UK Hydrological Status and Outlook Products: methods and production processes

Lucy J Barker

UKCEH Wallingford

13th December 2022

Ladybower Reservoir
November 2022
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UK Centre for Ecology & Hydrology

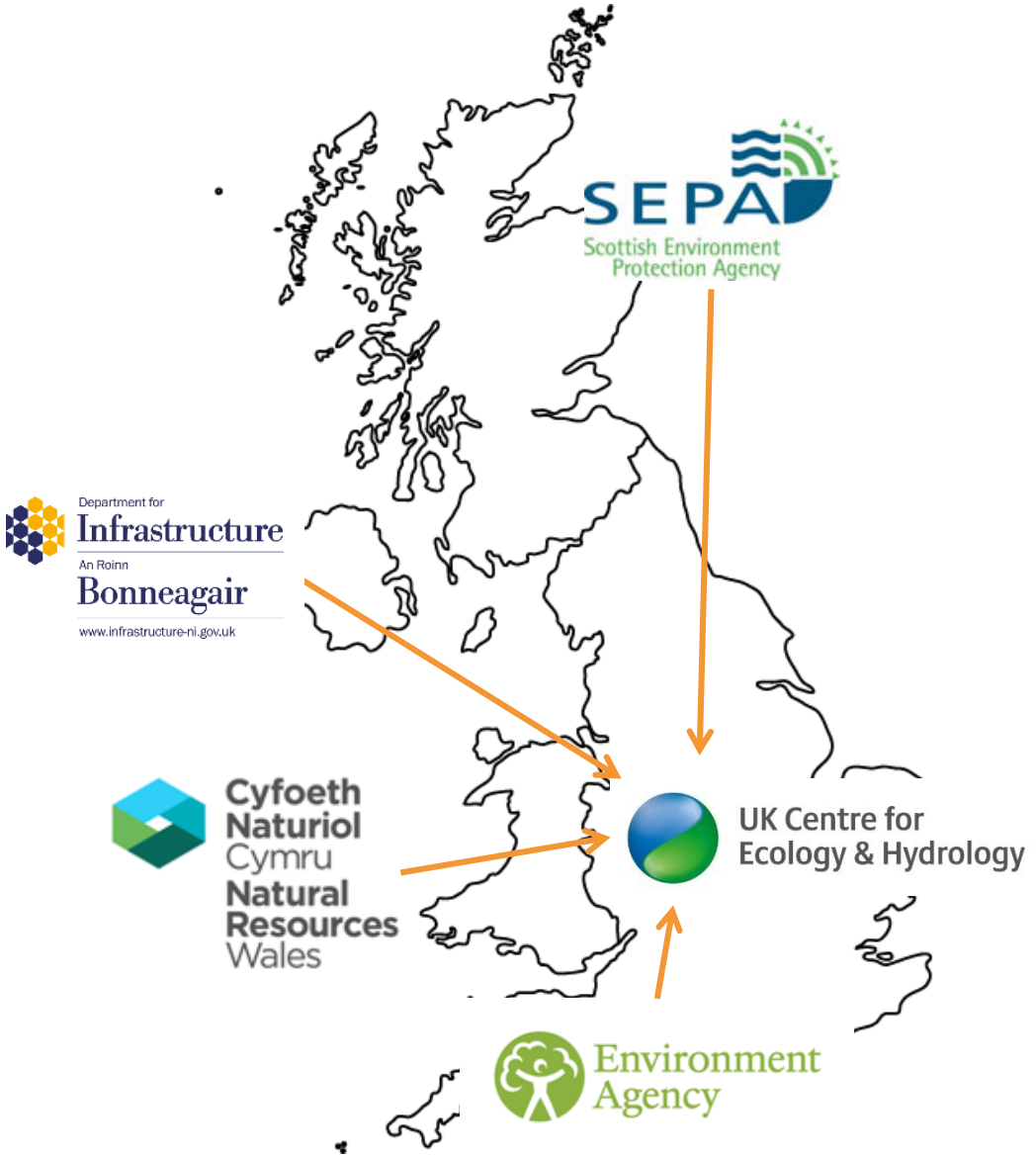
Hydrological monitoring and observations in the UK

= National Meteorological Service

Hydrological monitoring is undertaken by the four UK Measuring Authorities (i.e. environmental regulators) in each country of the UK

We hold data for ~1600 gauges across the UK in the National River Flow Archive at UKCEH

UK Measuring Authorities



UK Centre for Ecology & Hydrology

National River Flow Archive

UK Status and Outlook products

UKCEH works with the Measuring Authorities, NMS and the British Geological Survey (BGS) to produce monthly Status and Outlook products

UK Centre for Ecology & Hydrology

Met Office

Department for Infrastructure An Roinn Bonneagair www.infrastructure-ni.gov.uk

Cyfoeth Naturiol Cymru Natural Resources Wales

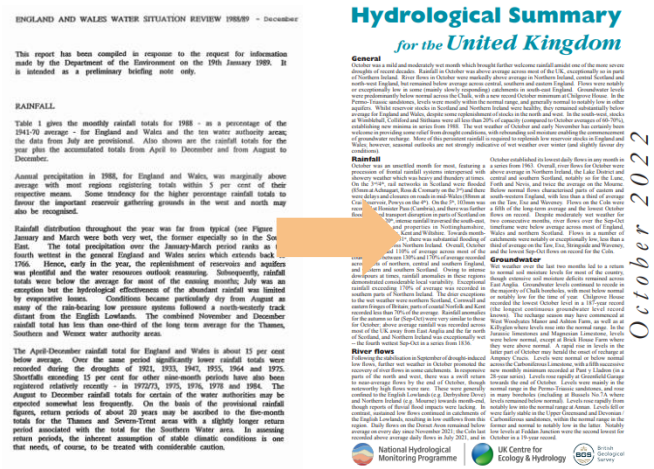
SEPA Scottish Environment Protection Agency

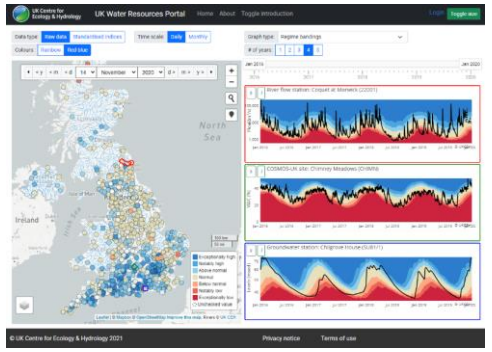
Environment Agency

BGS British Geological Survey

UK Centre for Ecology & Hydrology

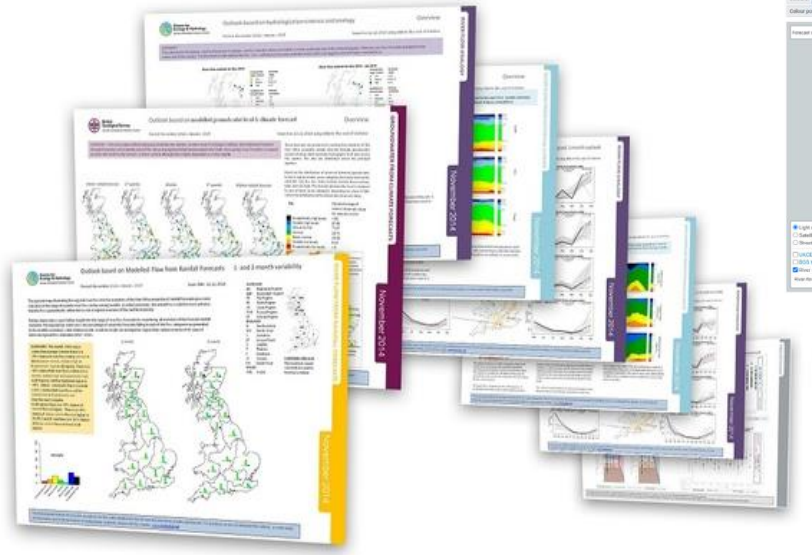
Hydrological Summary for the UK

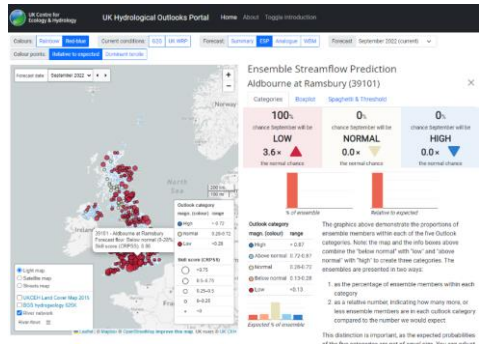




Operational status assessment since 1988

Hydrological Outlook UK





Operational seasonal forecasting since 2013

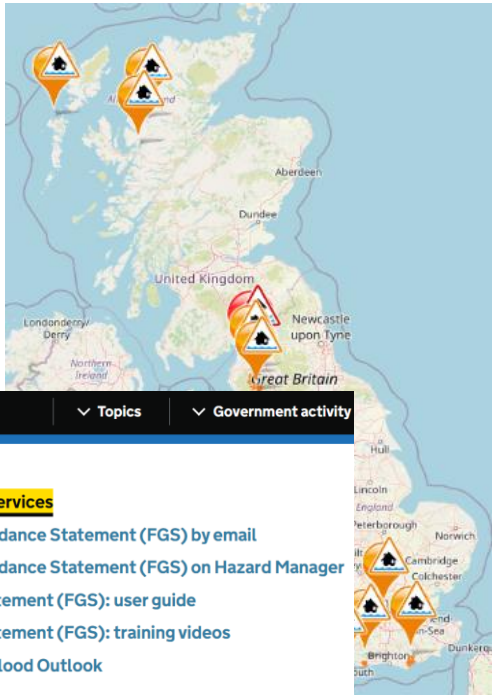
A note on floods and droughts

- Flood warnings issued by measuring authorities

- Flood forecasts are produced by the NMS and the measuring authorities in the Flood Forecasting Centre (England & Wales), and SEPA (Scotland)

- Drought declarations are made by the measuring authorities

- We can still monitor situation and forecast likelihood of drought and floods



GOV.UK | Topics | Government activity

Home > Organisations

FLOOD FORECASTING CENTRE

A working partnership between Environment Agency | Met Office

Find out about our services
Sign up to Flood Guidance Statement (FGS) by email
Sign up to Flood Guidance Statement (FGS) on Hazard Manager
Flood Guidance Statement (FGS): user guide
Flood Guidance Statement (FGS): training videos
Find out about the Flood Outlook
Our Strategic Plan

GOV.UK | Topics

Home > Environment > Water industry > Drought and water availability

Press release

All of England's South West region now in drought

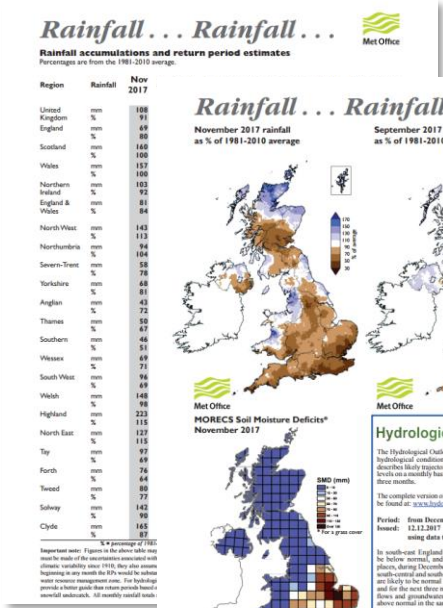
Bristol, Somerset, Dorset, south Gloucestershire and parts of Wiltshire have now moved to drought status.

