Understanding Drought Risks under Climate Change

Srinidhi Jha and the Water Resources and Drought Group

14.07.2026

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Some recent examples of droughts worldwide

UNITED KINGDOM

2025 had **hottest summer** on record and **driest spring** since **1893**

Severe water shortages and ecological impacts

SPAIN

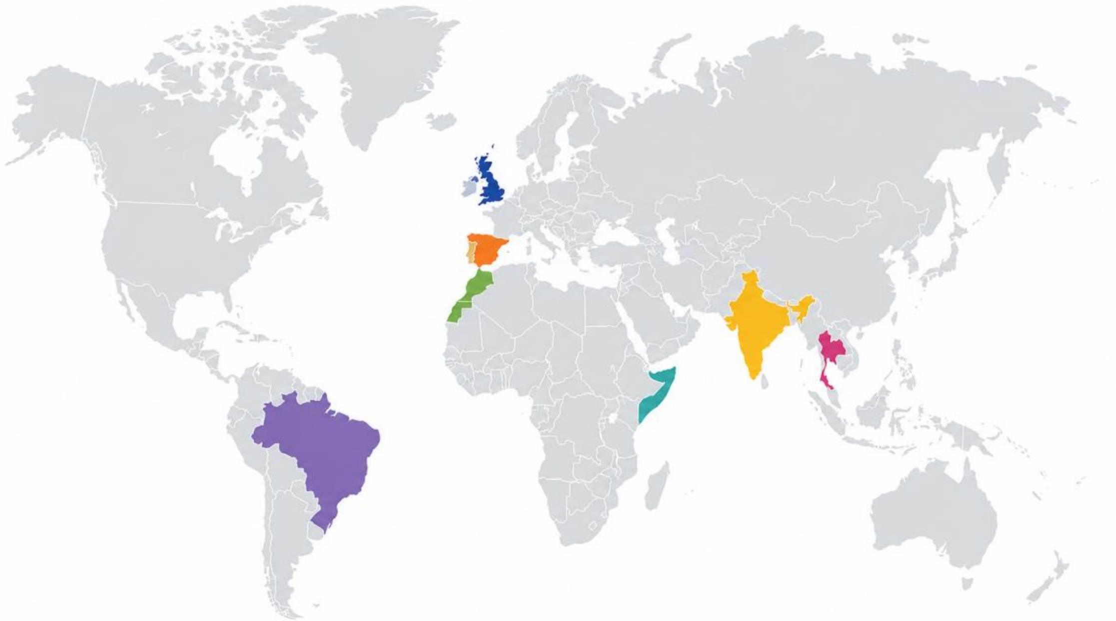
In 2023 olive harvest dropped by **50%** causing double prices

Tourism sector was badly hit

AMAZON BASIN

Record low river levels and **mass fish mortality** in 2023

Community isolated due to lack of navigation



75% of the world population is projected to be affected by drought by 2050. (UNCCD, 2022)

MOROCCO

Sheep population declined by **38%** in 2025 prompting a royal plea to cancel Eid Sacrifices

60% reduction in cereal production

SOMALIA

43,000 people died in 2022 due to drought linked huger

4.4 million people face crisis level food insecurity as of 2025

SOUTHEAST ASIA

Rice, sugar and coffee production affected disrupting supply chain.

Sugar prices increased in USA by **~10%** in 2023-2024

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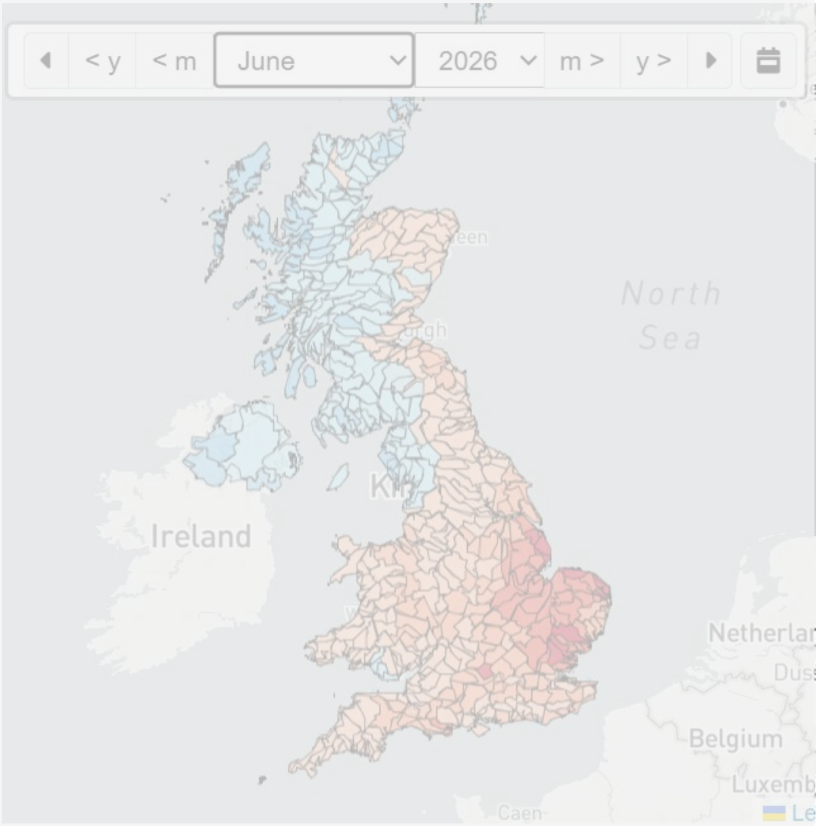
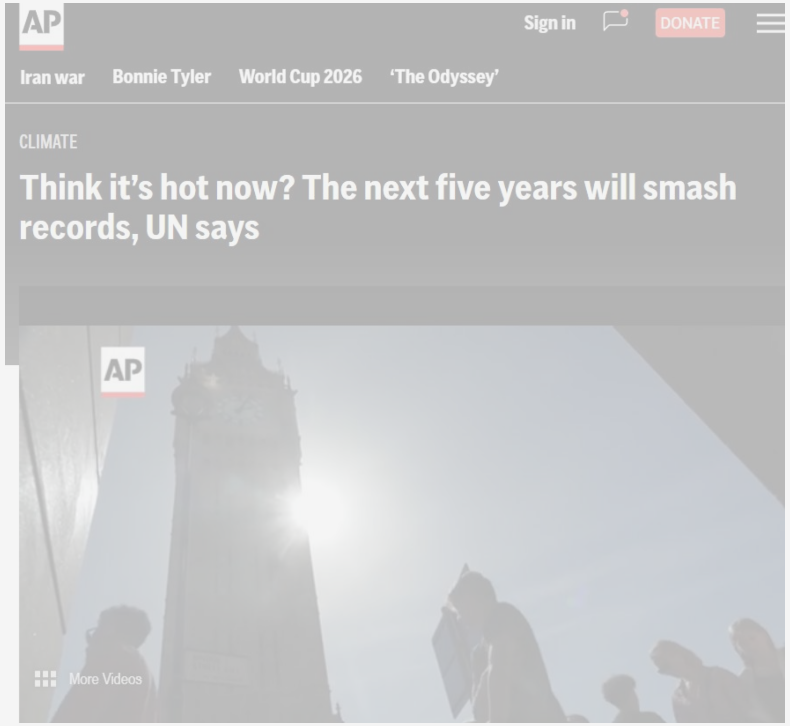
Understanding droughts past, present and future are key to improving management and mitigating impacts

PAST

PRESENT



FUTURE



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The story of year 2025

2025 DROUGHT IN ENGLAND – HOW IT DEVELOPED

JAN	FEB	MAR	APR	MAY	JUN
Wet month, water levels healthy	Rainfall declined, soils drying	Very dry month, flows falling	Dry weather continued, soil moisture drops	Driest spring since 1893, first drought declared	Record warm June, reservoir levels hit record low

JUL	AUG	SEP	OCT	NOV	DEC
Sixth dry month, water resources decline	Driest August since 2003, drought peaks	Rainl returns, rivers improve, reservoirs still low	Recovery uneven, levels below normal	Heavy rain improves rivers and reservoirs	Further recovery, some levels still low

WET WINTER → DRY SPRING → HEATWAVE SUMMER → AUTUMN RAIN → SLOW RECOVERY

Driest spring in England since **1893.**

46 drought permits granted to water companies.

15 key reservoirs were below 50% full at the end of September 2025.

~9 MILLION people affected by hosepipe bans.

20% of England's canal network was temporarily closed.

Sunniest year on record for **England.**

Warmest year on record for **England.**

Hottest summer, around **1.69°C** above the long-term average for England.

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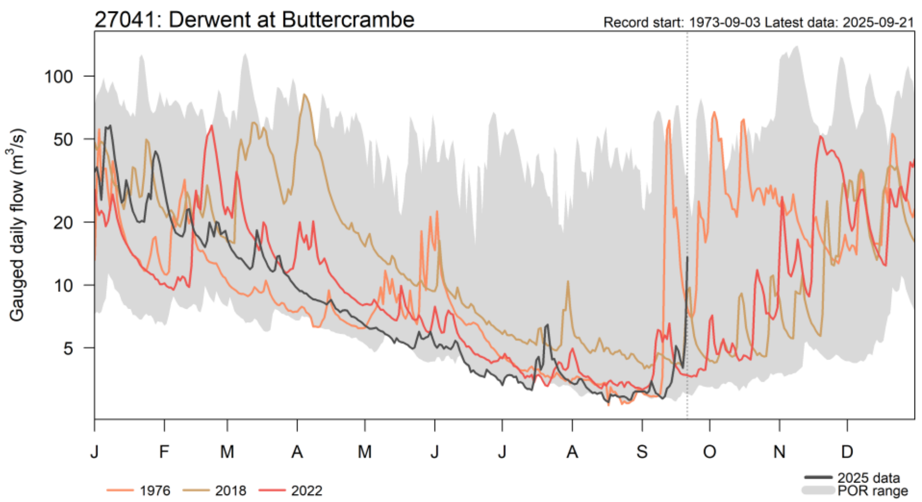
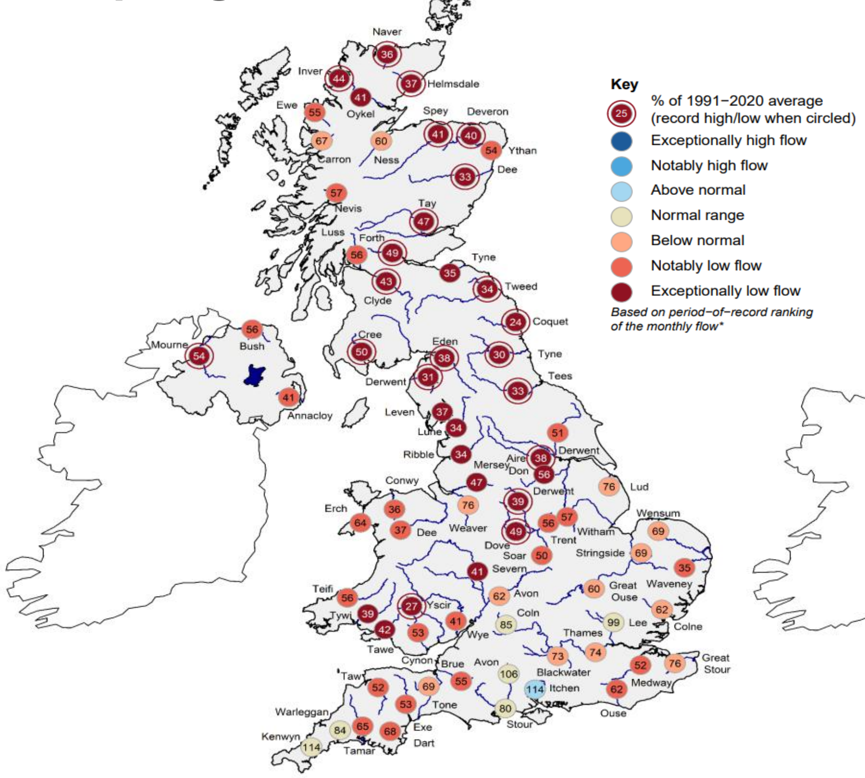
How severe was the 2025 UK drought - a look back at spring/summer

