Response to RC1

This manuscript presents the first systematic, nationally-consistent assessment of transitions between hydrological (and meteorological) wet and dry extremes across the UK, using the eFLaG dataset spanning 1989–2079. The authors define transitions as the period between consecutive opposite-sign extremes identified via SSI/SPI threshold crossings at a monthly timescale, characterizing them by magnitude, duration, intensity, and frequency for both dry-wet and wet-dry directions. Historically, the authors find a clear northwest-southeast gradient, with the NW showing higher-intensity, shorter-duration, more frequent transitions and the SE showing longer, lower-intensity transitions (linked to groundwater-dominated catchments). Under future RCP8.5 projections, most regions show increasing transition magnitude and intensity and decreasing duration, with the largest duration decreases in the SE and the largest frequency increases in the NW. With a few relatively minor revisions, I think the manuscript will present the main results of the study in a way that is easier for the reader to digest.

We would like to thank the reviewer for their comments and feedback on how our manuscript can be improved further. Please see below our detailed responses.

Major comments:

- The paper repeatedly contrasts itself with "drought-to-flood" transition studies (Götte and Brunner, 2024; the companion Yang, Villarini & Yang CONUS paper; Anderson et al., 2025) but the distinction between a "state-switch" (SPI/SSI threshold crossing at seasonal timescales) and a "true" DtF/FtD transition (event-based, sub-seasonal, 90-day window) could be made more explicit and earlier in the Introduction, not just in section 4.1.

  We agree that this is an important clarification that could be introduced earlier in the paper, especially when discussing literature that may use different definitions of transitions. We will add the distinction between seasonal and 'true'/rapid transitions to our introduction by making clear that it is possible to see a seasonal transition without a declared drought or flood event. We will also make sure that the introductory discussion of wet-dry and dry-wet transitions is framed around the seasonal transitions ('state switches').

  This distinction is now considerably sharper given the newly available companion results: Yang et al. (2025, in review for Earth's Future) report that across 2,000+ CONUS stations, drought-to-flood (DtF) events occur nearly three times more frequently than flood-to-drought (FtD) events, with DtF transitions occurring within ~41 days versus ~57 days for FtD, and with DtF intensity significantly higher than FtD (Mann-Whitney U, $P<0.05$). This is a striking asymmetry. By contrast, the present UK paper finds wet-dry and dry-wet transitions to be broadly symmetric in magnitude/duration/intensity changes (though differing in seasonality). Is this symmetry a property of the seasonal SSI/SPI approach (which by construction looks at smoothed, longer-duration anomalies, merging events separated by gaps) versus the asymmetry that emerges when looking at sub-seasonal/rapid threshold-crossing events with explicit drought/flood definitions tied to the 2-year-recurrence bankfull discharge and 7-day low-flow statistics? The authors should discuss this methodological dependency as a substantive finding, not just a caveat. It may be the single most important point of contrast between the UK seasonal-switch framework and the rapid-whiplash framework, and is directly relevant to readers trying to reconcile the two literatures.

  Thank you for bringing these results to our attention, we had not included reference to the Yang et al. (2026) paper in our original manuscript but will do so in the revised manuscript.

We agree that the symmetry in our wet-dry/dry-wet transitions compared to the asymmetry of FtD/DtF events in Yang et al. (2026) is a point of interest, and is useful in highlighting the difference in our methodology – and indeed, our seasonal transitions (i.e. state switches) – compared to 'rapid' transitions elsewhere in the literature. We will add to our discussion accordingly to reflect this. We discussed the use of initial condition large ensembles for investigating the drivers of transitions in line 447-450 of the original manuscript, and will expand on this to include the fact that due to the longer duration of 'state switch' transitions compared to 'rapid' transitions we may see fewer of these events in the historical record and need a large ensemble to fully sample rare events.

- The large overlapping ensemble spreads (Figures 8–9) are acknowledged, but the paper would benefit from a more quantitative treatment — e.g., what fraction of ensemble members agree on the sign of change for each metric/region? A simple "fraction of RCMs showing increase" map or table would help readers gauge robustness more than visual inspection of overlapping boxplots. As written, statements like "transition magnitude is projected to increase for most regions" are somewhat qualitative given the stated caveat that "internal variability... dominate the projected signal."

We will add text to the revised manuscript to include a quantification of the number of ensemble members showing a projected increase or decrease in transition metrics and will add the below tables to the supplementary. We do not feel it necessary to add a figure to the main manuscript for this.