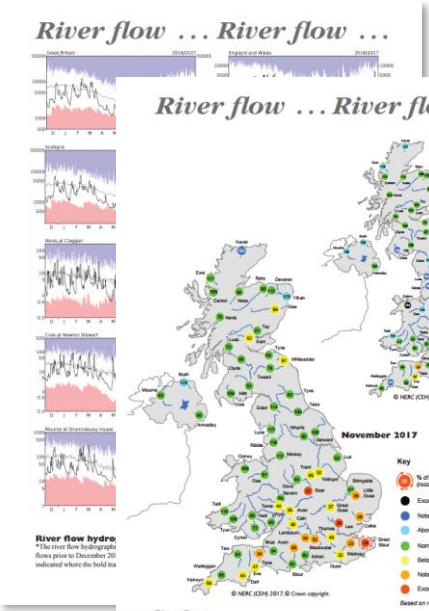
From: Environment Agency
Published 30 August 2022

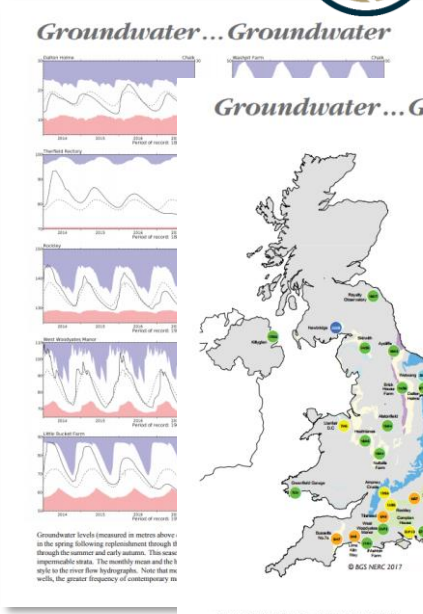
UK Centre for Ecology & Hydrology

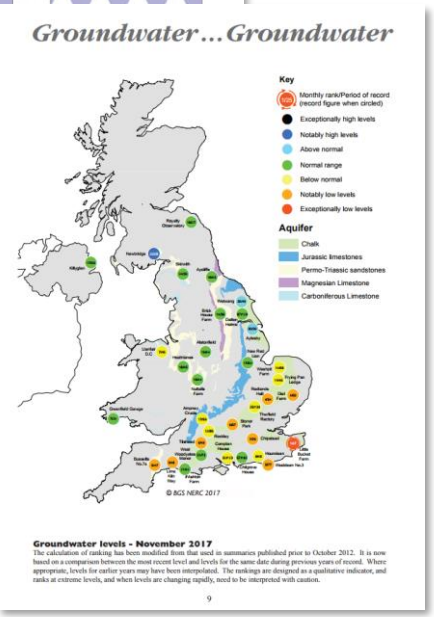
Hydrological Summary for the UK

British Geological Survey









Met Office

Hydrological Outlook UK

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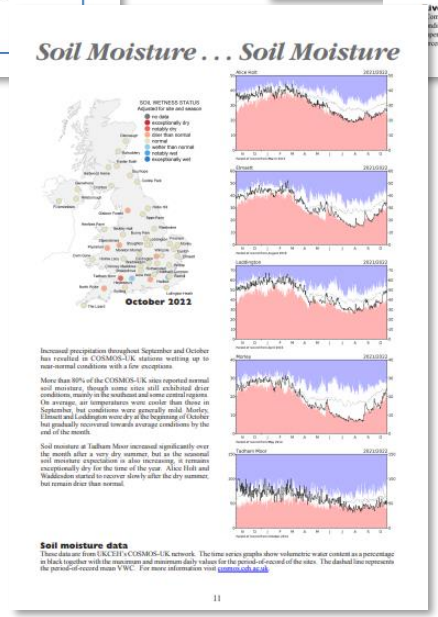

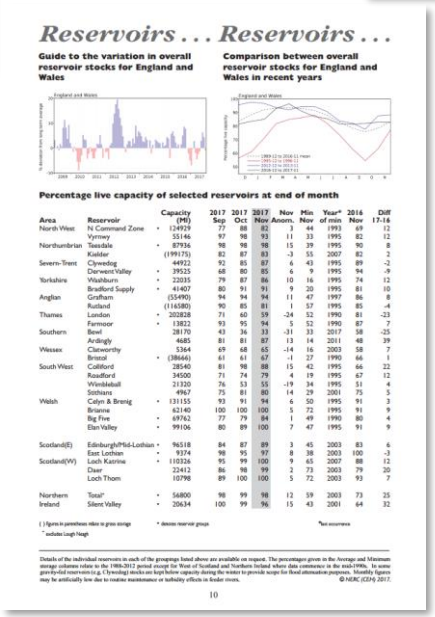

COSMOS-UK

Environment Agency

Department for Infrastructure An Roinn Bonneagair www.infrastructure-ni.gov.uk

https://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk

UK Centre for Ecology & Hydrology

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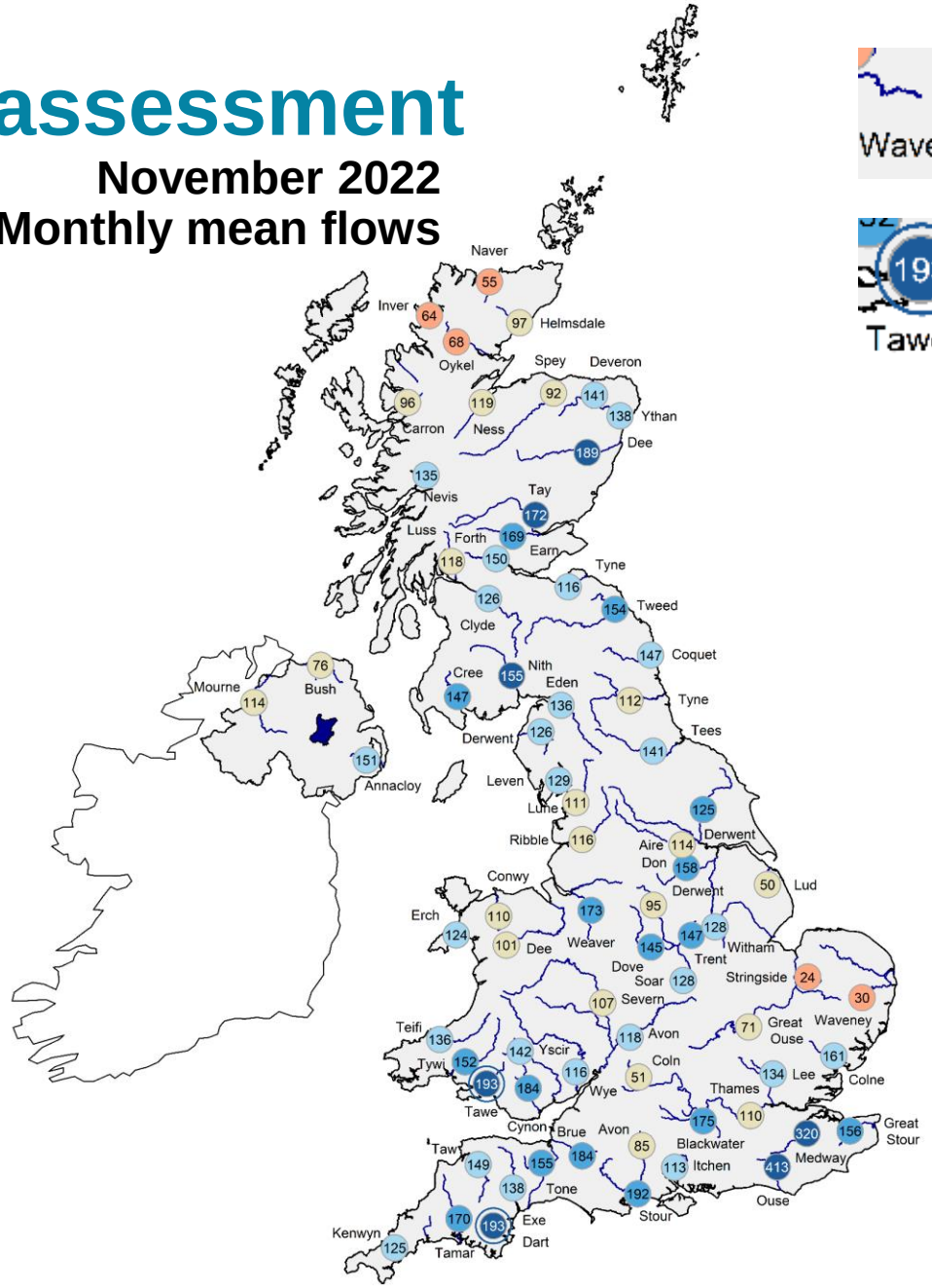
Individual water companies

River flow status assessment

November 2022
Monthly mean flows



Number is the % of the 1991-2020 average flow (for the given month)

Circled points = new monthly maximum (or minimum)

Coloured according to the category from exceptionally high to exceptionally low

Key

- 25 — % of 1991–2020 average (record high/low when circled)
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

*Based on period–of–record ranking of the monthly flow**

Catchments selected with:

- At least 40 years of data
- Reliable, good quality data
- Well distributed spatially
- Range of catchment properties
- Combination of near-natural and influenced catchments

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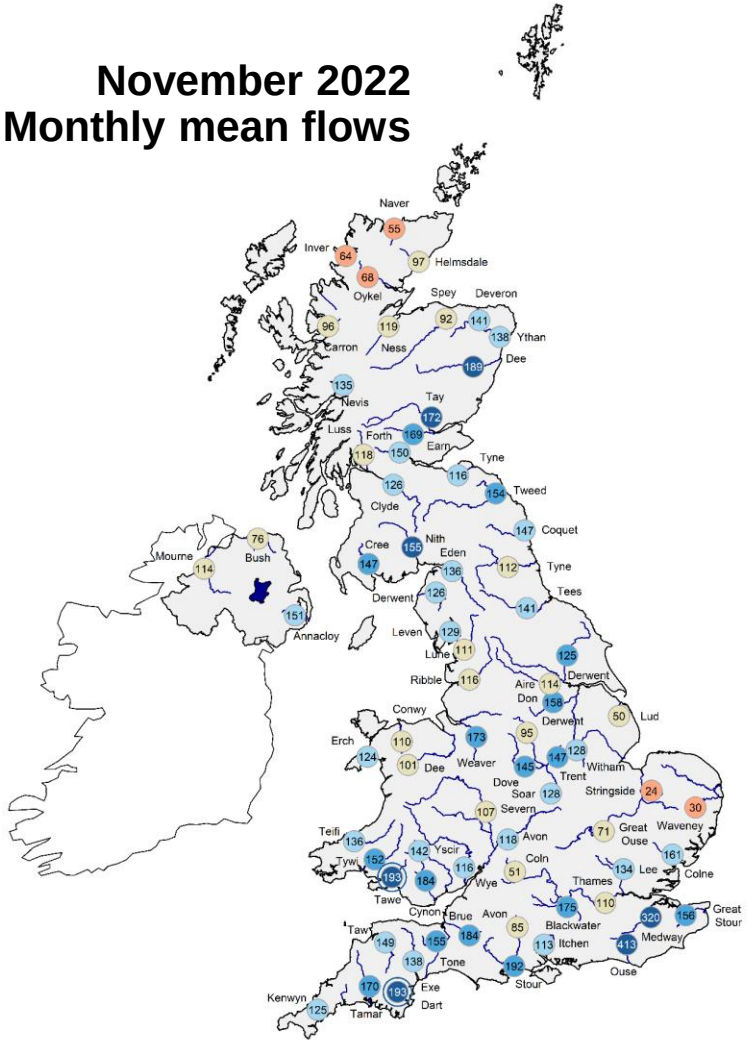
River flow status assessment