River flows

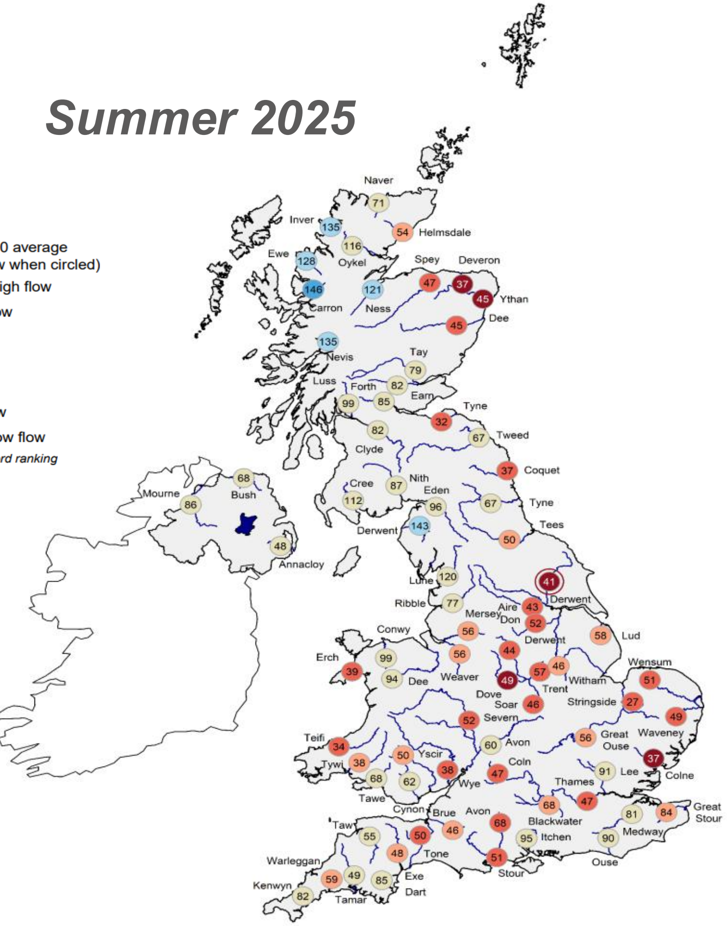


Spring 2025



Lowest spring flows on record for many rivers in northern Britain

Summer 2025



Notably or exceptionally low summer flows
Especially in the east

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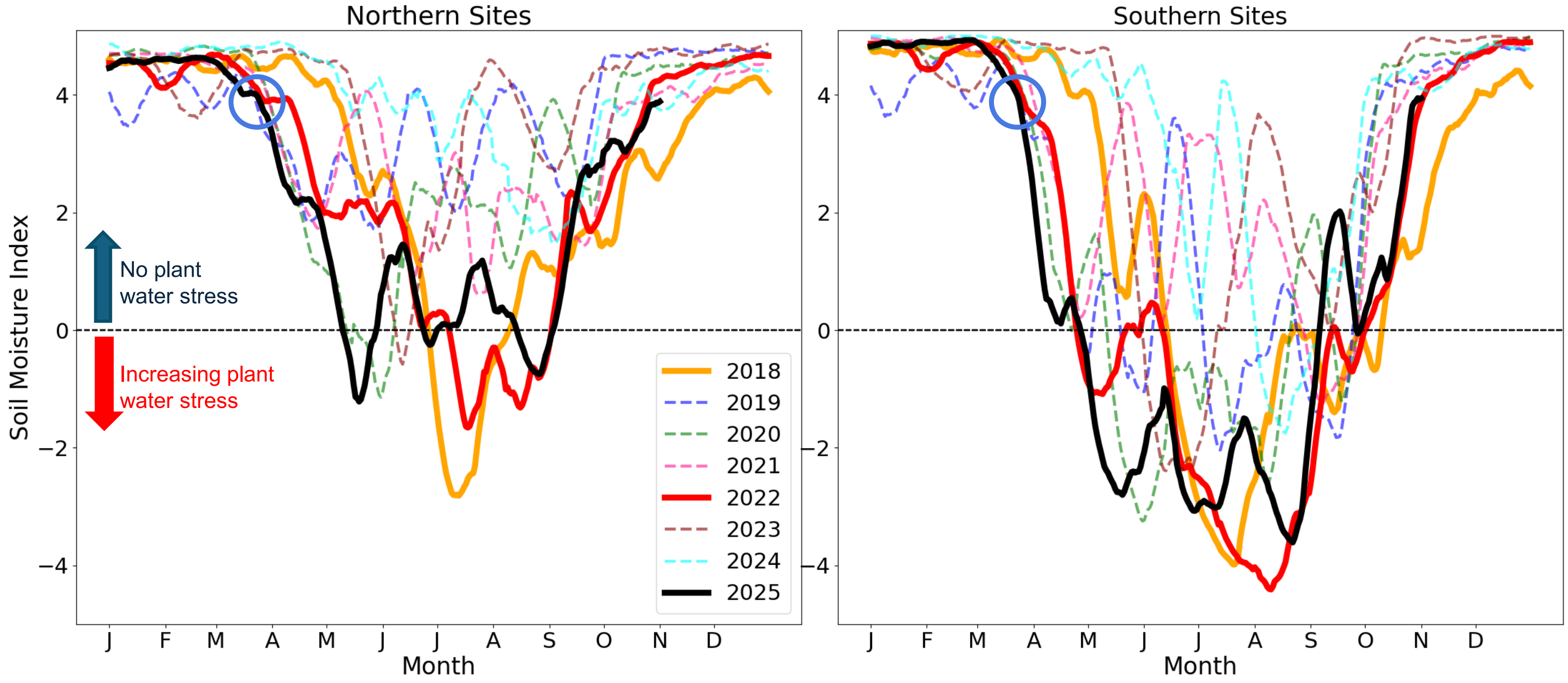
How severe was the 2025 UK drought - a look back at spring/summer

Soil Moisture: drought index

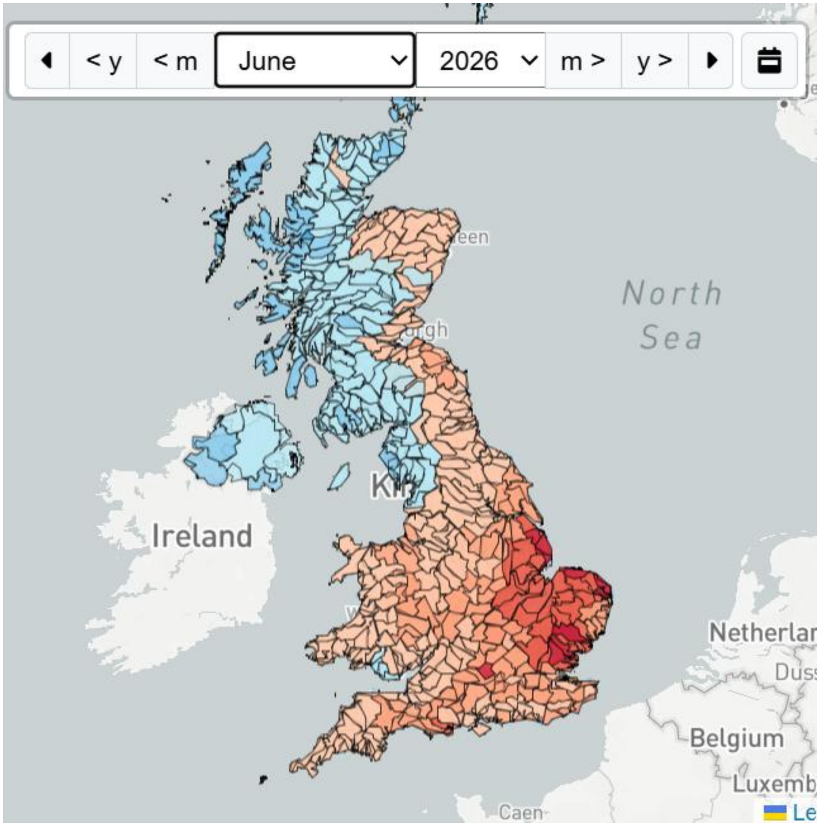


Drought 2025 has onset already in late March, with drought conditions starting in late April/ early May and sustaining throughout the summer. Southern sites are particularly affected with drought conditions similar to 2022

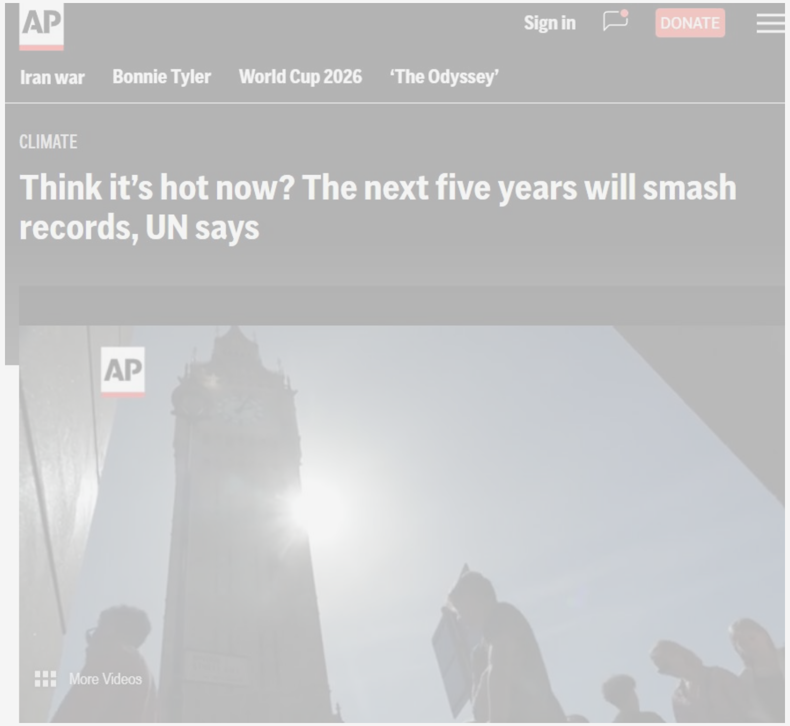
Understanding droughts past, present and future are key to improving management and mitigating impacts