Table R1 – The number of RCMs showing an increase in each transition metric from Baseline to Far Future period for Severe (±1.6) wet-dry and dry-wet transitions in SSI3 using the GR6J model.

	Wet-Dry			Dry-Wet		
	Magnitude	Duration	Intensity	Magnitude	Duration	Intensity
East Scotland	12	1	11	12	0	12
North East England	10	1	11	11	1	11
Yorkshire and Humber	11	0	11	12	0	12
East Midlands	11	0	12	9	2	10
East of England	12	0	12	12	2	11
South East England	10	0	12	11	1	11
South West England	11	0	12	12	0	12
West Midlands	10	0	11	11	0	11
Wales	12	0	12	12	0	12
North West England	12	1	11	12	1	12
Northern Ireland	10	1	10	10	1	11
West Scotland	11	1	12	12	1	11
North Scotland	11	1	10	12	0	12

- I think the main paper would benefit from figures showing a comparison of hydrological transition metrics of SimRCM minus SimOBS so the reader can clearly see where the RCM best matches simulated observations, ad where the two diverge.

We have looked at plotting the difference between SimRCM and SimObs for each transition metric and whilst we can appreciate why some readers may find it useful to have more of a quantitative comparison between the two however, we do not feel it necessary to include this figure in the revised manuscript as the 12-member climate ensemble (SimRCM) is not meant to, and will not, replicate SimObs exactly; they include a larger sample of transition events of different characteristics. Figure 5 in the original manuscript shows that the transition magnitude, duration and intensity in SimRCM, on average, are comparable in magnitude and spatial pattern to that in SimObs. Differences between SimRCM and SimObs are already discussed in line 150-152 of the original manuscript: "SimRCM runs do not attempt to replicate actual 'weather' but rather evolve according to the transient response of the RCM – and only replicate the long-term statistics of regimes rather than the day-to-day weather".

- Another set of panels on existing figures could show the difference in median NF and FF transition metrics as compared to BL metrics. It takes a lot of work looking back and forth between the boxplots to currently see this. The boxplots are very helpful for looking at the range and variability of metrics by scenario, but simple panels showing difference in medians would draw out some of the key results of the paper.

We agree that an additional panel showing difference in medians in future periods against the baseline period would be beneficial and will add to Figure 4 to include difference-in-median panels for each metric, example for intensity shown below.

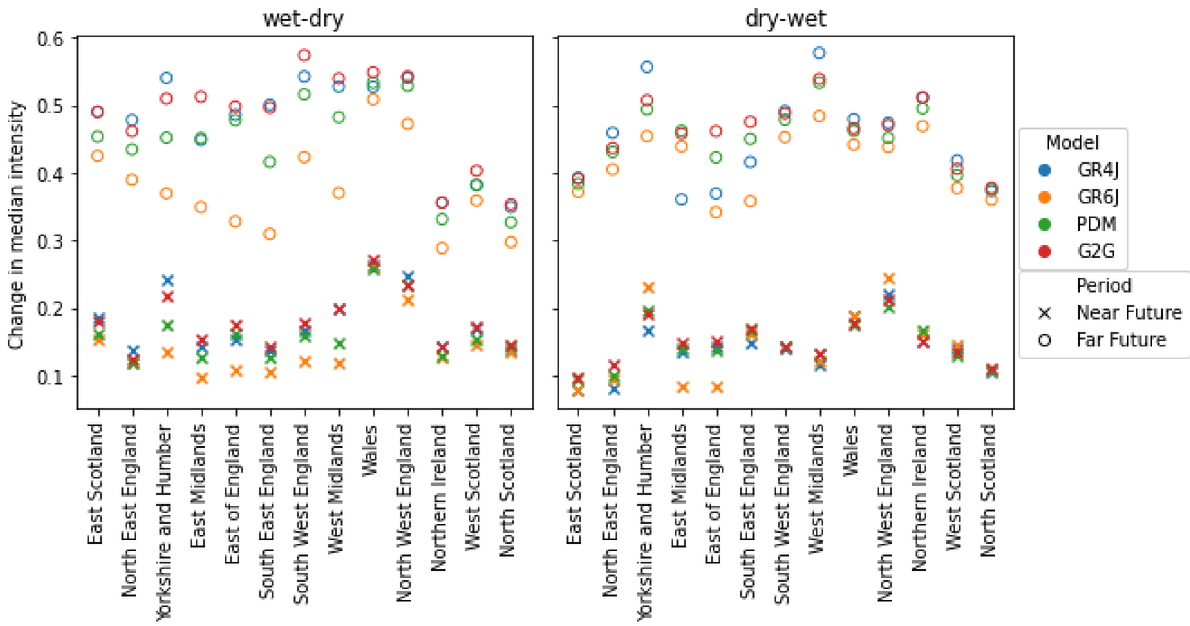

Figure R1 – Difference in median intensity of severe (threshold ±1.6) hydrological (SSI3) transitions relative to the Baseline period for Near Future and Far Future for each of the four hydrological models.