November 2022
Monthly mean flows



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- Exceptionally low flow

*Based on period−of−record ranking of the monthly flow**

Daily mean flow (m3/s)

↓

Calculate monthly mean flow

↓

Calculate monthly mean flow as a % of long-term average (1991-2020 reference period)

↓

Compare current month against previous monthly mean flows (for the given month)

↓

Points coloured according to the rank of the current month *n* against all previous *n* months using plotting positions

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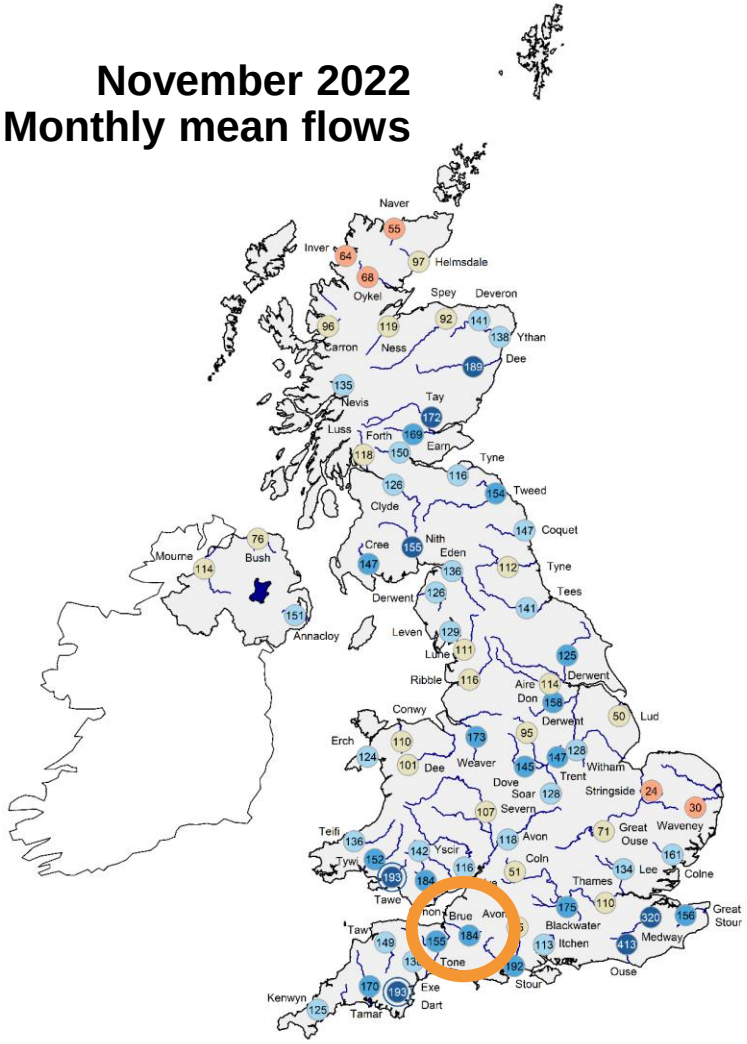
River flow status assessment

November 2022
Monthly mean flows



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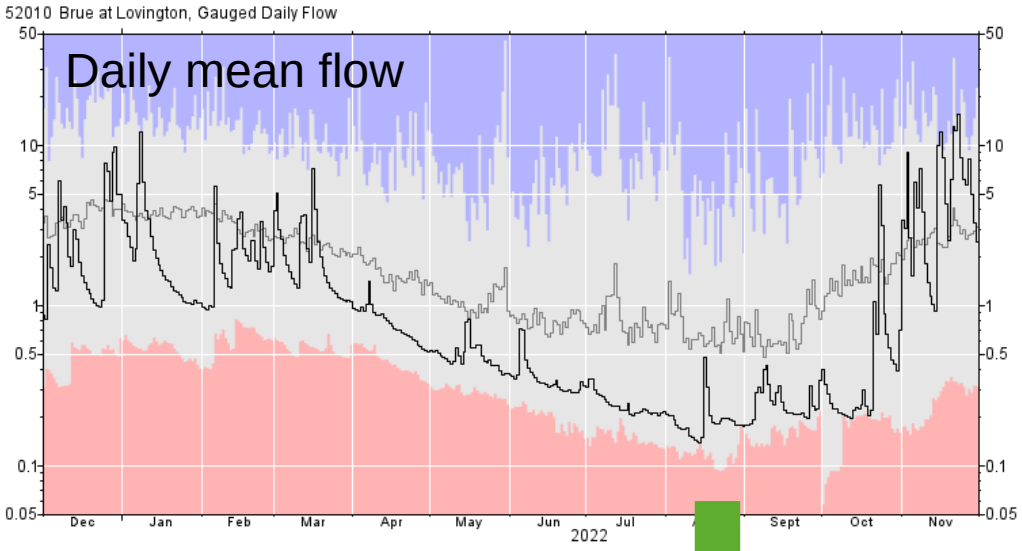

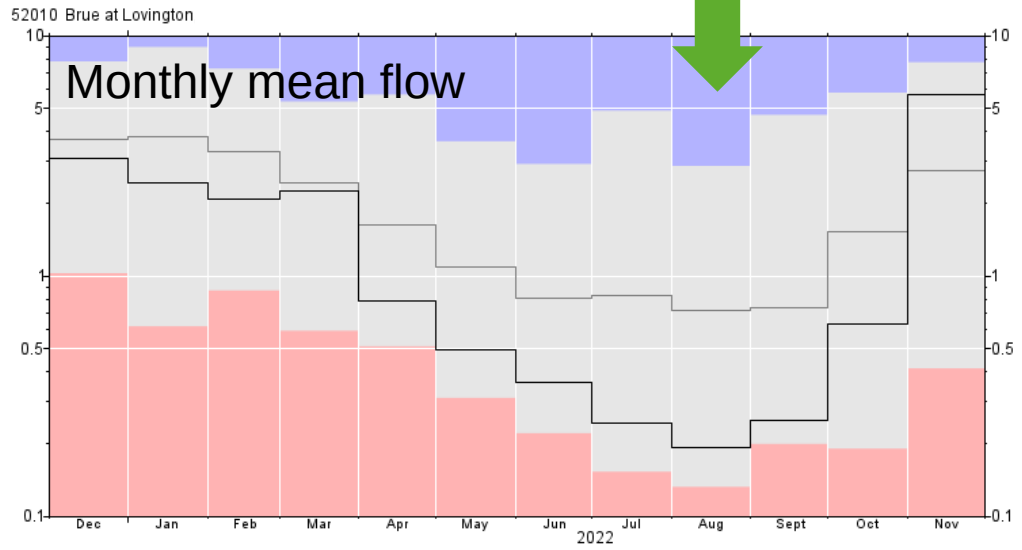

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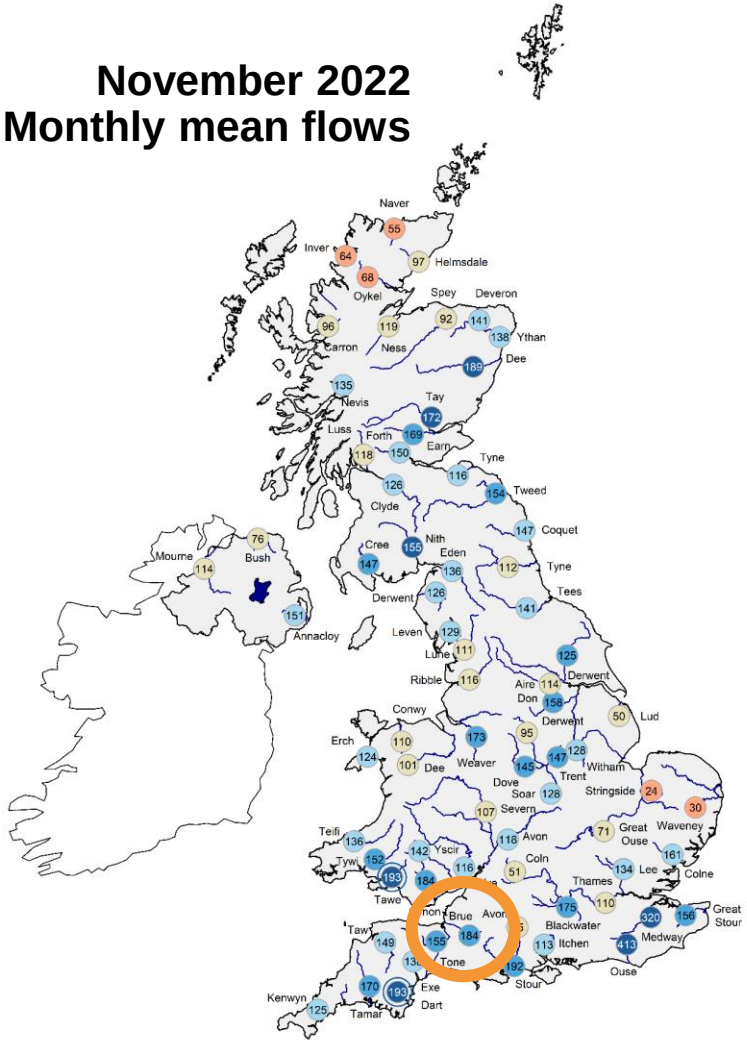

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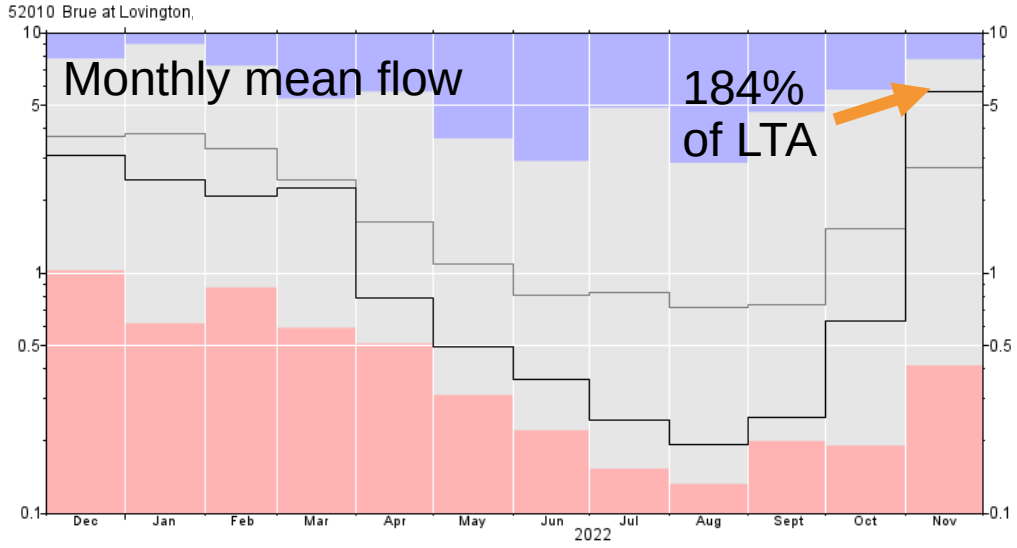