PAST

PRESENT



FUTURE



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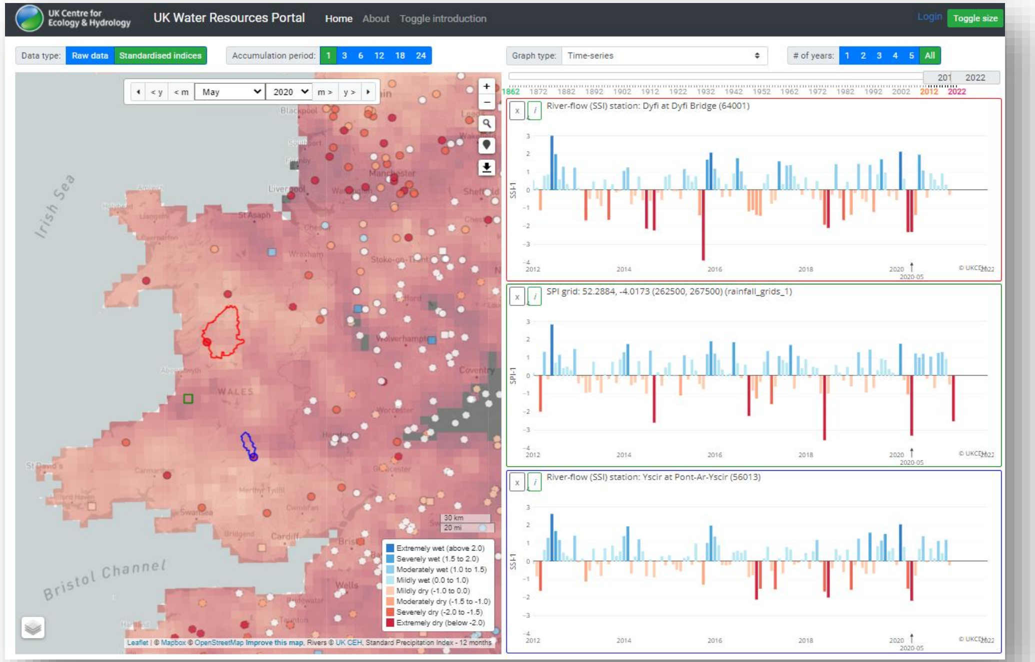
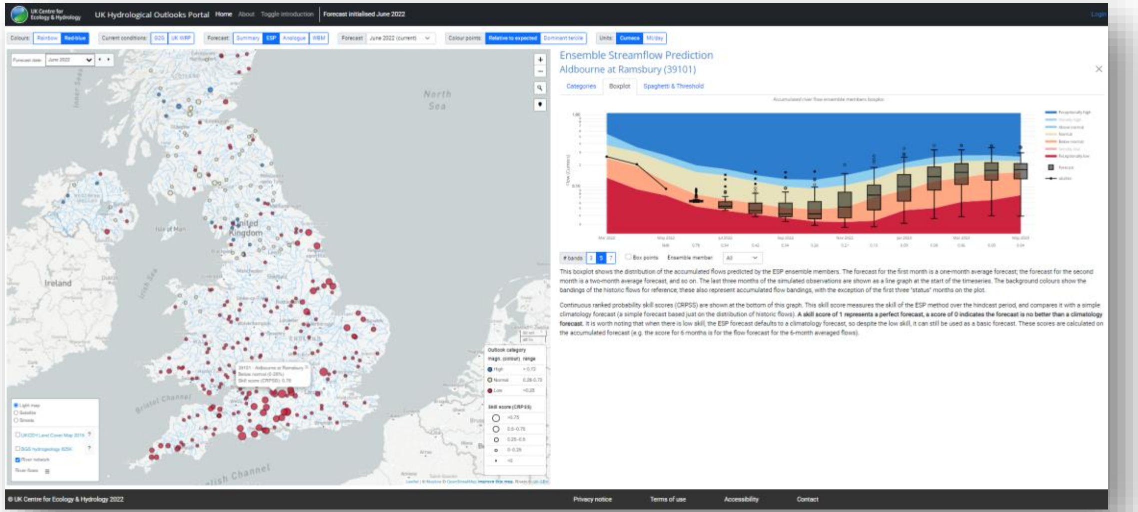
Drought monitoring and early warning systems

The UK Water Resources Portal (2020 onwards)



https://ukwrp.ceh.ac.uk/

The Hydrological Outlook UK (2013 onwards)



https://ukho.ceh.ac.uk/

Near-real-time, interactive access to rainfall, river flows, soil moisture, groundwater, **drought indicators**

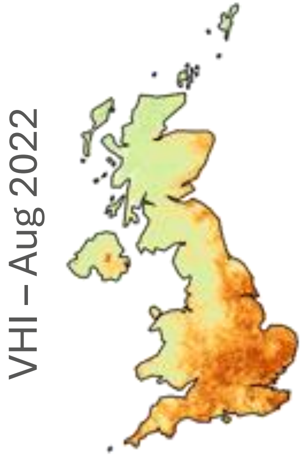
Seasonal forecasts for river flows and groundwater for the next 1 – 3 months (and beyond)

National Hydrological Monitoring Programme

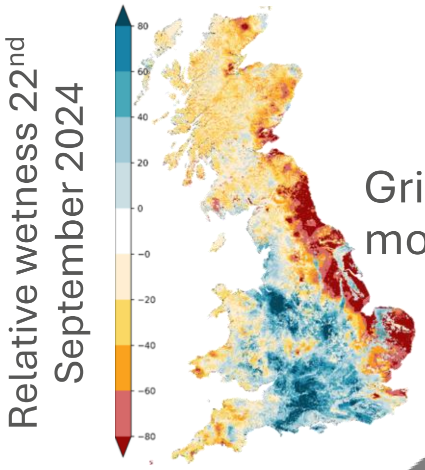
UK Hydrological Outlook

National River Flow Archive

UK Water Res. Portal: planned and future developments



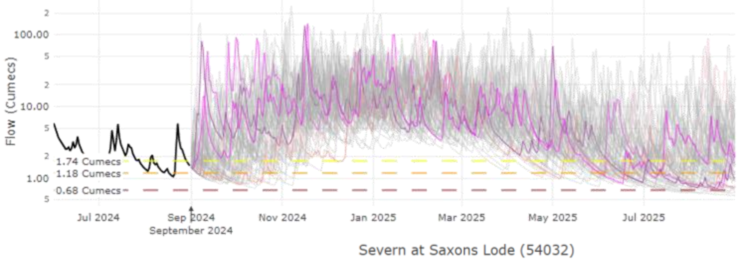
Monthly updates of Vegetation Indices (e.g. VCI, VHI, TCI)

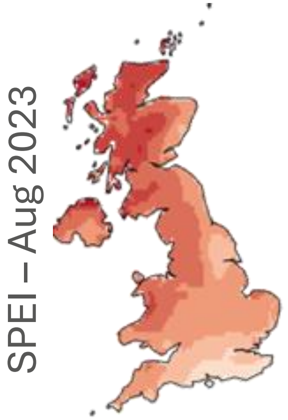


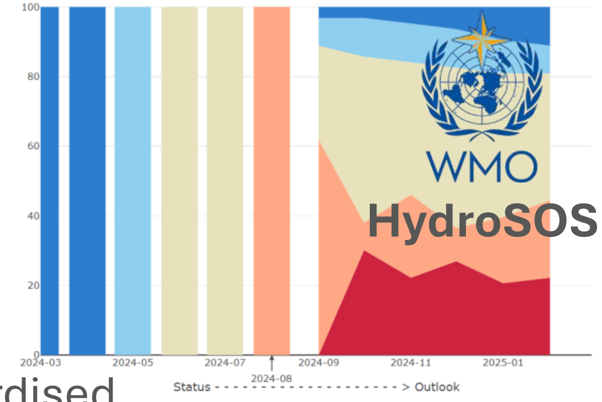
Gridded soil moisture

Operational drought impact forecasts

Integrated monitoring & seasonal forecasts

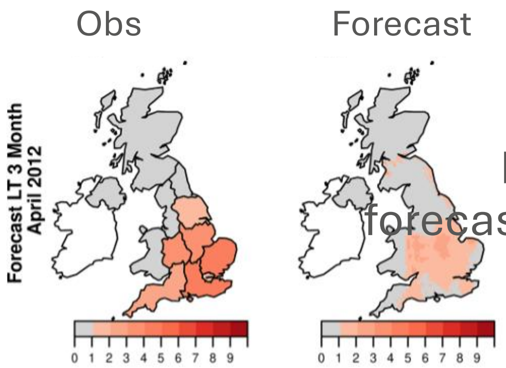






wmohydrosos.ceh.ac.uk/portal

Monthly updates of Standardised Precipitation Evapotranspiration Index (SPEI)



Develop impact forecasting framework

Bulut et al. (2025). Toward early warning of drought impacts: a framework for predicting drought impacts in the UK. NHESS

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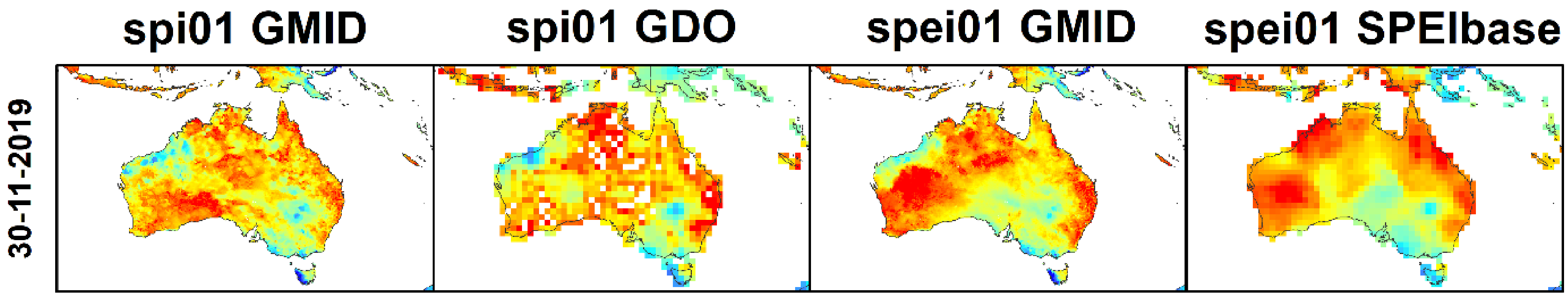
Global Multi-Index Drought (GMID): a high-resolution dataset from 1980 to near present

Other data sets	GMID
Low spatial and temporal resolution	High spatial (0.1º) and temporal resolution (weekly)
Focus on one drought index	Includes 5 drought indices: SPI, SPEI, EDDI, SEDI, SVPDI* at 1-12 month time scales
Based on a single methodology	Based on a flexible methodology
Data is often not updated	Will be updated annually



Available at EIDC!
Noguera et al. 2025

NATIONAL CAPABILITY FOR GLOBAL CHALLENGES
International science for net zero plus

* Standardised Precipitation Index, Standardised Evapotranspiration Index, Evaporative Drought Demand Index, Standardised Evapotranspiration Deficit Index, Standardised Vapor Pressure Index