- The Discussion (line 386-387) flags that temperature/evaporative demand differences could explain hydrological vs. meteorological transition differences, and suggests SPEI as future work. Given that PET-driven changes are central to the future projections (warming climate, RCP8.5), this omission is now harder to justify as a minor limitation. The Swain et al. (2025, Nature Reviews Earth & Environment) review, which the authors already cite, explicitly builds its entire "hydroclimate whiplash" framework around SPEI rather than SPI precisely because "definitions incorporating evapotranspiration-related ('demand side') variables are increasingly favored," and demonstrates that potential evapotranspiration substantially amplifies whiplash increases over continents relative to precipitation alone, particularly at high latitudes. Given that Swain et al. report interannual whiplash increases of 52% over land at 3°C warming using SPEI, and that the present paper's RCP8.5 scenario corresponds to a comparable warming trajectory, the omission of an SPEI-based comparison is a substantive gap rather than a future-work afterthought. At minimum, the Discussion should explicitly frame the SPI/SSI-only approach as likely underestimating future transition magnitude/frequency changes relative to what an SPEI-based analysis would show, citing Swain et al.'s finding that evapotranspiration-inclusive metrics are "not detected in precipitation-only metrics."

We appreciate the concerns raised. We agree with the Swain et al. (2025) paper that using SPEI will result in different transition magnitudes compared to the sole use of SPI given the inclusion of evaporative demand, especially in a warming climate. In our paper, we use the standardised streamflow index (SSI) computed from simulated river flows, which does, in fact, already integrate precipitation and evapotranspiration, to analyse transitions in river flows on a seasonal scale. Our study explicitly aims to focus on hydrological transitions and we strongly feel that the SSI is a better indicator of seasonal river flow transitions, which is our priority due to their relevance for water resources. SPEI may be the better choice if we were interested in transitions with a particular impact (e.g. on agriculture). We explicitly compare SPI with SSI transitions for the exact reason the reviewer suggests; that precipitation-only metrics could miss crucial information when compared with indices that integrates precipitation and evapotranspiration (i.e. river flows and SSI).

Minor comments:

- Line 32-37: The list of "pseudonyms" (hydrological whiplash, hydroclimate volatility, drought-to-flood events) is useful, but could also mention "compound drought-flood events" (Matanó et al.) and "drought termination" (Parry et al.) explicitly here since both are discussed later. Could help orient readers to the terminological landscape upfront.

  We will look at the list of pseudonyms we include in the introduction to check they are representative of those we discuss in detail later in the manuscript, including adding 'compound drought-flood events'. However, we will likely not include 'drought termination' in this initial list as this is not necessarily a transition from drought to flood but rather recovery from drought to 'normal' conditions – we feel this distinction is already covered sufficiently when drought termination is discussed in line 110 of the original manuscript.

- Line 66-69: The assumption that "following a flood, sufficient water would remain stored to buffer the impacts of a subsequent drought" is asserted but not cited. Is there a reference for this being a stated assumption in the literature, or is this the authors' inference?

  We will update this to read, "following a flood, in some catchments sufficient water could remain stored to buffer the impacts of subsequent drought (e.g. Peskett et al., 2023)".

- Line 150-156: The description of SimObs vs SimRCM and their respective roles is clear, but it might help to add a sentence on the magnitude of "inherent biases" mentioned (line 155-156) — is there a citable RMSE/bias statistic from Hannaford et al. (2023) that could be quoted to give readers a sense of scale?

We will add “with median NSE and KGE2 >0.7 for all four models” to line 155. Overall model performance for the hydrological models used are presented in Figure 4 of Hannaford et al. (2023).

- Line 184-185: “we use the 3-month accumulation period (SPI-3 and SSI-3)” — please justify this choice more explicitly. A sensitivity check (or at least a citation) showing that SPI-1/SSI-1 or SPI-6/SSI-6 would yield qualitatively different transition counts/durations would strengthen the methodological robustness, especially given how central the “moderate/severe/extreme” thresholds and accumulation period are to all subsequent results.