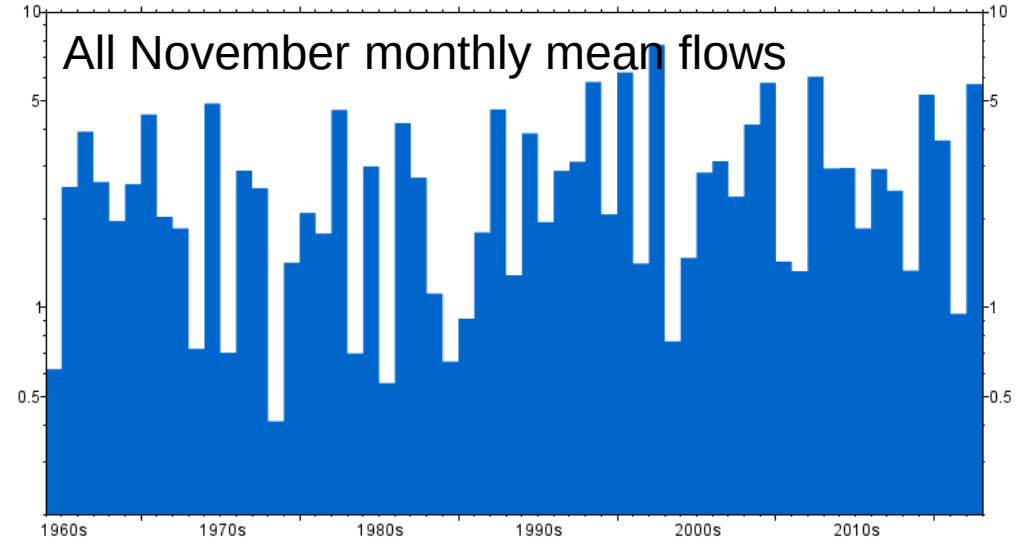

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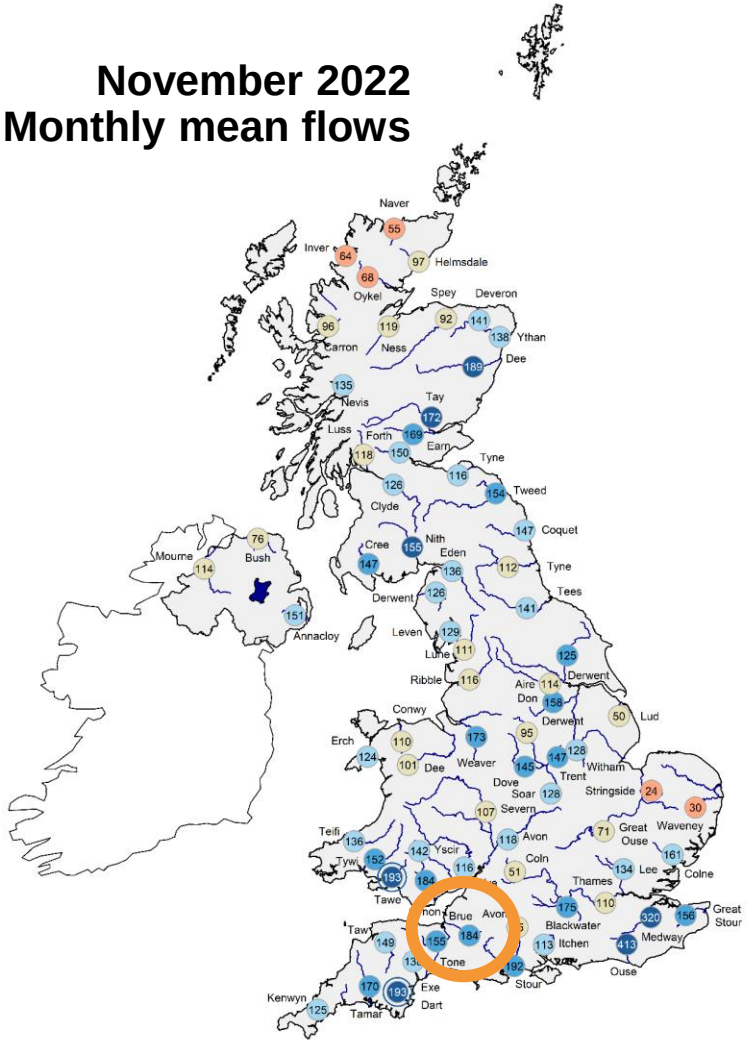

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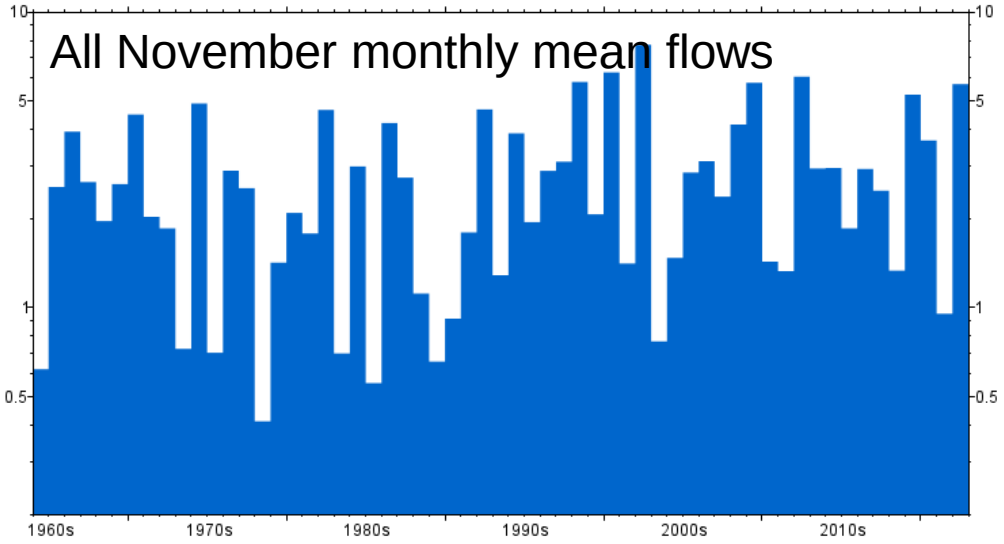

Date	52010/gdf
2002-...	7.741
2000-...	6.241
2012-...	6.032
1998-...	5.795
2009-...	5.755
2022-...	5.695
2019-...	5.245
1974-...	4.896
1992-...	4.675
1982-...	4.659
1970-...	4.497
1986-...	4.210
2008-...	4.158
1966-...	3.931
1994-...	3.883
2020-...	3.672
2006-...	3.124
1997-...	3.112
1984-...	2.999

November 2022 ranks 6th highest November flow

Record starts 1964

53rd out of 59 Novembers

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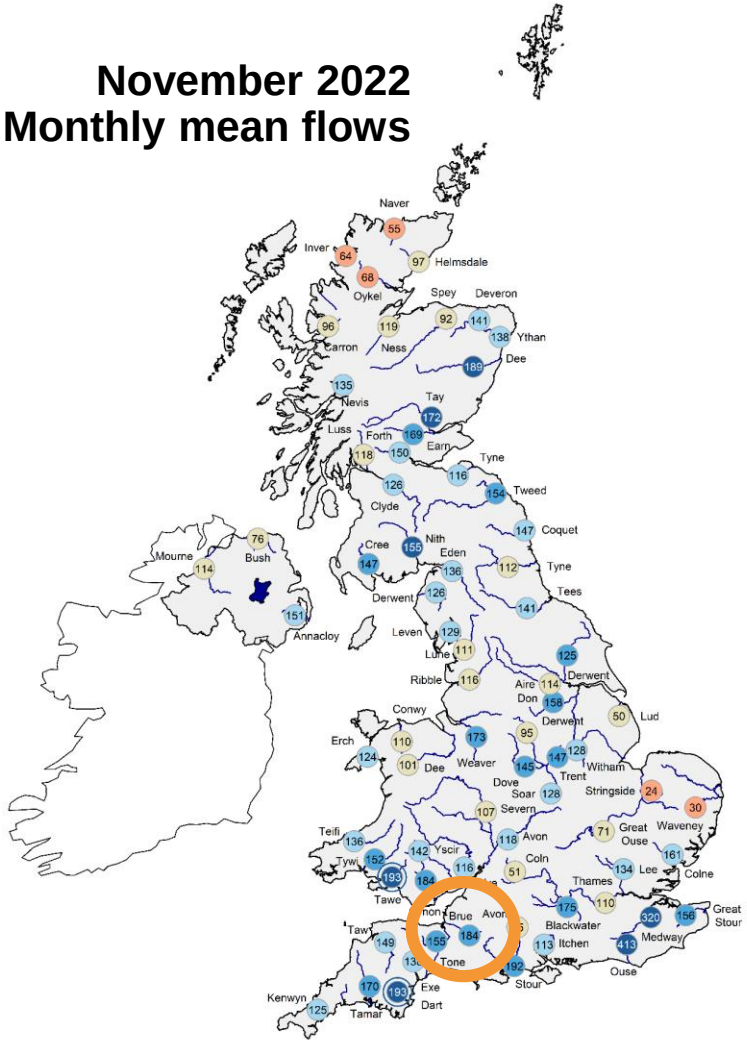
River flow status assessment

November 2022
Monthly mean flows



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1974-...	4.896
1992-...	4.675
1982-...	4.659
1970-...	4.497
1986-...	4.210

November 2022 ranks 6th highest November flow

Record starts 1964

So is ranked 53rd out of 59 Novembers

The points are coloured according to the rank of the current month (e.g. Novmeber 2022) compared to all the other Novembers derived using plotting positions (Cunane, 1978)

We calculate the rank as i/(N+1), where i is the rank of the current month and N is the number of months in the period of record

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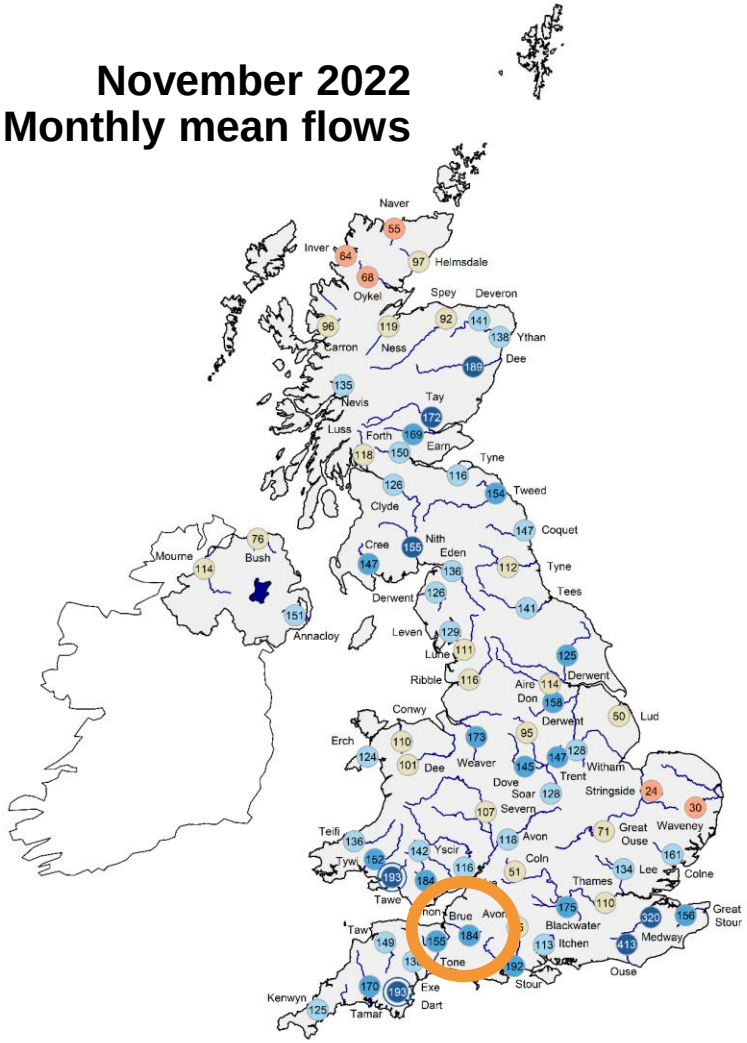
River flow status assessment