Slide: Ivan Noguera

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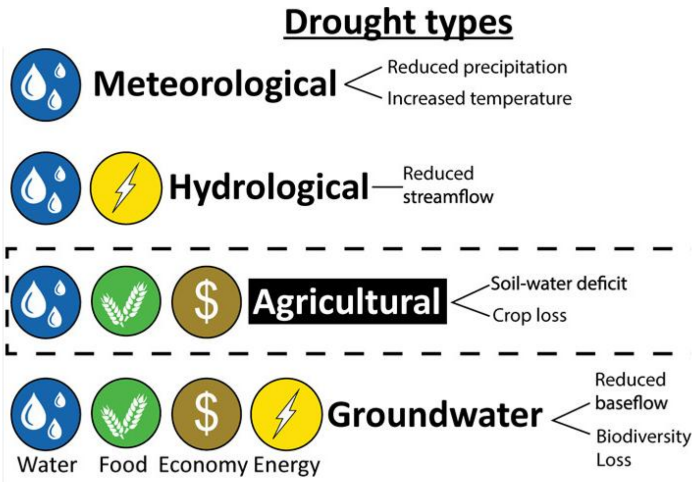
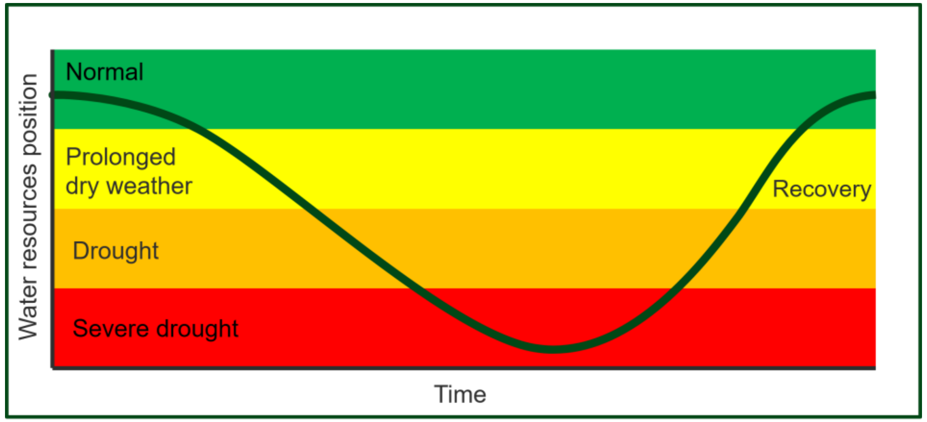
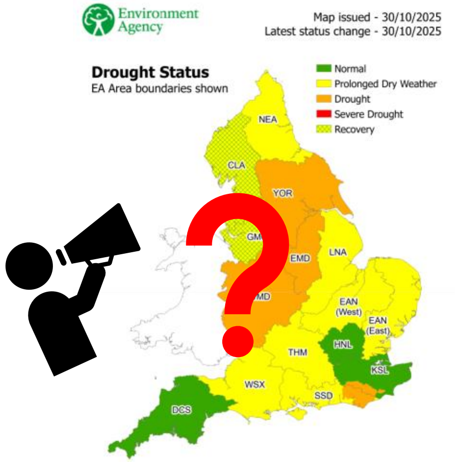
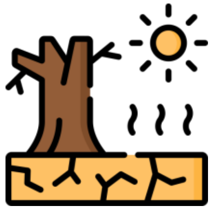
Environment agency drought alert system

Indicators → **Assessment/Detection** → **Sometimes False Alerts**









Drought is observable on ground

But NOT on paper

Action or No Action?

Human Decision Making?

What if MACHINE could LEARN from how EA experts think?

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Environment agency drought alert system

Experts' opinion play an important role in declaring drought alerts.

Survey with experts:

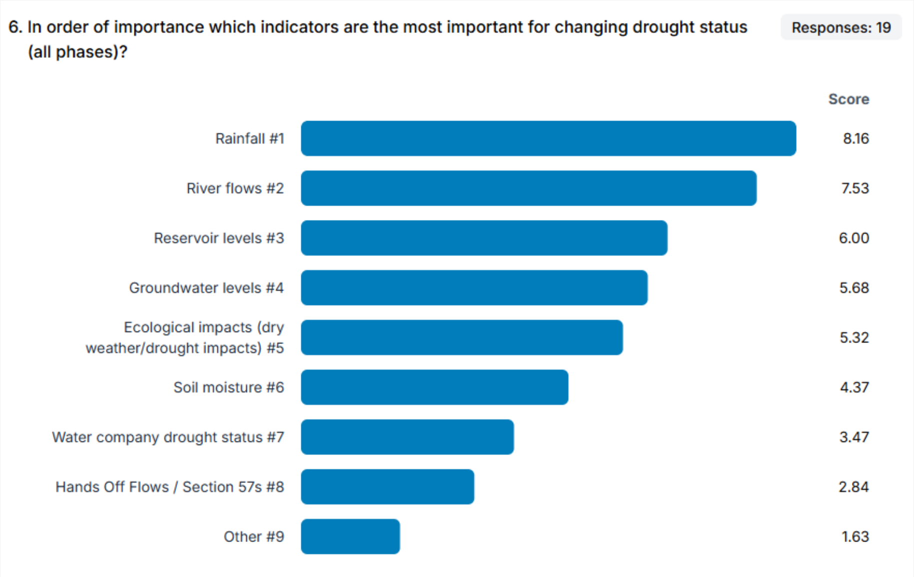
About indicators

About temporal characteristics

About spatial characteristics

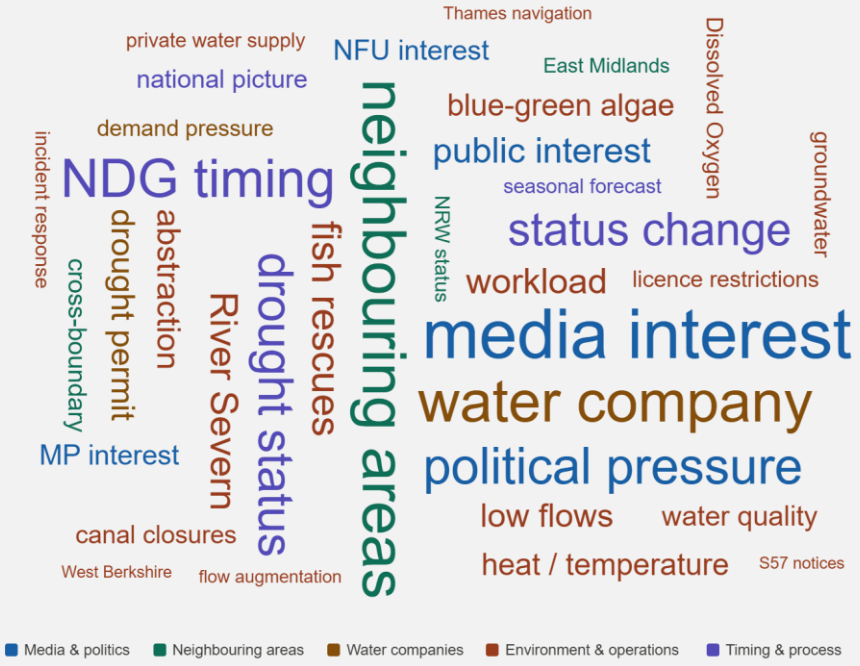
Other factors

Which indicator to follow?



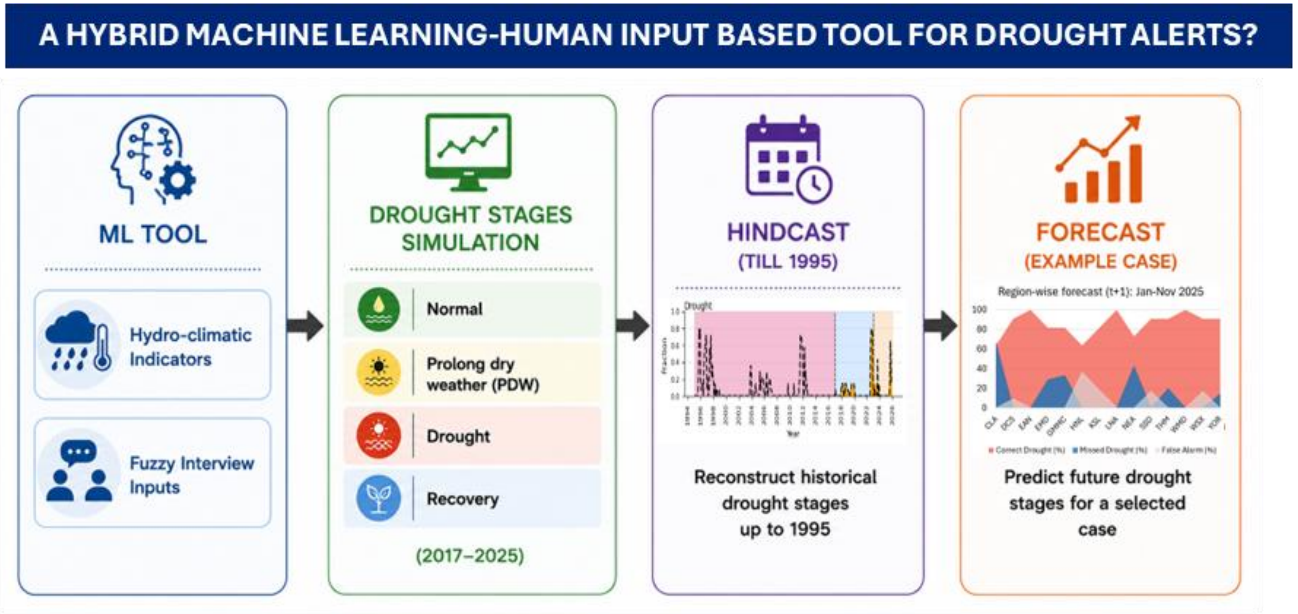
(both figures are based on EA-wide survey only)

Which factor to consider?

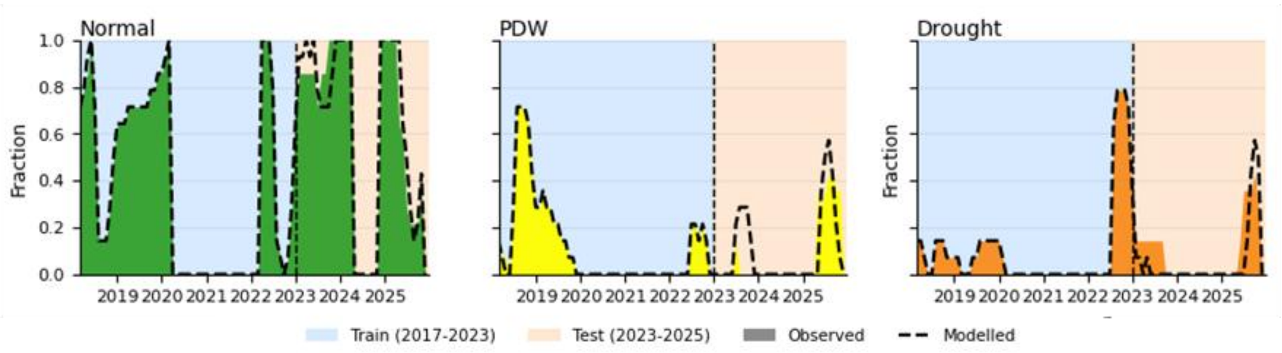


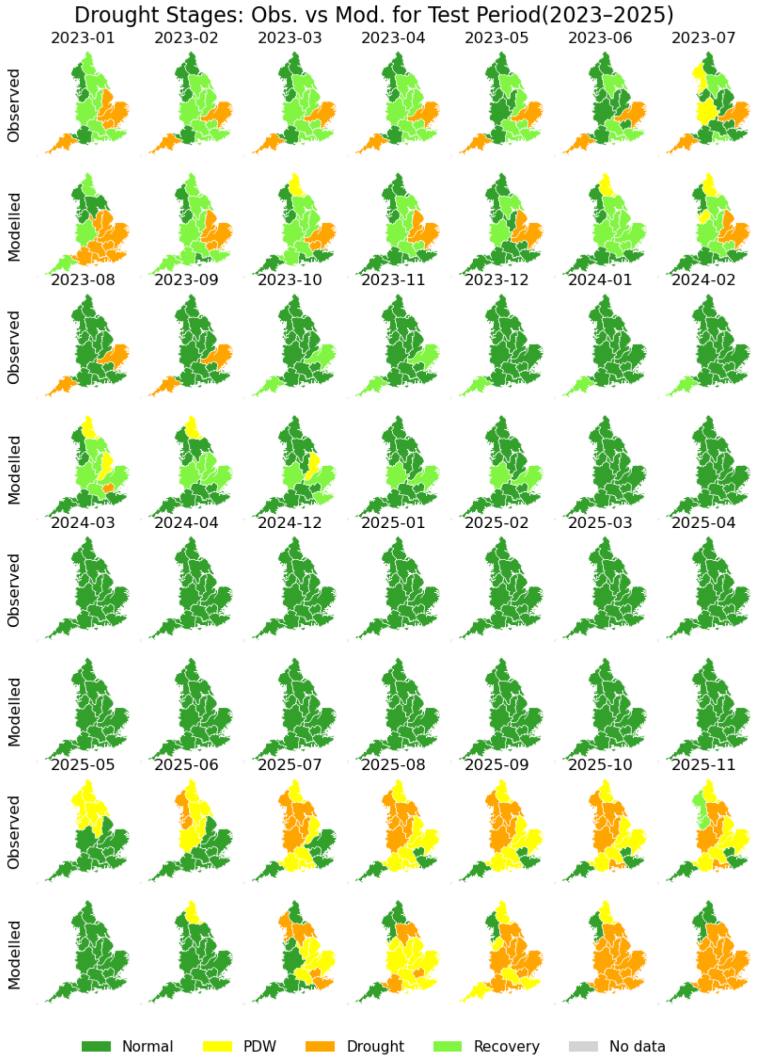
Words sized by how frequently it was mentioned across the responses, and colours are grouped by theme