  We chose to focus on the 3-month accumulation period as this best represents the seasonal scale transitions we are interested in for water resources. In our initial analysis, we compared mean transition metrics using 1- and 6-month accumulations in addition to 3-month but found the mean transition characteristics to be broadly similar (other than the number of transition events detected, which is higher for the lower accumulations as these are a less smoothed timeseries) and so chose not to include these in the manuscript to avoid having too many figures distracting from the main conclusions. We will however add mention of the alternative accumulations to line 184-185, add the below plots to the supplementary material and include a brief discussion of their implications in the revised manuscript.

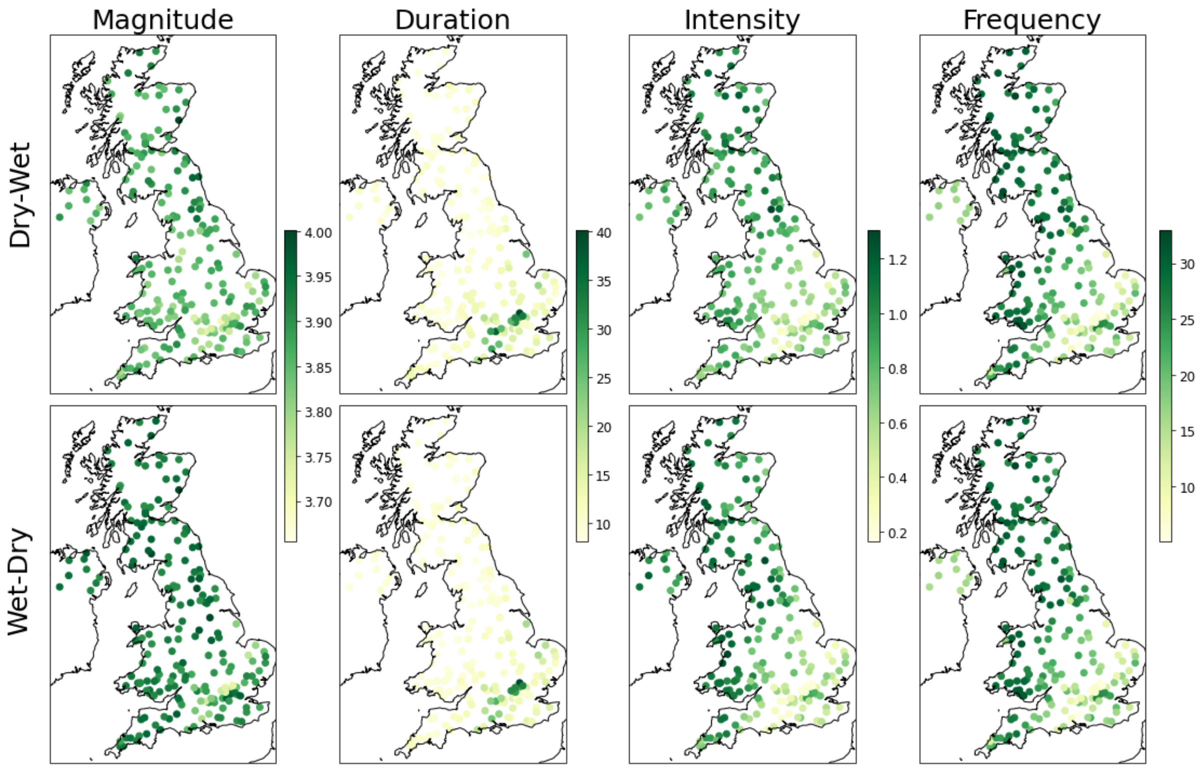

Figure R2 – As for Figure 5 in the original manuscript: Mean magnitude (no units), duration (months), intensity (no units) and frequency (transition events per decade) of severe (threshold ±1.6) dry-wet and wet-dry hydrological transitions in the Baseline period (1989-2018) of SimRCM using SSI1.