November 2022
Monthly mean flows



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*Based on period-of-record ranking of the monthly flow**

Example:
November 2022 Brue at Lovington (52010)

We calculate the rank as i/(N+1), where i is the rank of the current month and N is the number of months in the period of record

The rank for the Brue was 53/(59+1) = 0.883

Flows are then assigned to a category based on their rank:

Category	Rank
Exceptionally high flow	0.950000 - 1.00000
Notably high flow	0.870000 - 0.949999
Above normal	0.720000 - 0.869999
Normal range	0.280002 - 0.719999
Below normal	0.130002 - 0.280001
Notably low flow	0.050002 - 0.130001
Exceptionally low flow	0.000000 - 0.050001

November 2022 flows on the Brue were therefore **'Notably high'**

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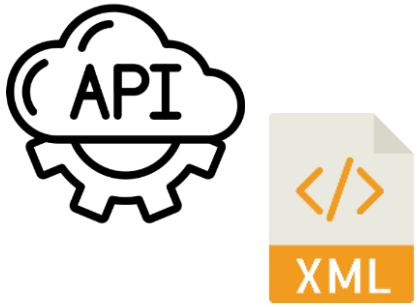
River flow status assessment: production process

Daily river flow data sent to UKCEH by measuring authorities

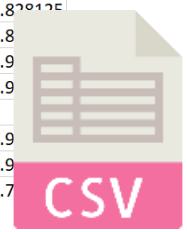
Data loaded to UKCEH Oracle database

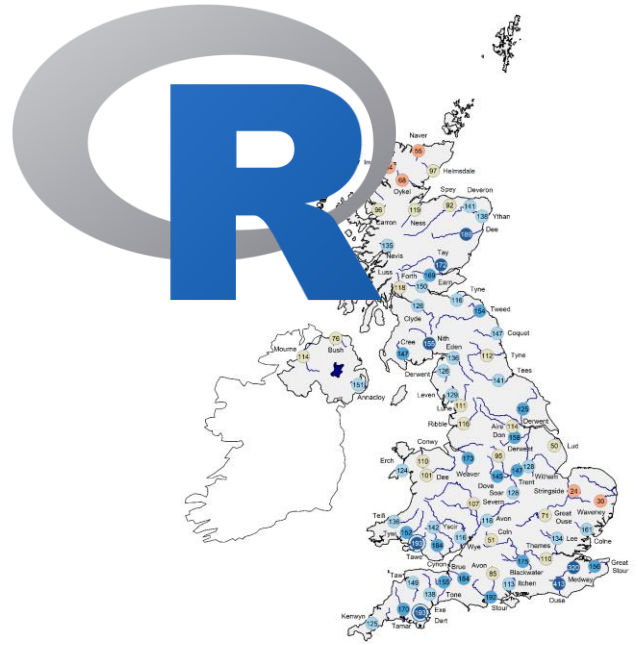
Anomalies and monthly rankings exported from database

R code run to produce maps



	A	B	C
1	station	pcnt_1991_2020	rank_all
2	2001	96.954	0.44898
3	3003	67.594	0.276596
4	6007	118.804	0.692308
5	7003	53.706	0.245902
6	8006	91.852	0.527778
7	9002	140.665	0.8
8	10003	138.083	0.8
9	11002	199.642	0.9
10	12001	189.445	0.9
11	13001	358.998	
12	15006	172.097	0.9
13	16001	169.025	0.9
14	18011	150.34	0.7





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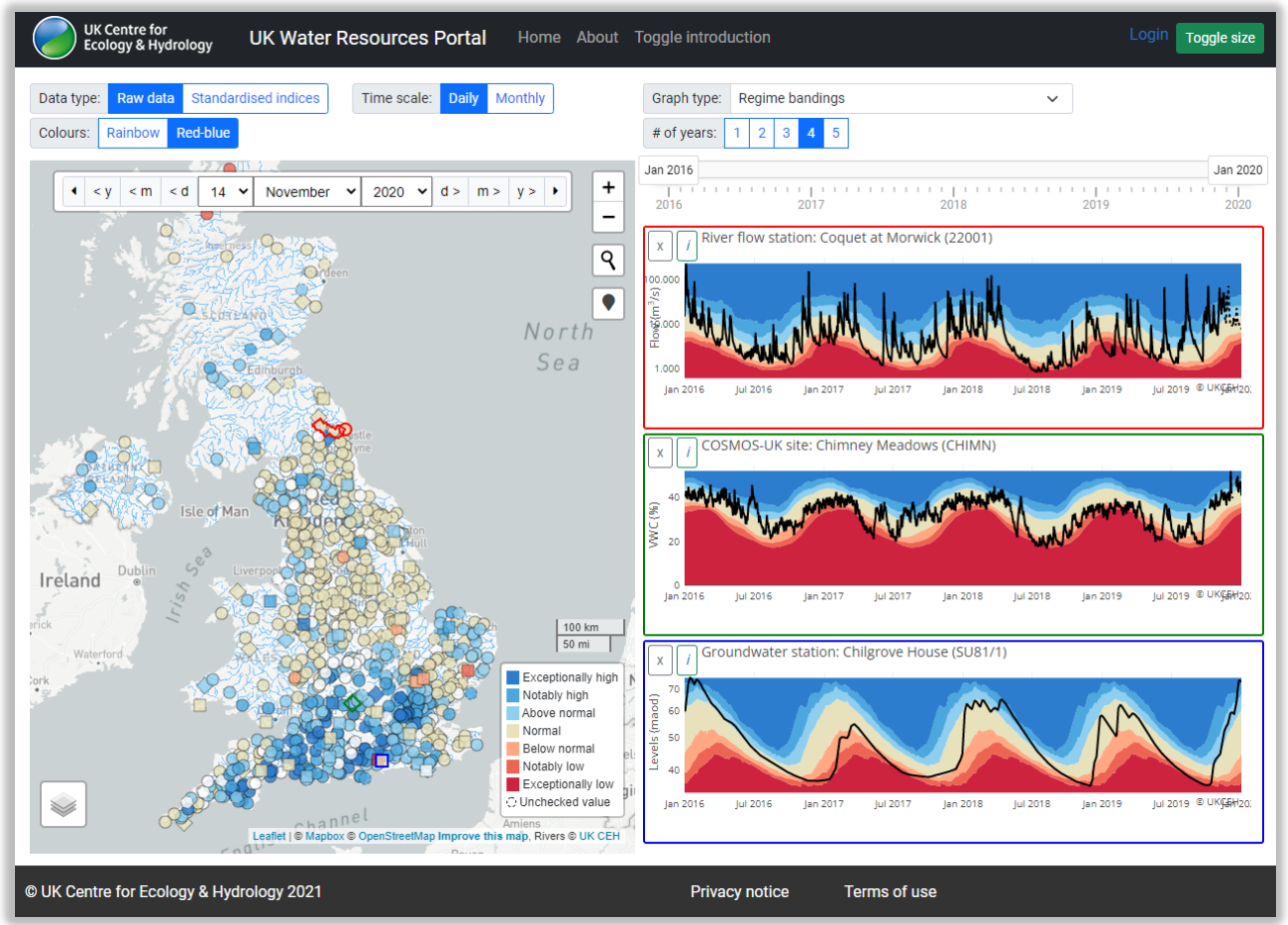
UK Water Resources Portal



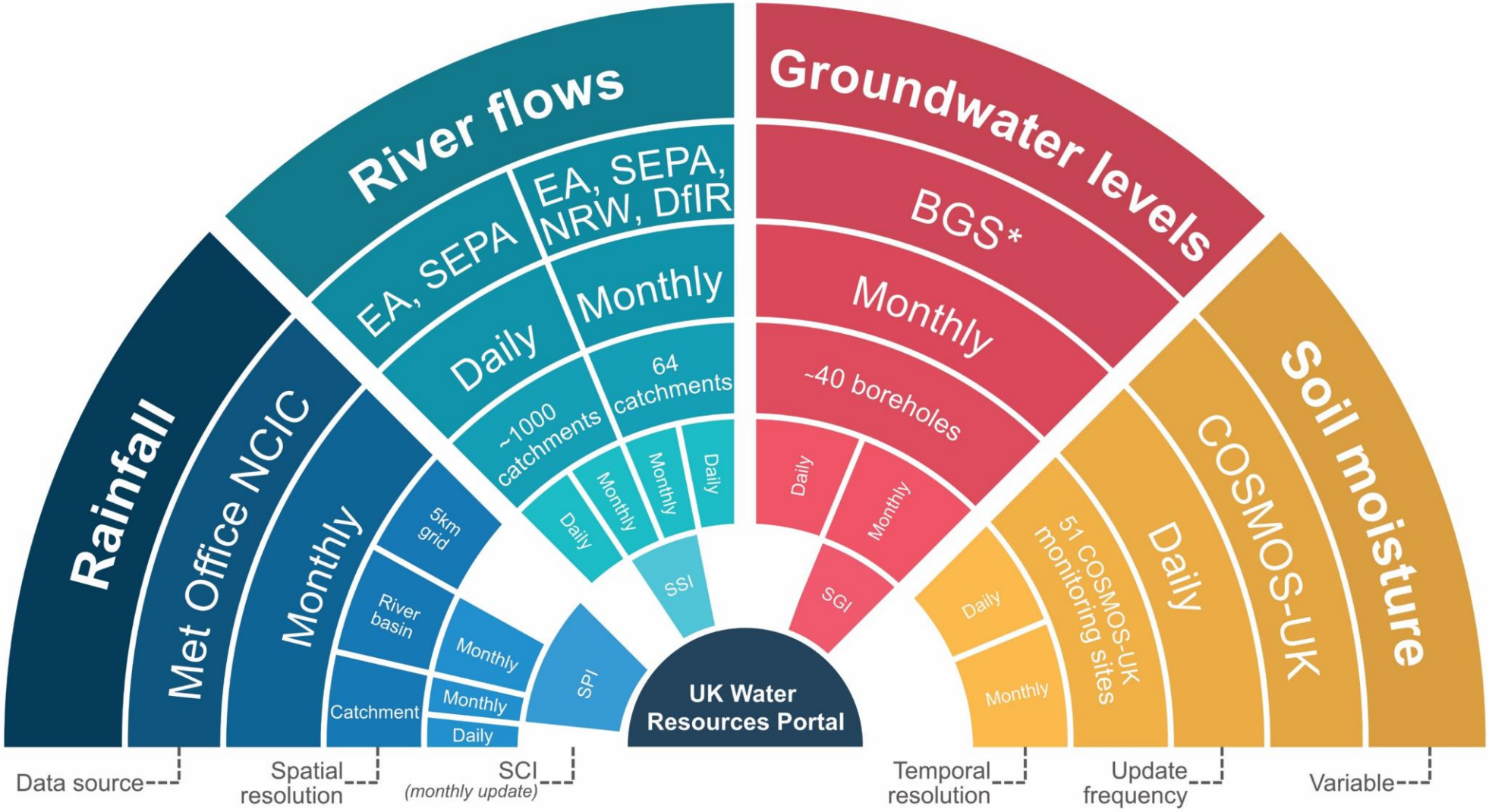
An interactive web-based tool for high-resolution hydrological status assessment in (near) real-time