Machine learning to improve EA drought alert system



Fraction of areas per year in different drought stages for training and test period





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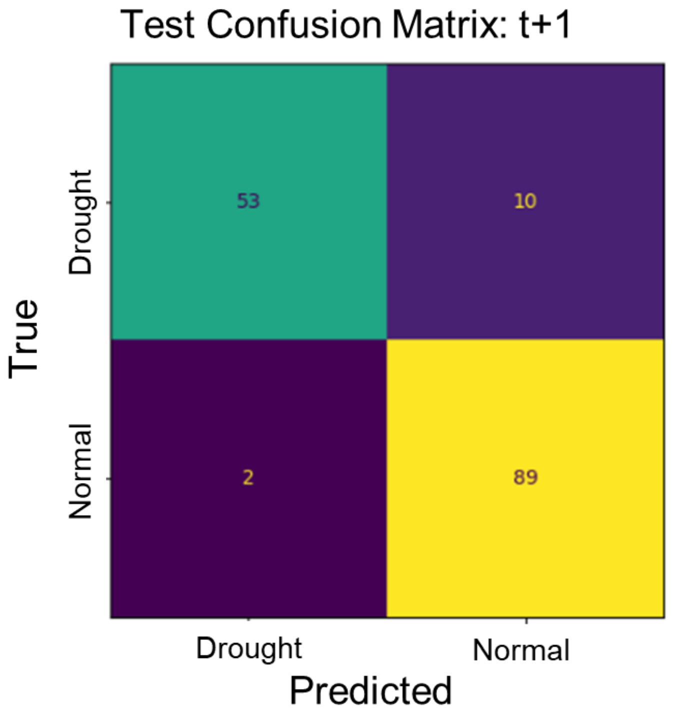
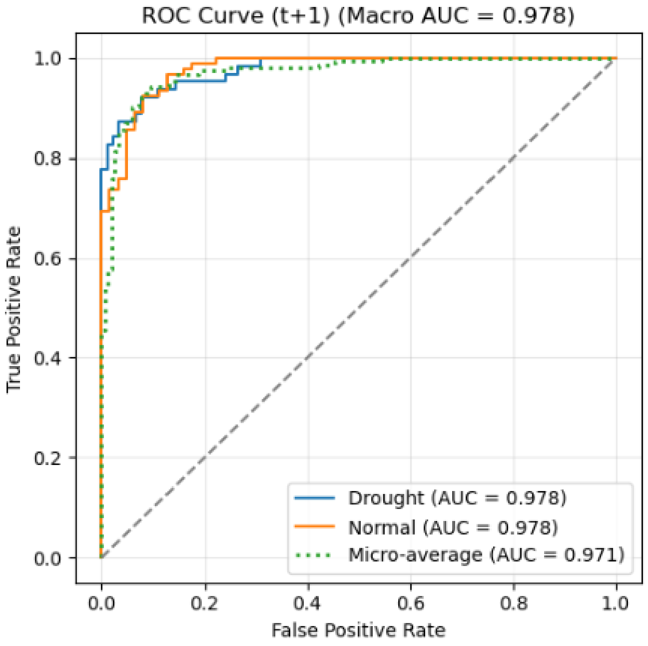
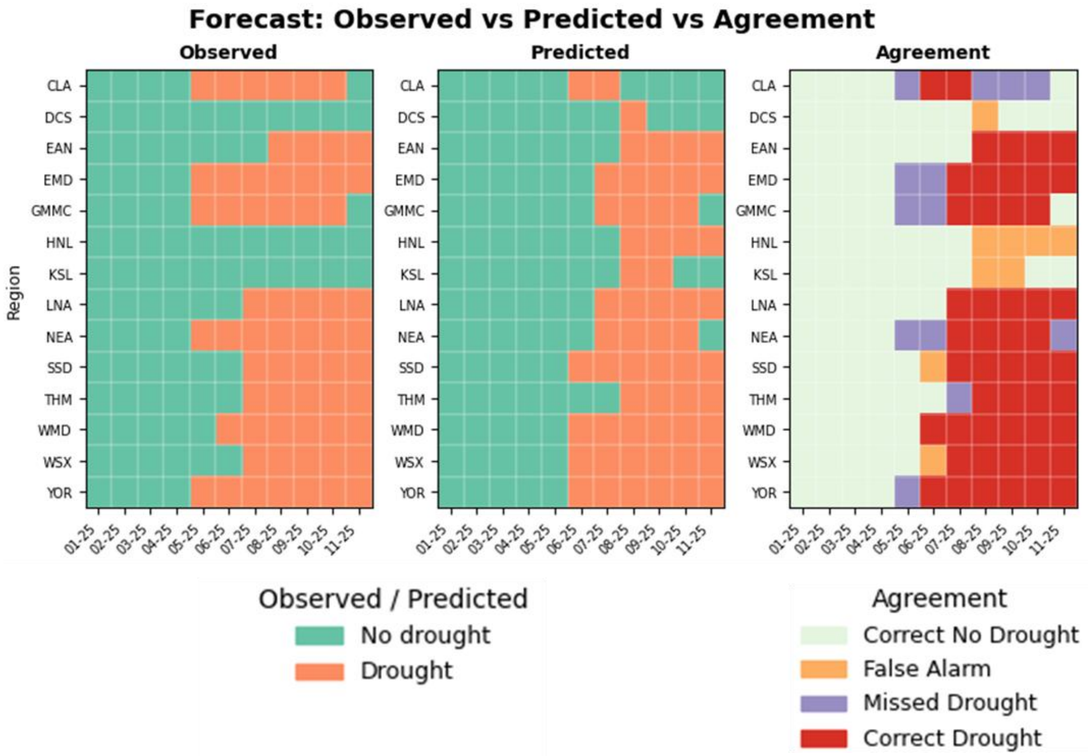
Forecast results over all areas for: Jan 2025-Nov 2025







	precision	recall	f1-score
Drought	0.96	0.84	0.90
No Drought	0.90	0.98	0.94

- For 154 data points (14 areas x 11 months), 63 were drought months, 91 were normal months.
- **Out of 63 actual drought events**, the model got **53 right** and **missed 10**.
- Out of **91 actual no-drought**, the model got **89 right** and gave **2 false alarms.**

But understanding the impacts of droughts is the key to effective and proactive drought management


Overview

Drought indicators revisited: the need for a wider consideration of environment and society

Sophie Bachmair,[1*] Kerstin Stahl,[1] Kevin Collins,[2] Jamie Hannaford,[3] Mike Acreman,[3] Mark Svoboda,[4] Cody Knutson,[4] Kelly Helm Smith,[4] Nicole Wall,[4] Brian Fuchs,[4] Neville D. Crossman[5] and Ian C. Overton[5]

Sophie Bachmair et al., WIRES 2016


commentary

Drought in the Anthropocene

Anne F. Van Loon, Tom Gleeson, Julian Clark, Albert I. J. M. Van Dijk, Kerstin Stahl, Jamie Hannaford, Giuliano Di Baldassarre, Adriaan J. Teuling, Lena M. Tallaksen, Remko Uijlenhoet, David M. Hannah, Justin Sheffield, Mark Svoboda, Boud Verbeiren, Thorsten Wagener, Sally Rangecroft, Niko Wanders and Henny A. J. Van Lanen

Drought management is inefficient because feedbacks between drought and people are not fully understood. In this human-influenced era, we need to rethink the concept of drought to include the human role in mitigating and enhancing drought.

Anne van Loon et al., Nat. Geos, 2016

"Impacts are often used to define drought but this is normally done in hindsight, rather than impacts being actively monitored..."
(*Hannaford et al. Weather, Climate & Society, 2019*)

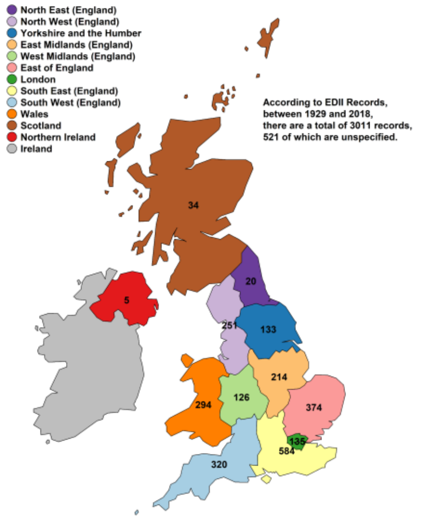
The DrIVER project: advancing impact-focused monitoring on three continents, 2014 - 2017

driver

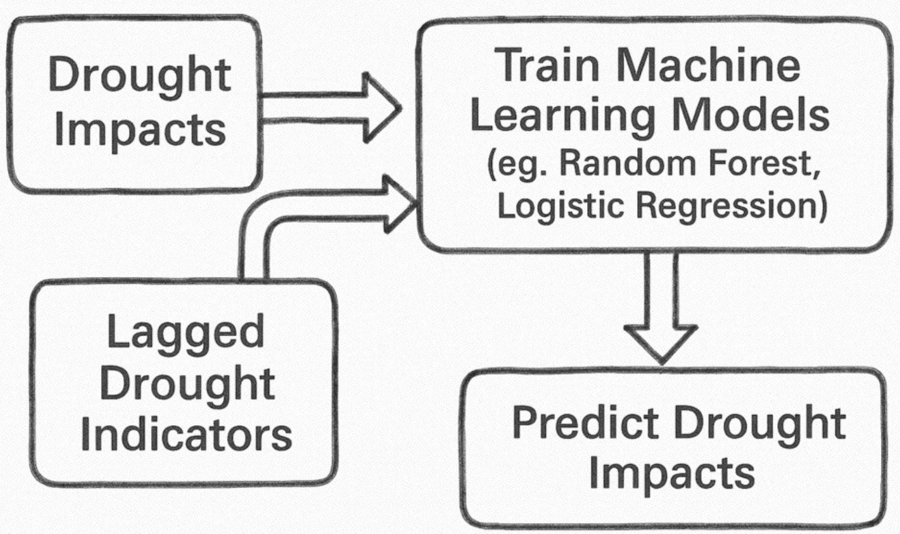
Predicting drought impacts on the environment and agriculture: IRIS and MONARK