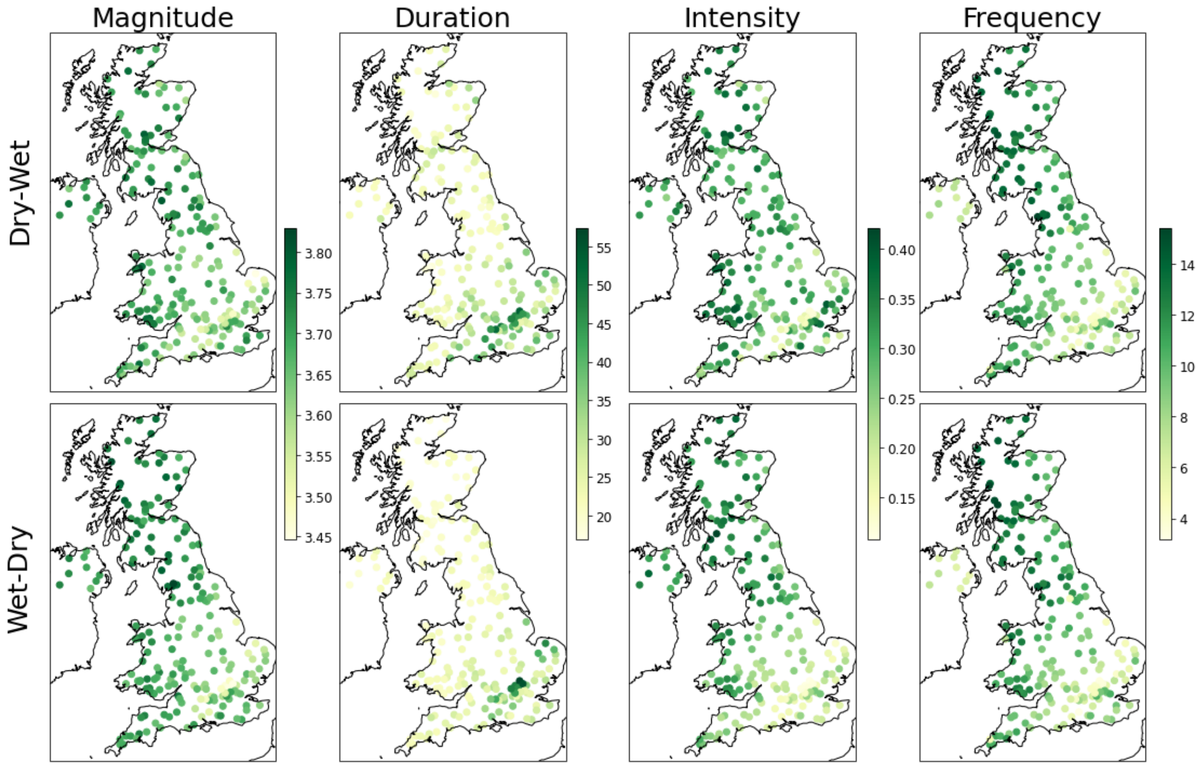

Figure R3 – As for Figure 5 in the original manuscript: Mean magnitude (no units), duration (months), intensity (no units) and frequency (transition events per decade) of severe (threshold ±1.6) dry-wet and wet-dry hydrological transitions in the Baseline period (1989-2018) of SimRCM using SSI6.

- Line 257-262: “A few catchments in the southeast show notably high duration and low intensity transitions… situated in the chalk aquifer north of London” — this is a nice mechanistic explanation. Could the authors quantify this more precisely, e.g., by overlaying baseflow index (BFI) or an aquifer productivity classification on Figure 5, or computing a correlation between BFI and transition duration across all 200 catchments? This would convert an anecdotal/visual observation into a more quantitative structural finding.

  Thank you for this suggestion, we will update the revised manuscript to include a scatterplot showing the correlation between mean transition duration and BFI.