- Co-designed with stakeholders
- Demonstrator launched July 2019
- Operational March 2020

UK Centre for Ecology & Hydrology

eip.ceh.ac.uk/hydrology/water-resources/

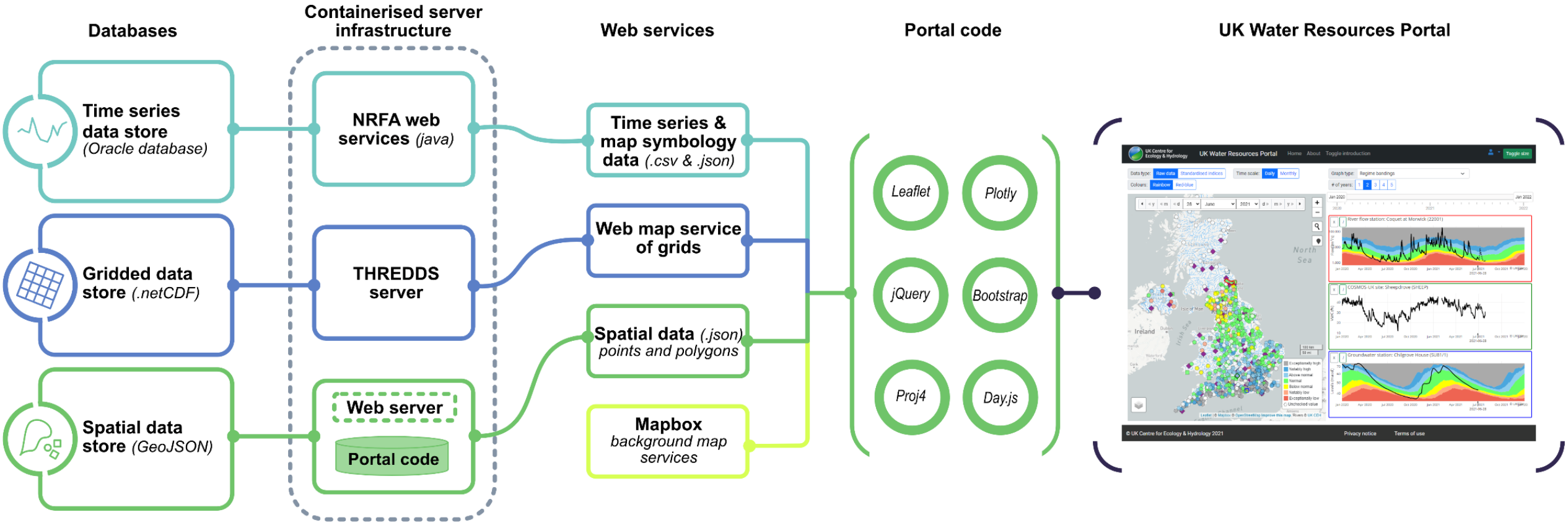
UK Water Resources Portal: Data



UK Centre for Ecology & Hydrology

Barker et al., 2022. Frontiers in Environmental Science
https://doi.org/10.3389/fenvs.2022.752201

UK Water Resources Portal: Infrastructure



Barker et al., 2022. Frontiers in Environmental Science
https://doi.org/10.3389/fenvs.2022.752201

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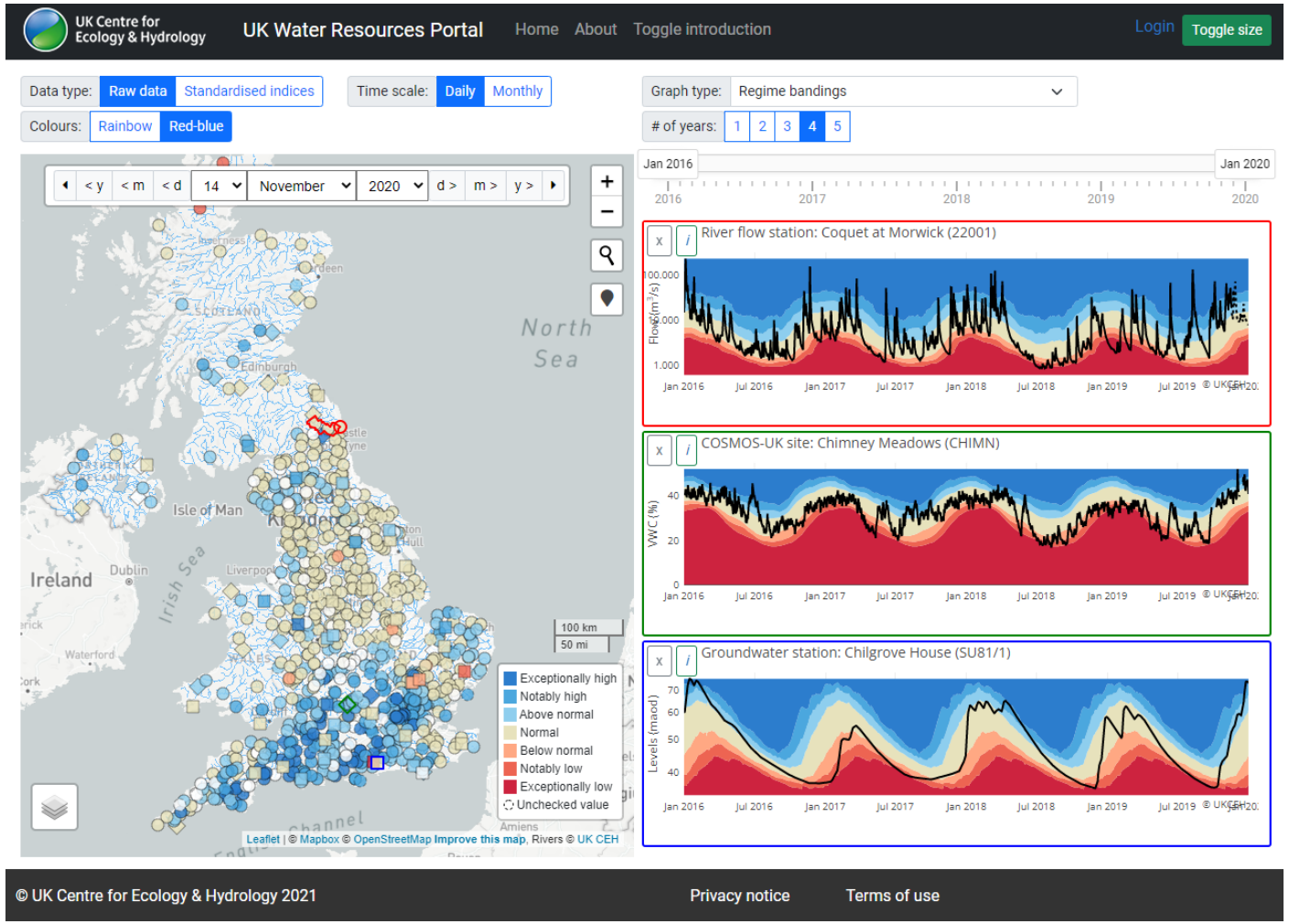
UKWRP: Status assessment



UK Centre for Ecology & Hydrology

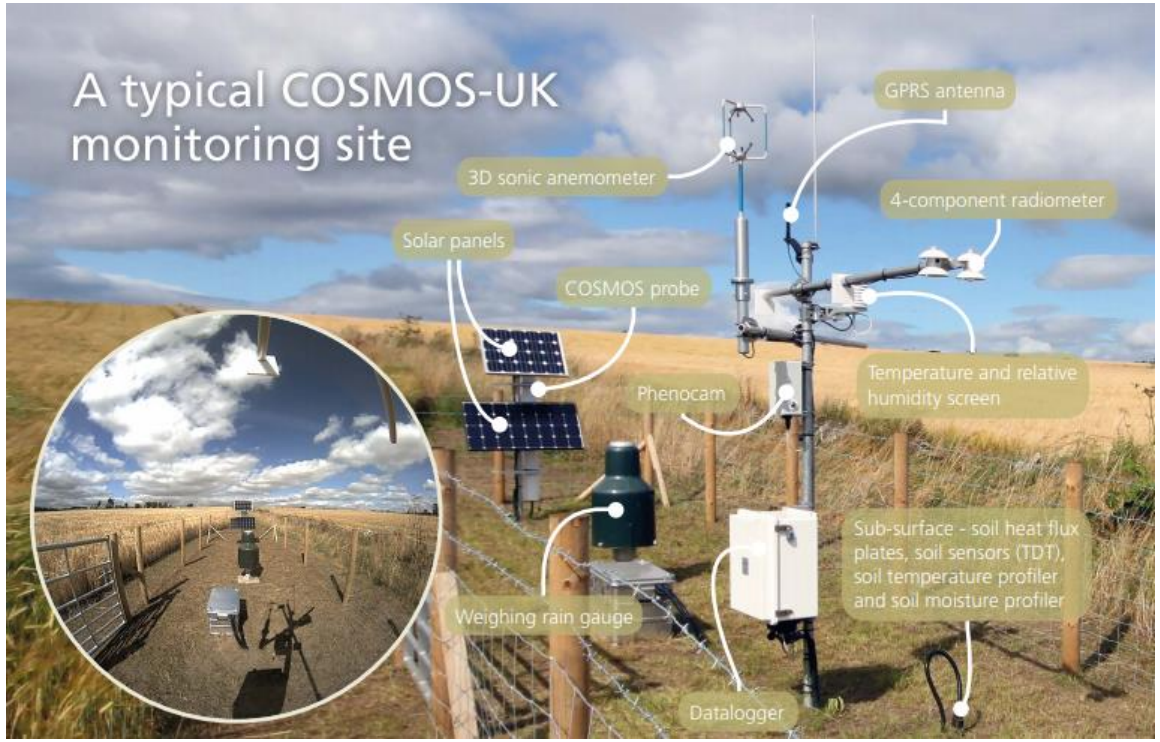
The portal includes more gauges than we use in the Hydrological Summary, many with shorter records

- We normalise for each site against its historic data - minimum of 20 years from start of the record to the end of December 2017
- For each day, the values are ranked and the percentiles calculated
- For river flows values in a 30-day period are pooled to reduce the influence of extreme daily values
- Percentile values are then categorised:

Category	Percentile range
Exceptionally high flow	> 95%
Notably high flow	87-95%
Above normal	72-87%
Normal range	28-72%
Below normal	13-28%
Notably low flow	5-13%
Exceptionally low flow	<5%