IRIS: Indicators to Impacts for Drought Surveillance

Impact data:
European database of impact reports
Stahl et al., 2016
NHESS

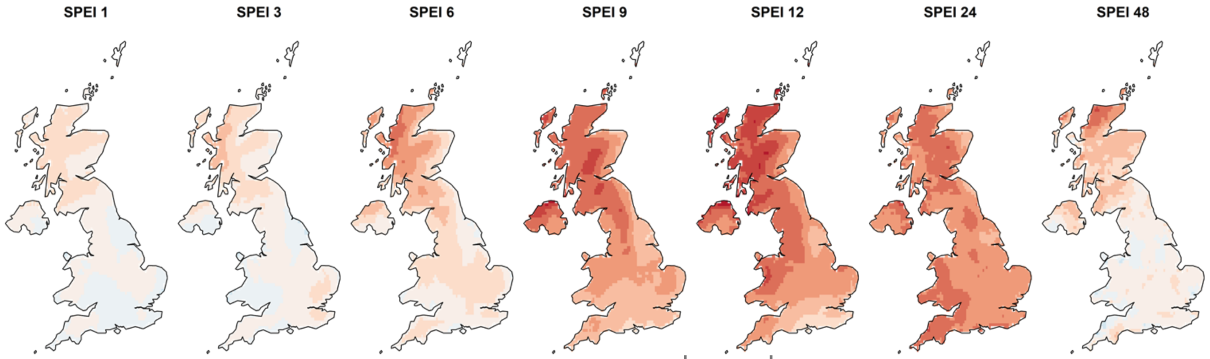


EDII impact reports for the UK (NUTS1 regions)



MONARK: Monitoring Agricultural drought impacts in the UK

Impact data: High resolution crop yield data



IRIS

AgZero+
Towards sustainable, climate-neutral farming

https://www.ceh.ac.uk/our-science/projects/iris

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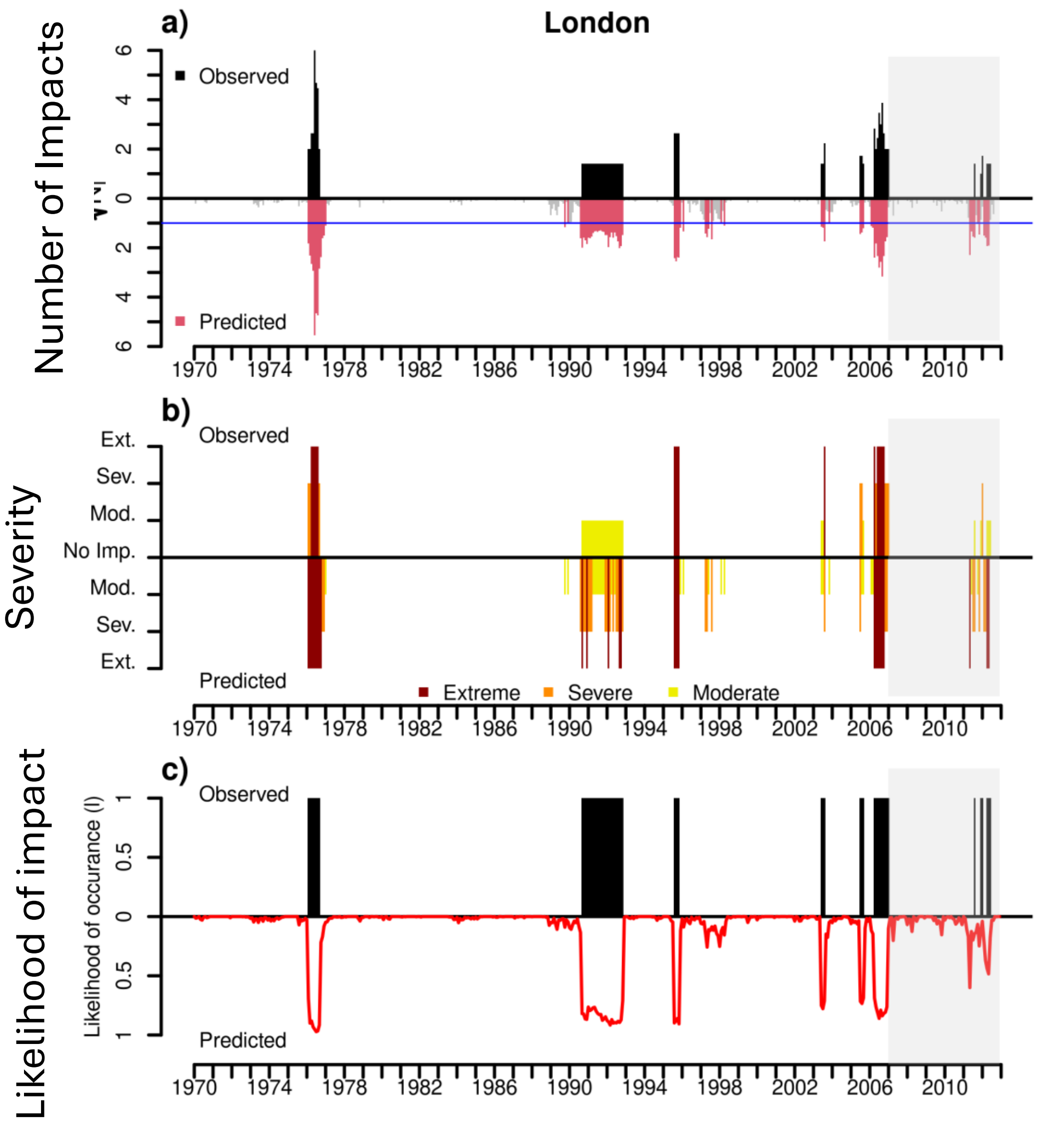
Results

- **Grey-shaded areas** show periods where the model is applied to data not used for training
- Raw number of impacts converted to severity categories
- Model accurately predicts impact timing
- Some observed events missed, indicating possible false negatives



[Bulut et al., 2025 NHESSD](#)

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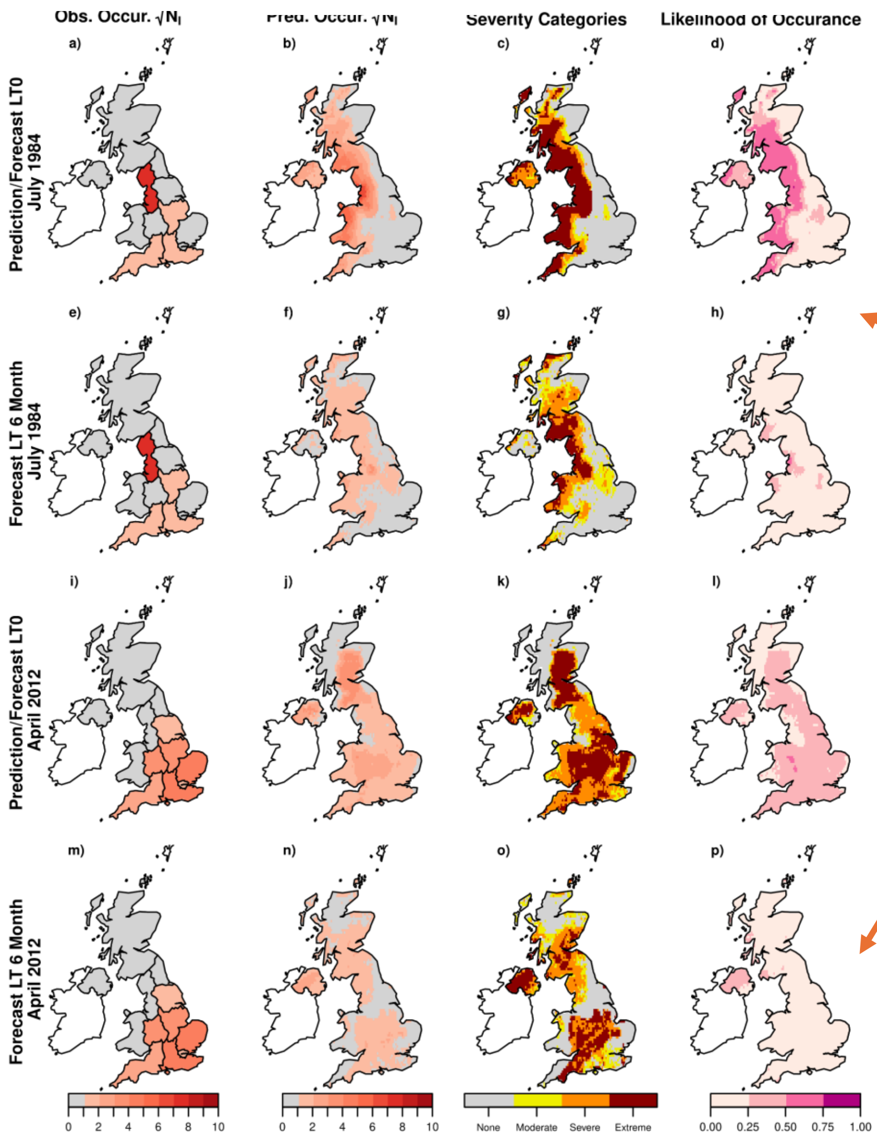
Results

- Accurate short-term forecasts, including unseen events like April 2012.
- Validation limited in northern UK, highlighting data gaps in underreported regions.
- Forecast confidence drops at 3-month lead, reflecting increased uncertainty.
- Severity remains predictable at 6-month lead, despite lower spatial accuracy.

Observed Occurrences | **Predicted Occurrences** | **Predicted Severity** | **Predicted Likelihood**



Lead Time 6 Months

IRIS

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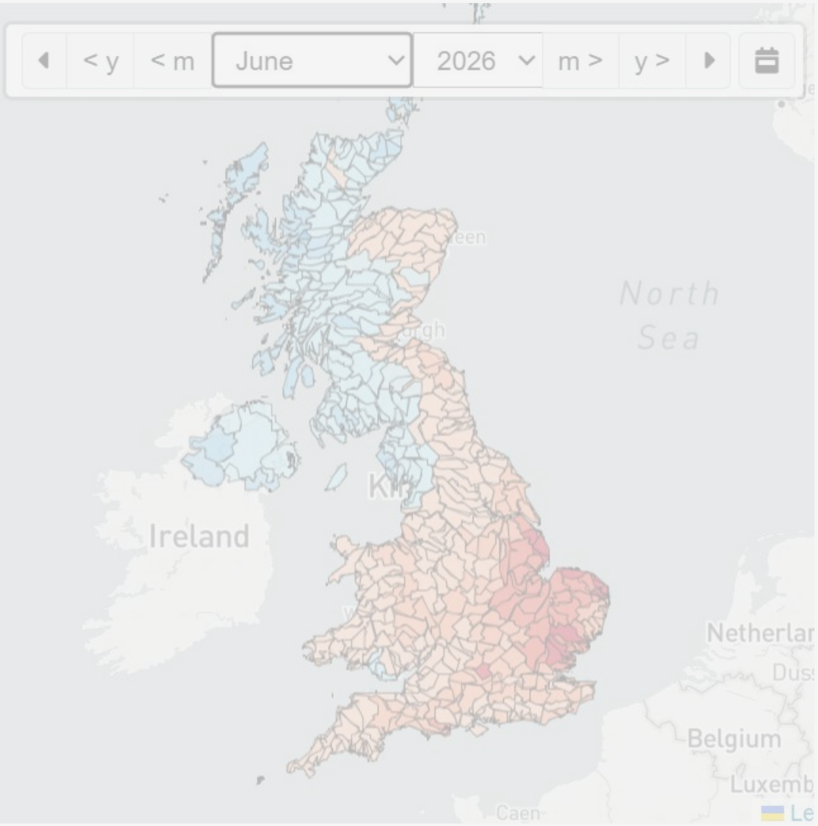
Understanding droughts past, present and future are key to improving management and mitigating impacts