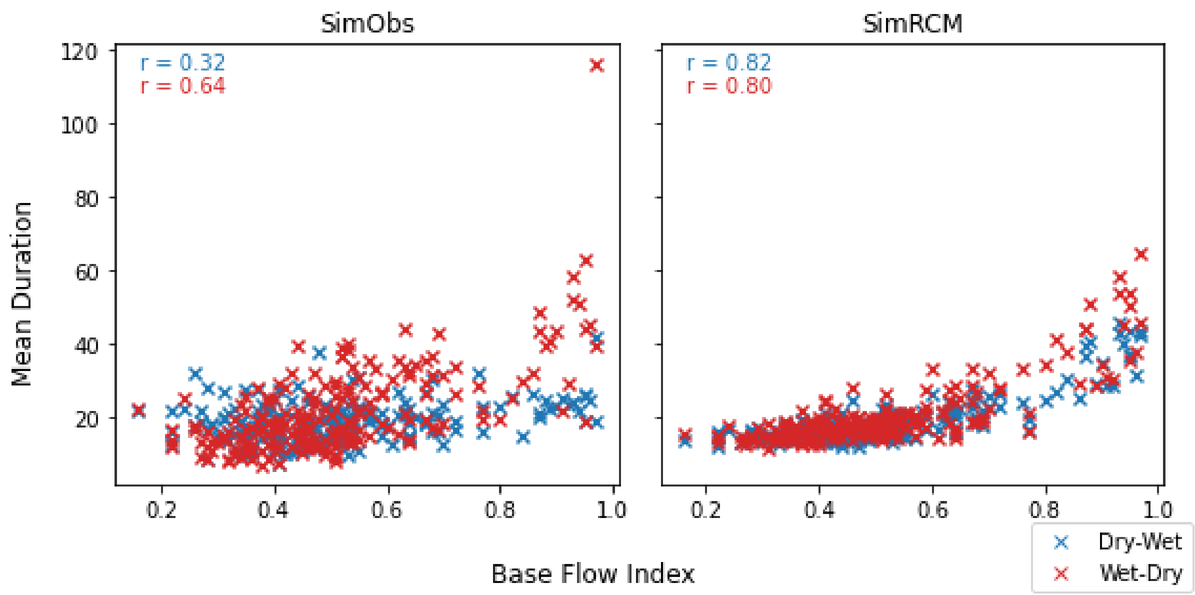

Figure R4 – Scatter plot between baseflow index (BFI, no units) and mean transition duration (months) across all 200 catchments for wet-dry (red) and dry-wet (blue) transitions using SimObs (left) and SimRCM (right). Correlation coefficients (r) are given within the plots and all shown values are significant at the 0.05 level.

- Line 422-423: "Infrastructure needs to be designed not only for more extreme or intense wet and dry events than currently specified, but also have flexibility built in to adapt for transitions" — this is a good high-level recommendation, but feels slightly generic; given the SE-specific finding about a shift from multi-annual to seasonal transitions (line 314-318), could the Discussion include a more targeted recommendation specific to chalk/groundwater-dominated catchment management (e.g., implications for conjunctive use schemes, aquifer recharge management)?

  Thank you for the suggestion to better link our results with our recommendations, we agree that the current recommendation is rather generic. We will update the revised manuscript with more detail here and further discussion on the different management measures that will be needed for different regions of the UK given our results.

- Line 488-492 (Data Availability): Good that eFLaG and SPI/SSI source data are referenced, but given the extensive transition-identification methodology developed here, would the authors consider releasing the derived transition event catalogue (onset/end dates, magnitude, duration, intensity per catchment/scenario) as a data product? This could substantially increase the paper's value for follow-on UK water-management research .

  Thank you for the suggestion for increasing the potential value of our paper. We will publish the SPI and SSI data on zenodo and also make the dataset of identified transitions available and update the data availability statement accordingly. We will also add a code availability statement for the code used in identifying and characterising the transitions.

References:

Hannaford, J., Mackay, J. D., Ascott, M., Bell, V. A., Chitson, T., Cole, S., Counsell, C., Durant, M., Jackson, C. R., Kay, A. L., Lane, R. A., Mansour, M., Moore, R., Parry, S., Rudd, A. C., Simpson, M., Facer-Childs, K., Turner, S., Wallbank, J. R., Wells, S., and Wilcox, A.: The enhanced future

Flows and Groundwater dataset: development and evaluation of nationally consistent hydrological projections based on UKCP18, Earth Syst. Sci. Data, 15, 2391–2415, https://doi.org/10.5194/essd-15-2391-2023, 2023.

Peskett, L. M., Heal, K. V., MacDonald, A. M., Black, A. R., and McDonnell, J. J.: Land cover influence on catchment scale subsurface water storage investigated by multiple methods: Implications for UK Natural Flood Management, J. Hydrol. Reg. Stud., 47, 101398, https://doi.org/10.1016/J.EJRH.2023.101398, 2023.

Swain, D. L., Prein, A. F., Abatzoglou, J. T., Albano, C. M., Brunner, M., Diffenbaugh, N. S., Singh, D., Skinner, C. B., and Touma, D.: Hydroclimate volatility on a warming Earth, Nature Reviews Earth & Environment 2025 6:1, 6, 35–50, https://doi.org/10.1038/s43017-024-00624-z, 2025.

Yang, Y., Villarini, G., and Yang, L.: Spatiotemporal Dynamics of Hydrological Whiplash Events Across the Contiguous United States, Earths Future, 14, e2025EF008000, https://doi.org/10.1029/2025EF008000;WEBSITE:WEBSITE:AGUPUBS;WGROUP:STRING:PUBLICATION, 2026.