COSMOS-UK: soil moisture monitoring network

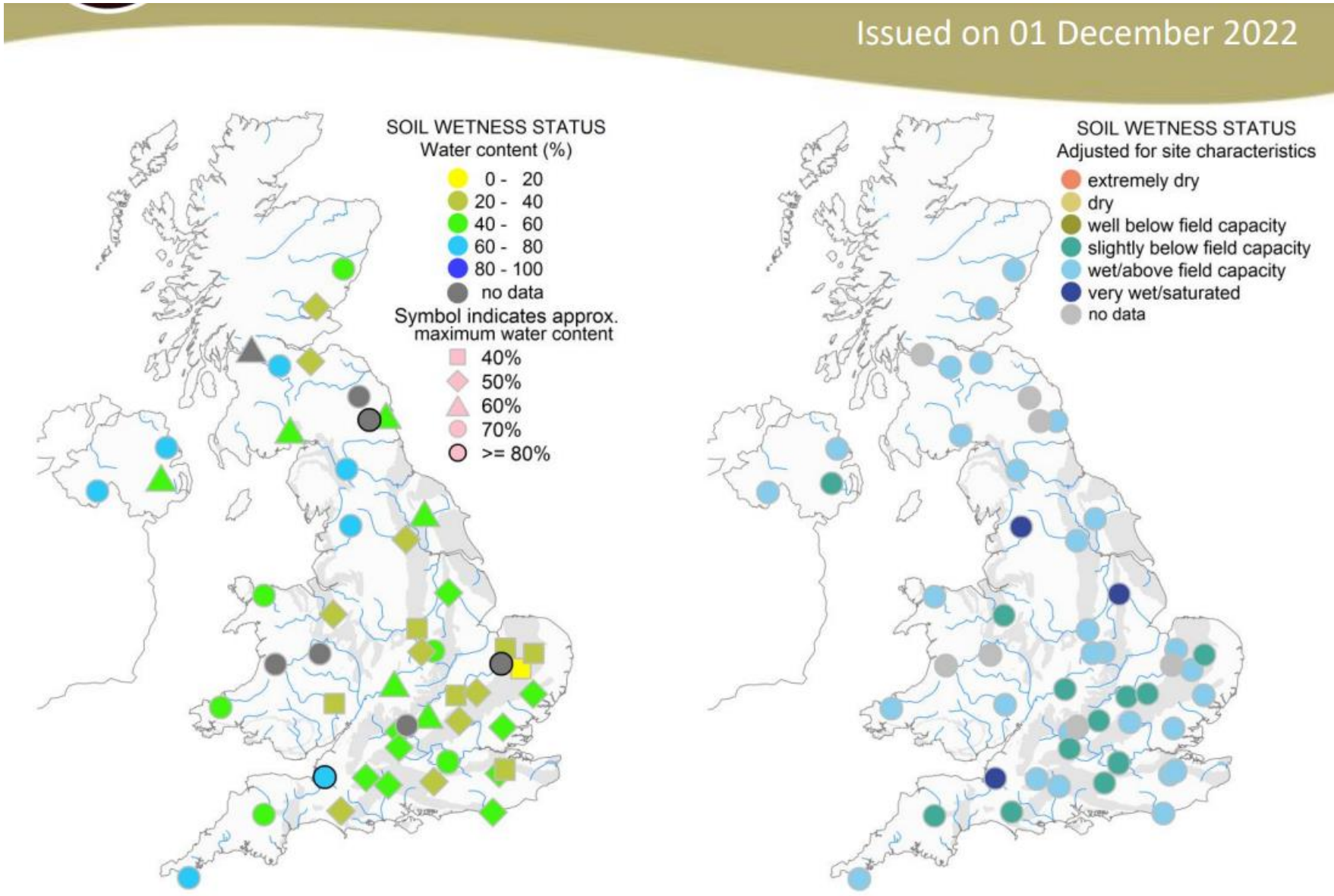
- COSMOS-UK real-time field-scale (12ha) soil moisture observations
- Network of ~50 sites across the UK covering a range of soil & vegetation types
- Use cosmic-rays to sense soil moisture
- N.B. Records quite short – longest records start in 2013



www.cosmos.ceh.ac.uk/

COSMOS-UK: soil moisture monitoring network

- Need to account for the fact different soil types hold different amounts of data
- Use modelled data to normalise



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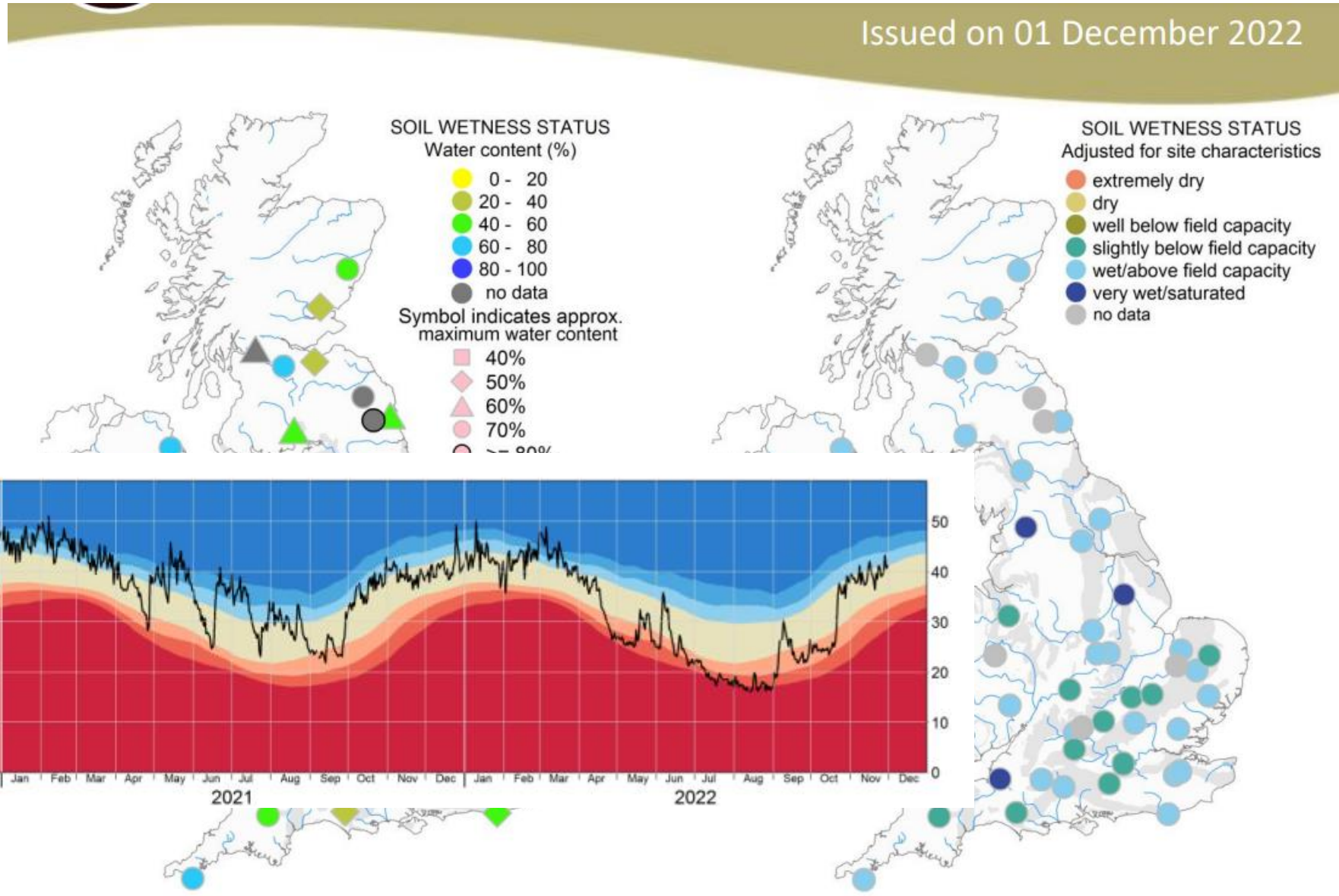


UK Centre for Ecology & Hydrology

Hydrological Outlook UK

Freely available: http://www.hydoutuk.net/

Provides UK-wide seasonal (1- and 3-month) forecasts of river flow and groundwater levels

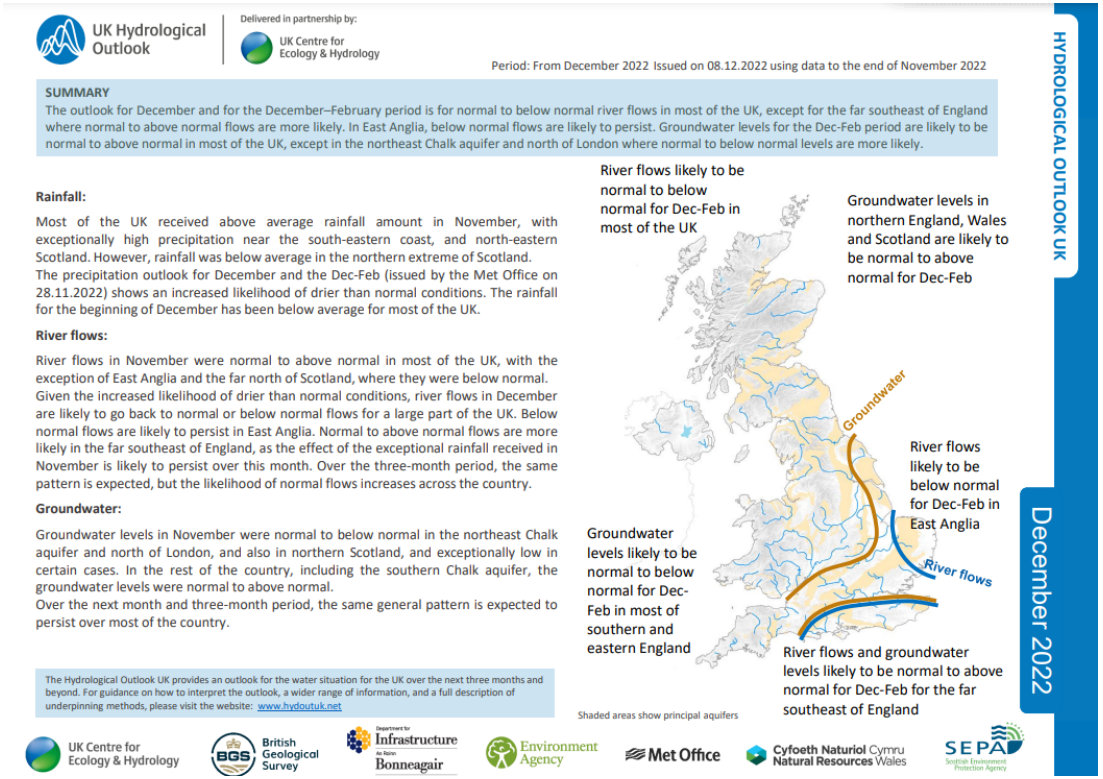
Monthly, operational since summer 2013

Three modelling methods for hydrology:

1. Persistence and Analogy,
2. Ensemble Streamflow Prediction,
3. Dynamic Rainfall Forecast

Prudhomme, et al. (2018). Hydrological Outlook UK: an operational streamflow and groundwater level forecasting system at monthly to seasonal time scales
Hydrological Sciences Journal

Hydrological Outlook UK



UK Hydrological Outlook

Delivered in partnership by: UK Centre for Ecology & Hydrology

Period: From December 2022 Issued on 08.12.2022 using data to the end of November 2022

SUMMARY

The outlook for December and for the December–February period is for normal to below normal river flows in most of the UK, except for the far southeast of England where normal to above normal flows are more likely. In East Anglia, below normal flows are likely to persist. Groundwater levels for the Dec-Feb period are likely to be normal to above normal in most of the UK, except in the northeast Chalk aquifer and north of London where normal to below normal levels are more likely.

Rainfall:

Most of the UK received above average rainfall amount in November, with exceptionally high precipitation near the south-eastern coast, and north-eastern Scotland. However, rainfall was below average in the northern extreme of Scotland.
The precipitation outlook for December and the Dec-Feb (issued by the Met Office on 28.11.2022) shows an increased likelihood of drier than normal conditions. The rainfall for the beginning of December has been below average for most of the UK.

River flows:

River flows in November were normal to above normal in most of the UK, with the exception of East Anglia and the far north of Scotland, where they were below normal.
Given the increased likelihood of drier than normal conditions, river flows in December are likely to go back to normal or below normal flows for a large part of the UK. Below normal flows are likely to persist in East Anglia. Normal to above normal flows are more likely in the far southeast of England, as the effect of the exceptional rainfall received in November is likely to persist over this month. Over the three-month period, the same pattern is expected, but the likelihood of normal flows increases across the country.