PAST

PRESENT



FUTURE

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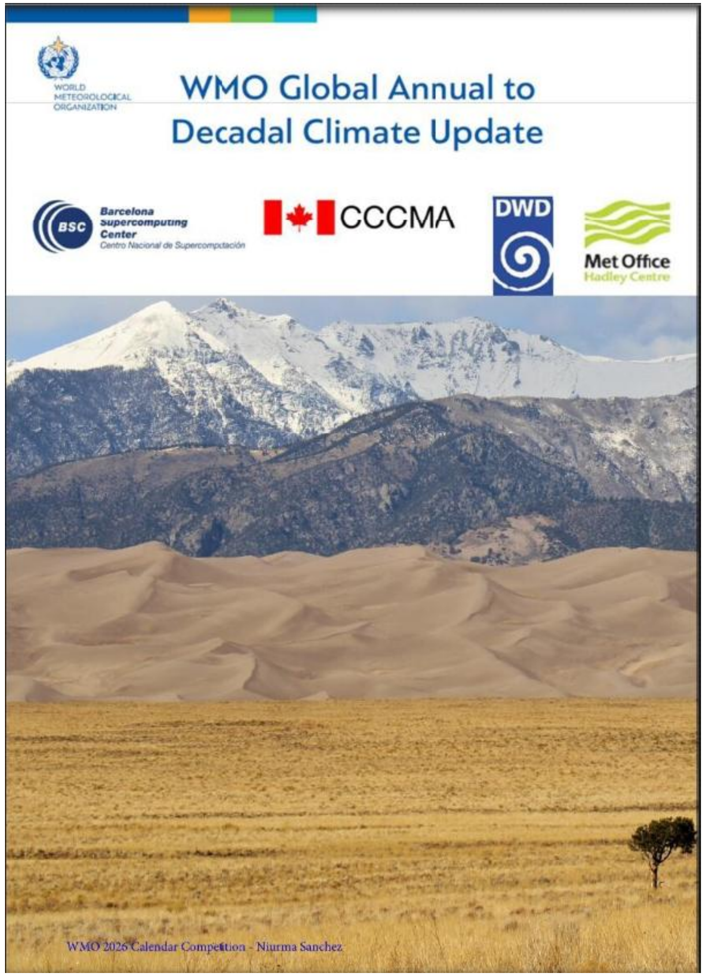
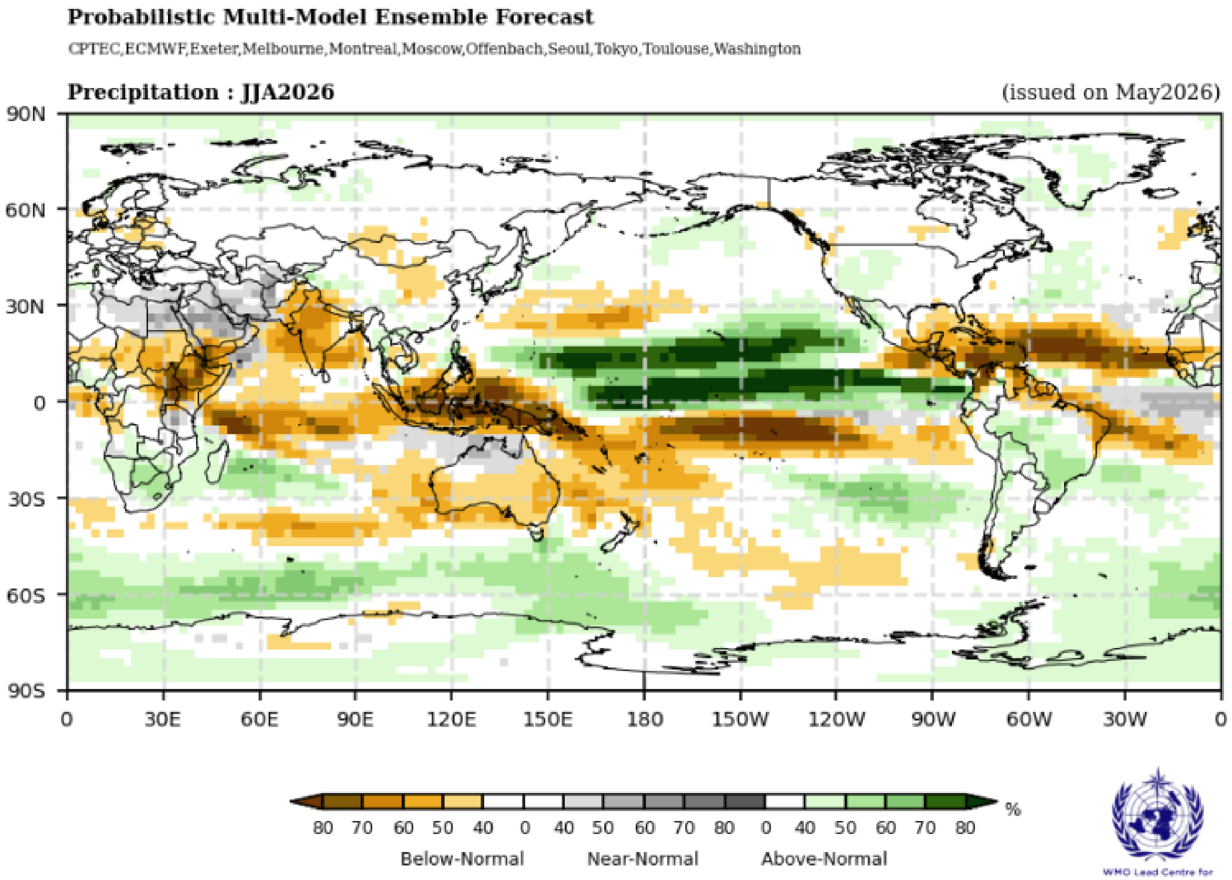
Droughts in a warming world

“It is likely (75% chance) that the 2026-2030 five-year mean will exceed 1.5°C above the 1850-1900 average.”

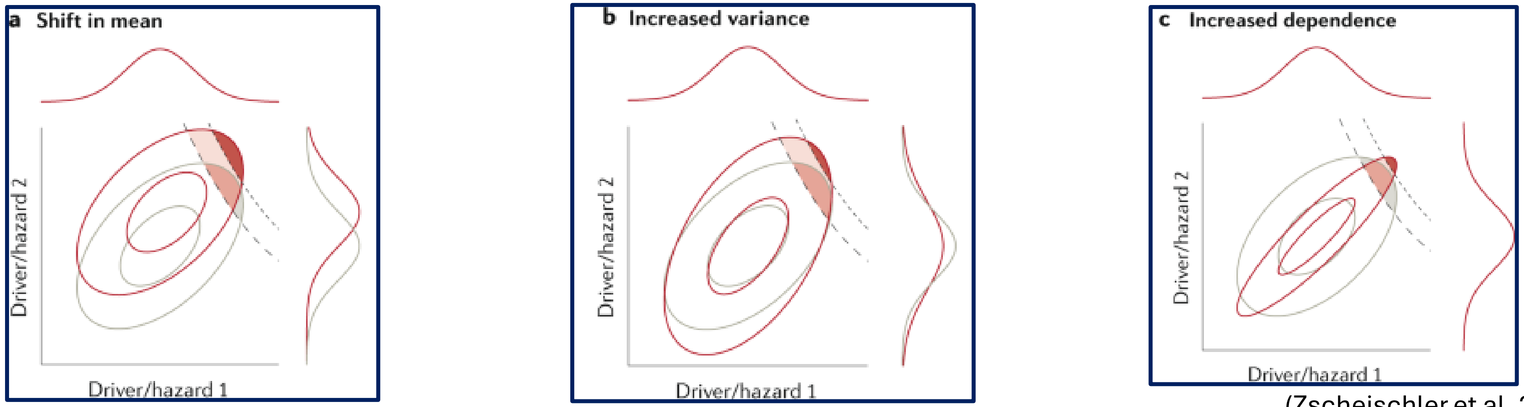


“There is an El Niño predicted for the end of 2026, which increases the chances of the following year, 2027, being the next record-breaking year”



Nonstationarity in droughts due to changing temperature

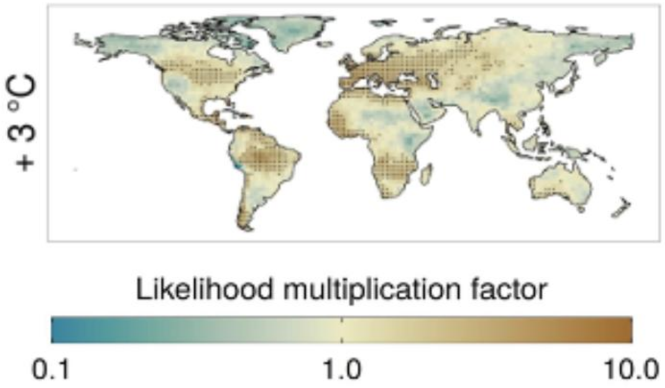
P, ET and SM feedbacks (red- warming/drying and blue- wetting/cooling) contributes to drought dynamics.



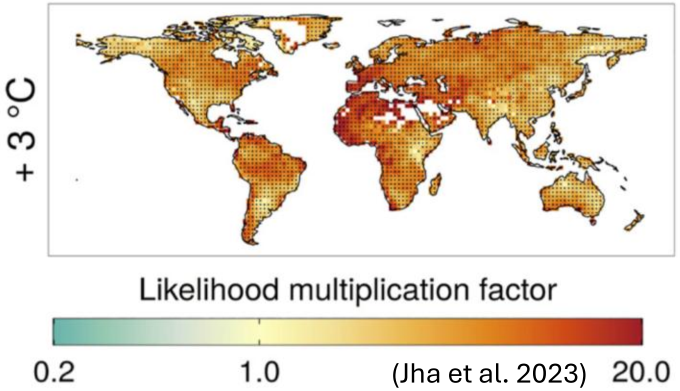
(Zscheischler et al. 2020)

Nonstationarity in the drivers can lead to combined shift in mean, variance and even changing dependence.

Likelihood of univariate dry events



Likelihood of compound hot-dry events



(Jha et al. 2023)

Dependence between drivers can lead to higher likelihood.

