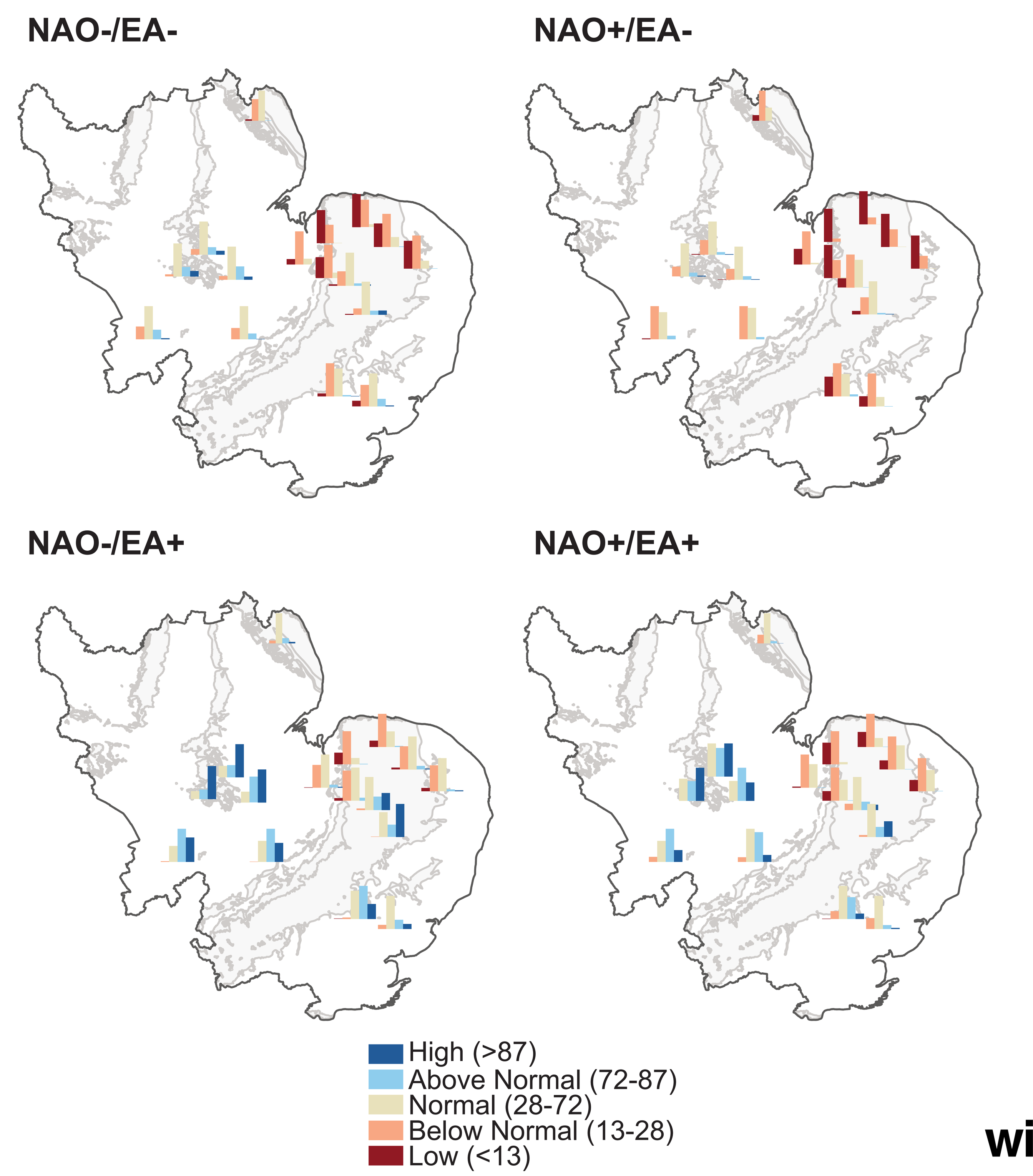
Can we create outlooks of a current drought conditioned on atmospheric circulation patterns?

The 2850 plausible SEAS5 winters were separated into La Niña and El Nino and subsequently clustered into four clusters via k-means clustering (using NAOI, EAI, ENSO, Vortex strength). The resulting clusters roughly resemble the four combinations of NAO and EA and different states of the polar vortex.

Outlook of 2022 drought

The 2022 drought was characterised by a dry spring-summer sequence. Storylines were created in autumn 2022 assuming no knowledge of winter 2022/23 to represent plausible pathways of the drought. GR6J simulations were run assuming winter 2022/23 resembled each of the four SEAS5 winter clusters. The likelihood of river flows across East Anglia in different categories by the end of spring 2023 for each storyline is shown in **Figure 4**.

4



Other work

Storylines of UK drought based on the 2010-12 event

Review of impacts of climate change on UK river flows

Abstract info.

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