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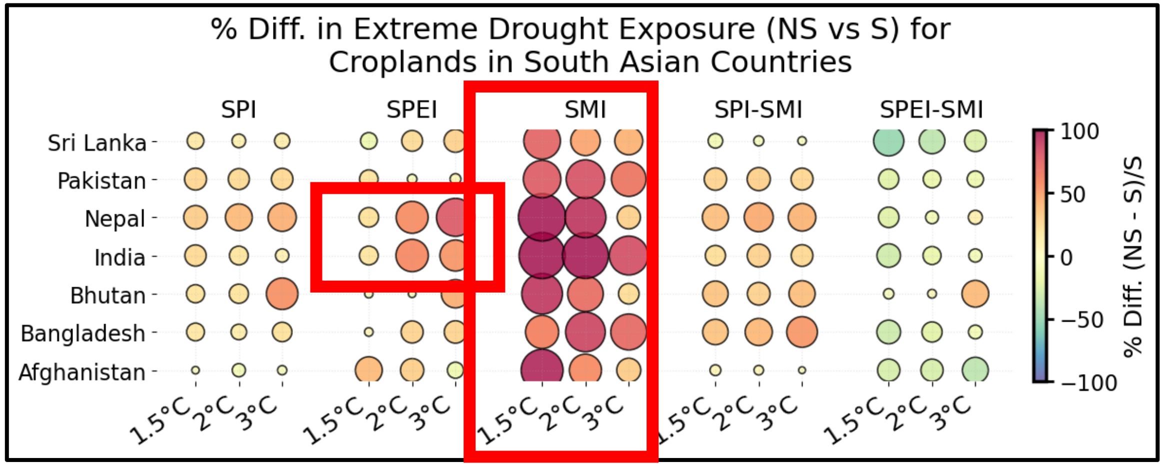
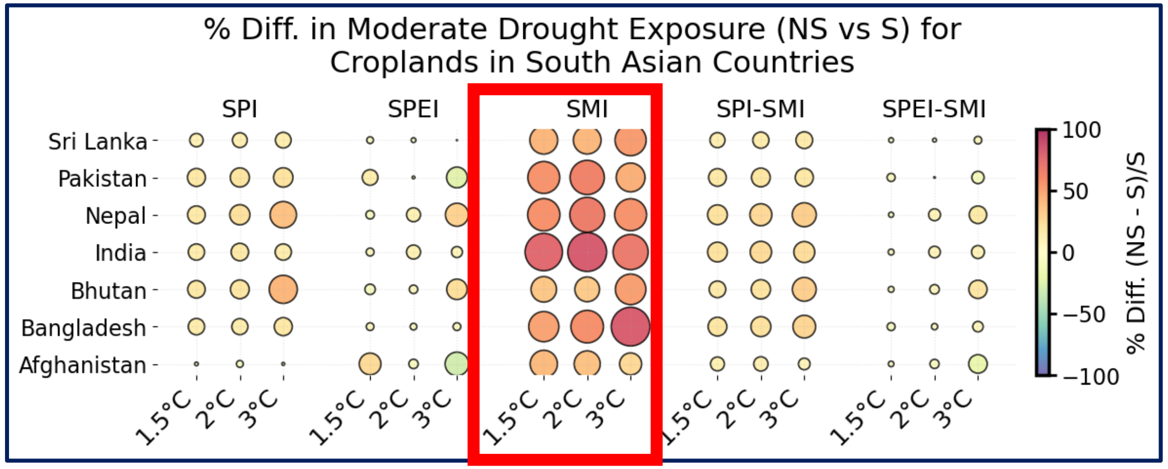
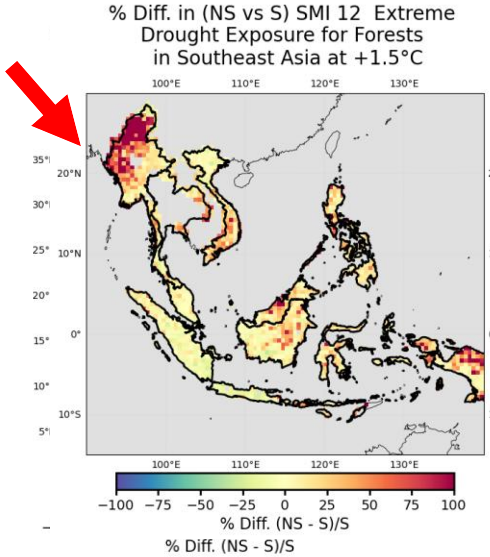
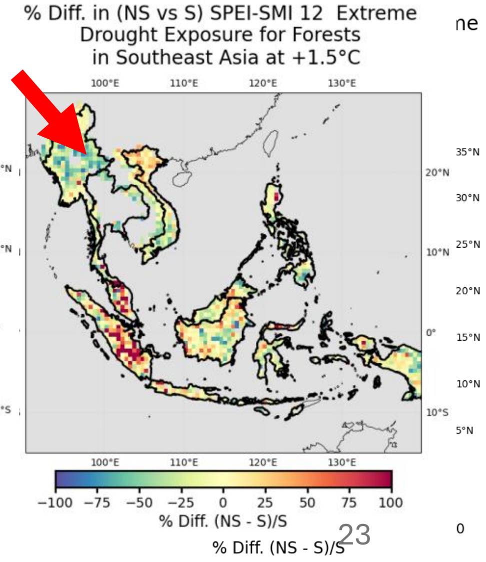
Drought exposure difference after incorporating role of temperature





- Nonstationarity due to temperature most significantly governs the occurrence of soil moisture droughts and hence the compound droughts.
- The influence of temperature intensifies over warming levels (e.g. extreme droughts for SPEI)
- Ignoring the effects might lead under/overestimation of risks.





(Jha et al. under prep.)

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Future rare droughts under climate change in the UK

Hydrol. Earth Syst. Sci., 30, 2685–2701, 2026
https://doi.org/10.5194/hess-30-2685-2026

Hydrology and Earth System Sciences
Open Access
EGU

Evolution of nonstationary hydrological drought characteristics in the UK under warming

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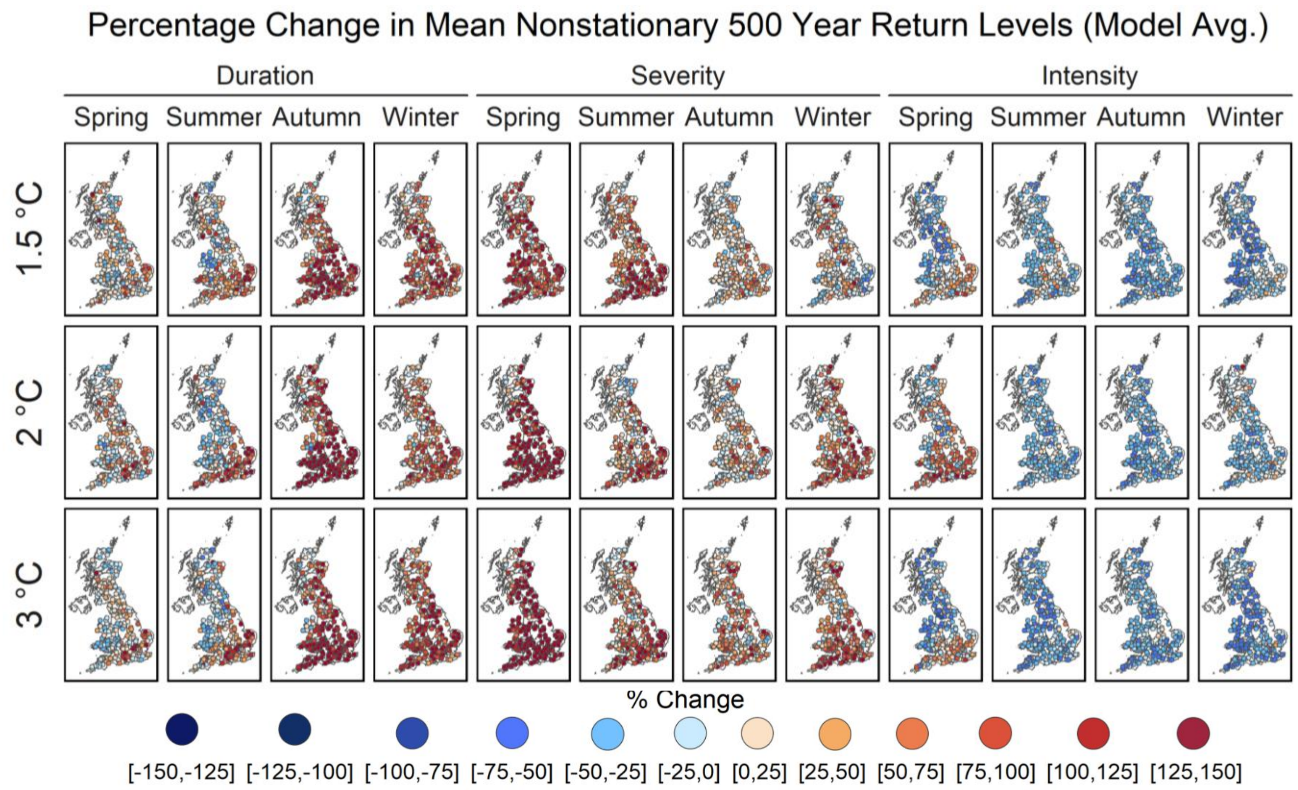
Abstract. Although the United Kingdom (UK) is relatively wet, there is an increasing awareness of the impacts of droughts, and an expectation that droughts will become worse in the future. This has motivated studies that have developed projections of future UK drought charac- tionarity, and seasonal controls on the future evolution of hydrological droughts in the region. Furthermore this framework could be used to support similar analyses in other environments where analogous datasets of transient hydroclimate projections are available.

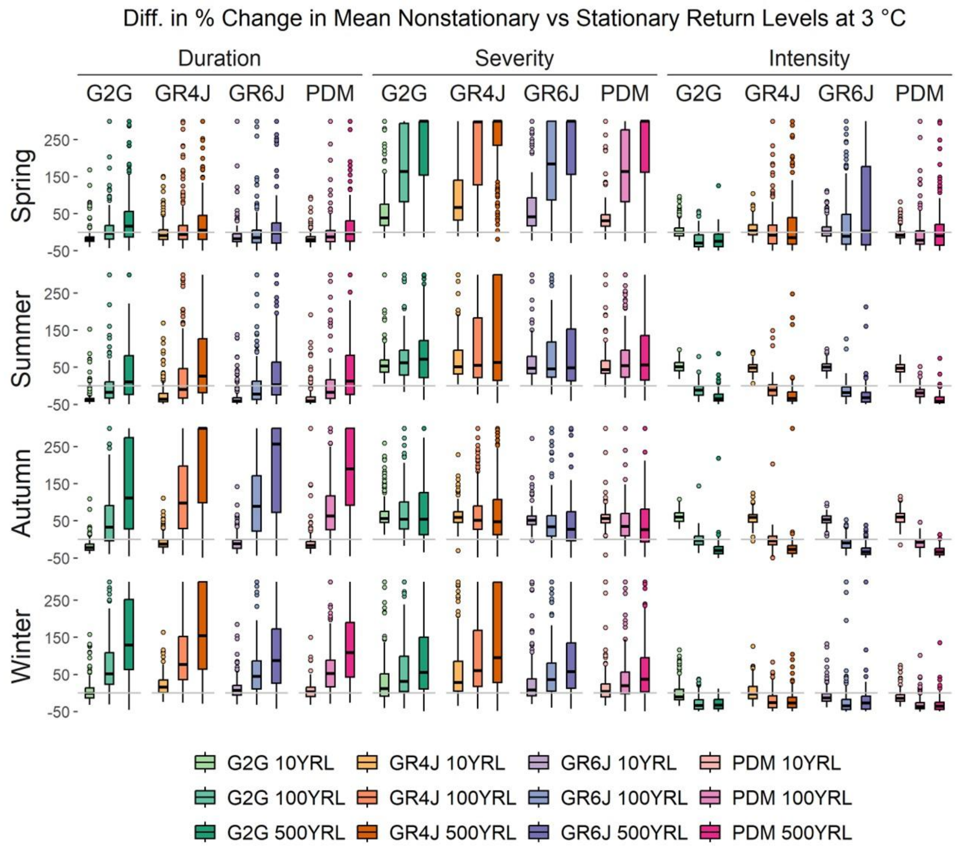
Key question addressed:

"How will rare, once in a 100 year or once in 500 year ***nonstationary*** *hydrological droughts change as temperature continue to rise in the UK?"*

Future rare droughts under climate change in the UK



Model average percentage change in mean nonstationary 500-year return levels for drought characteristics across all warming levels and seasons.



Difference in spatial average percentage change in return levels for mean nonstationary and stationary estimates

Thank you

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