Groundwater:

Groundwater levels in November were normal to below normal in the northeast Chalk aquifer and north of London, and also in northern Scotland, and exceptionally low in certain cases. In the rest of the country, including the southern Chalk aquifer, the groundwater levels were normal to above normal.
Over the next month and three-month period, the same general pattern is expected to persist over most of the country.

The Hydrological Outlook UK provides an outlook for the water situation for the UK over the next three months and beyond. For guidance on how to interpret the outlook, a wider range of information, and a full description of underpinning methods, please visit the website: www.hydoutuk.net

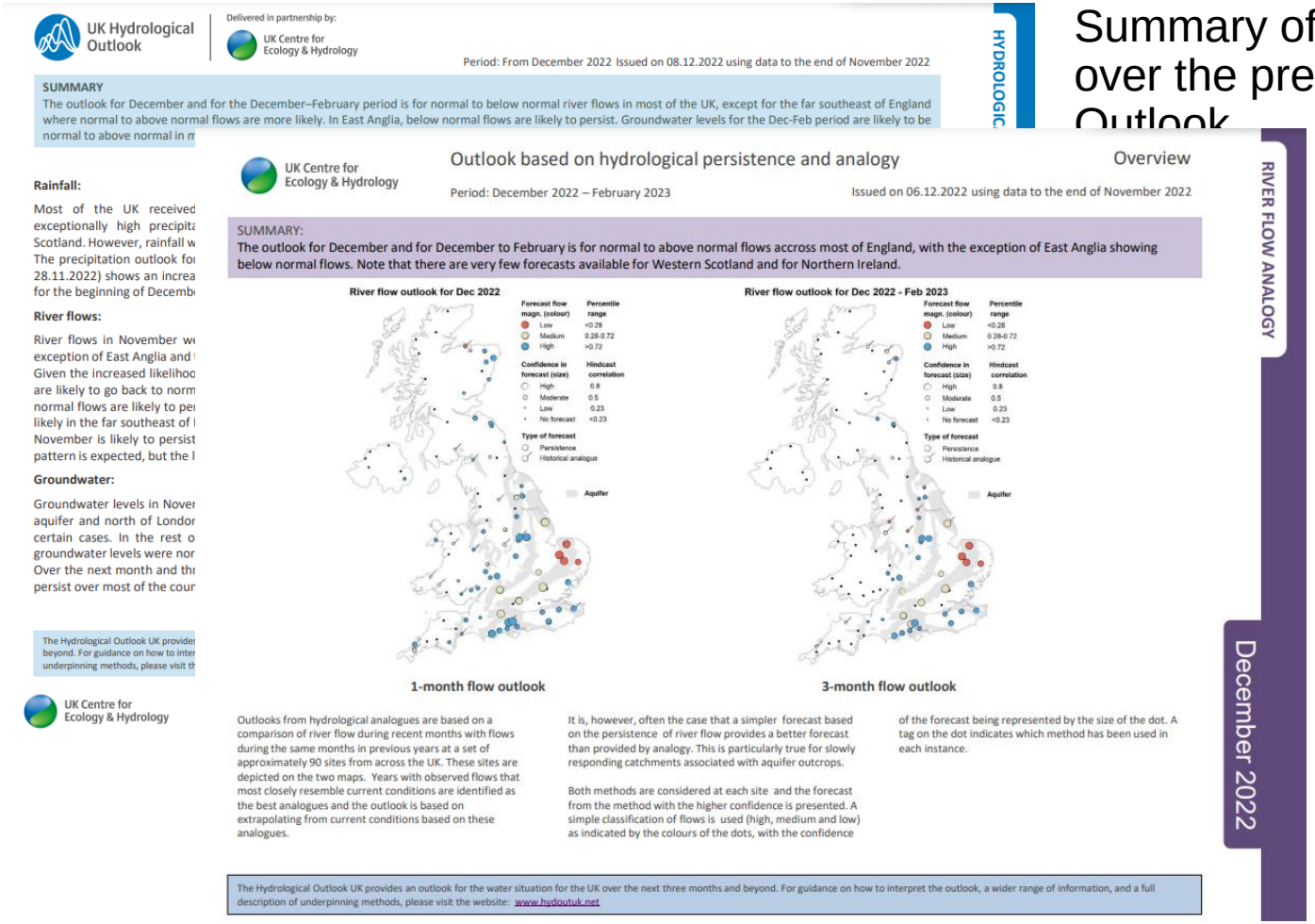
HYDROLOGICAL OUTLOOK UK

December 2022

UK Centre for Ecology & Hydrology · British Geological Survey · Department for Infrastructure Bonneagair · Environment Agency · Met Office · Cyfoeth Naturiol Cymru Natural Resources Wales · SEPA Scottish Environment Protection Agency

Summary of rainfall, river flows and groundwater levels over the previous month, plus high level summary of the Outlook

Hydrological Outlook UK



UK Hydrological Outlook

Delivered in partnership by: UK Centre for Ecology & Hydrology

Period: From December 2022 Issued on 08.12.2022 using data to the end of November 2022

HYDROLOGIC

SUMMARY

The outlook for December and for the December–February period is for normal to below normal river flows in most of the UK, except for the far southeast of England where normal to above normal flows are more likely. In East Anglia, below normal flows are likely to persist. Groundwater levels for the Dec-Feb period are likely to be normal to above normal in n

Rainfall:

Most of the UK received exceptionally high precipita Scotland. However, rainfall w The precipitation outlook fo 28.11.2022) shows an increa for the beginning of Decemb

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River flows in November w exception of East Anglia and Given the increased likelihoo are likely to go back to norm normal flows are likely to pe likely in the far southeast of November is likely to persist pattern is expected, but the

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Groundwater levels in Nover aquifer and north of Londor certain cases. In the rest o groundwater levels were nor Over the next month and th persist over most of the cour

The Hydrological Outlook UK provides beyond. For guidance on how to inter underpinning methods, please visit th

UK Centre for Ecology & Hydrology

UK Centre for Ecology & Hydrology

Outlook based on hydrological persistence and analogy

Overview

Period: December 2022 – February 2023

Issued on 06.12.2022 using data to the end of November 2022

SUMMARY:

The outlook for December and for December to February is for normal to above normal flows accross most of England, with the exception of East Anglia showing below normal flows. Note that there are very few forecasts available for Western Scotland and for Northern Ireland.

River flow outlook for Dec 2022

River flow outlook for Dec 2022 - Feb 2023

Forecast flow magn. (colour) / Percentile range: Low <0.28; Medium 0.28-0.72; High >0.72

Confidence in forecast (size) / Hindcast correlation: High 0.8; Moderate 0.5; Low 0.23; No forecast <0.23

Type of forecast: Persistence; Historical analogue

Aquifer

1-month flow outlook

3-month flow outlook

Outlooks from hydrological analogues are based on a comparison of river flow during recent months with flows during the same months in previous years at a set of approximately 90 sites from across the UK. These sites are depicted on the two maps. Years with observed flows that most closely resemble current conditions are identified as the best analogues and the outlook is based on extrapolating from current conditions based on these analogues.

It is, however, often the case that a simpler forecast based on the persistence of river flow provides a better forecast than provided by analogy. This is particularly true for slowly responding catchments associated with aquifer outcrops.

Both methods are considered at each site and the forecast from the method with the higher confidence is presented. A simple classification of flows is used (high, medium and low) as indicated by the colours of the dots, with the confidence of the forecast being represented by the size of the dot. A tag on the dot indicates which method has been used in each instance.

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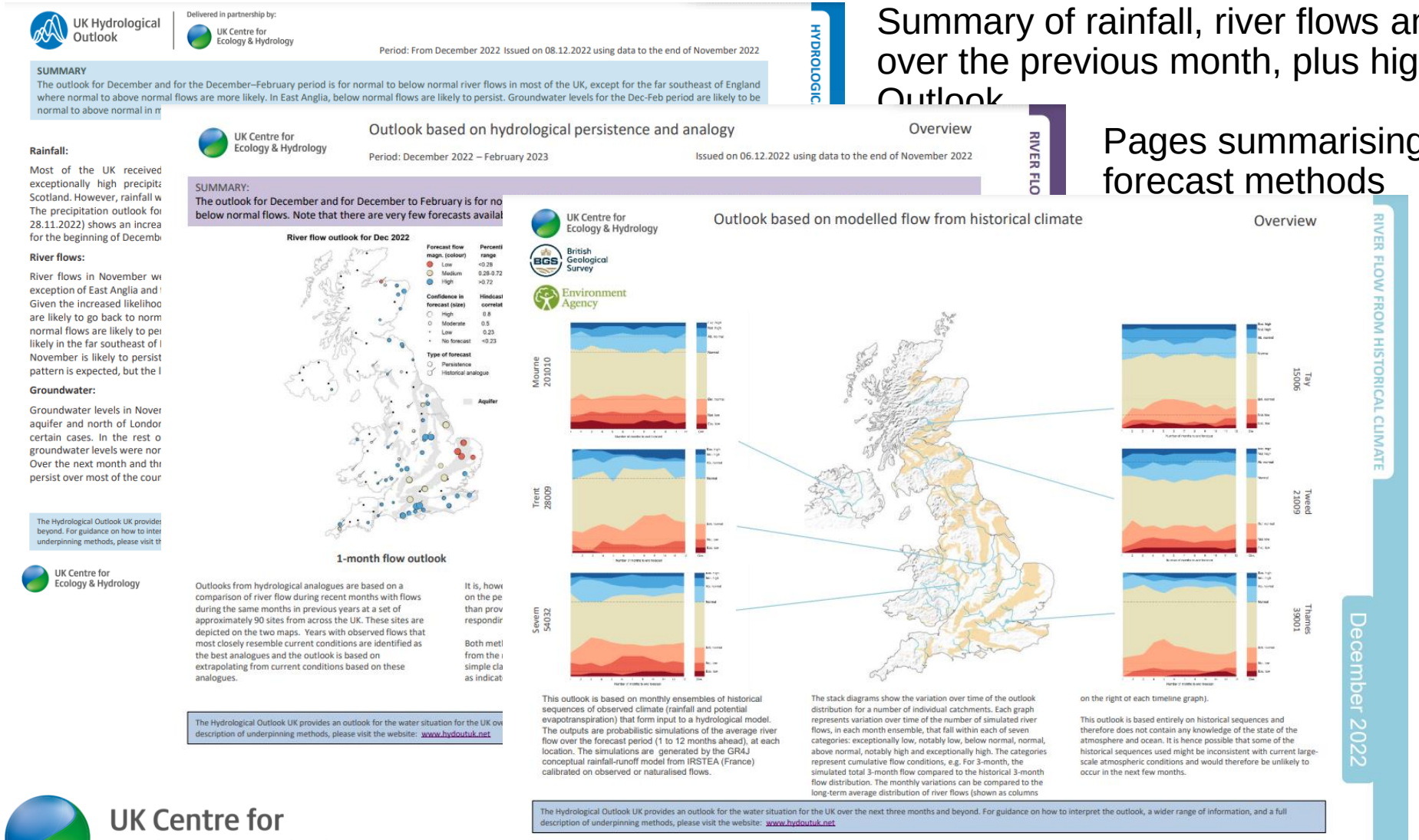
RIVER FLOW ANALOGY

December 2022

Summary of rainfall, river flows and groundwater levels over the previous month, plus high level summary of the Outlook

Pages summarising outputs from different forecast methods

Hydrological Outlook UK

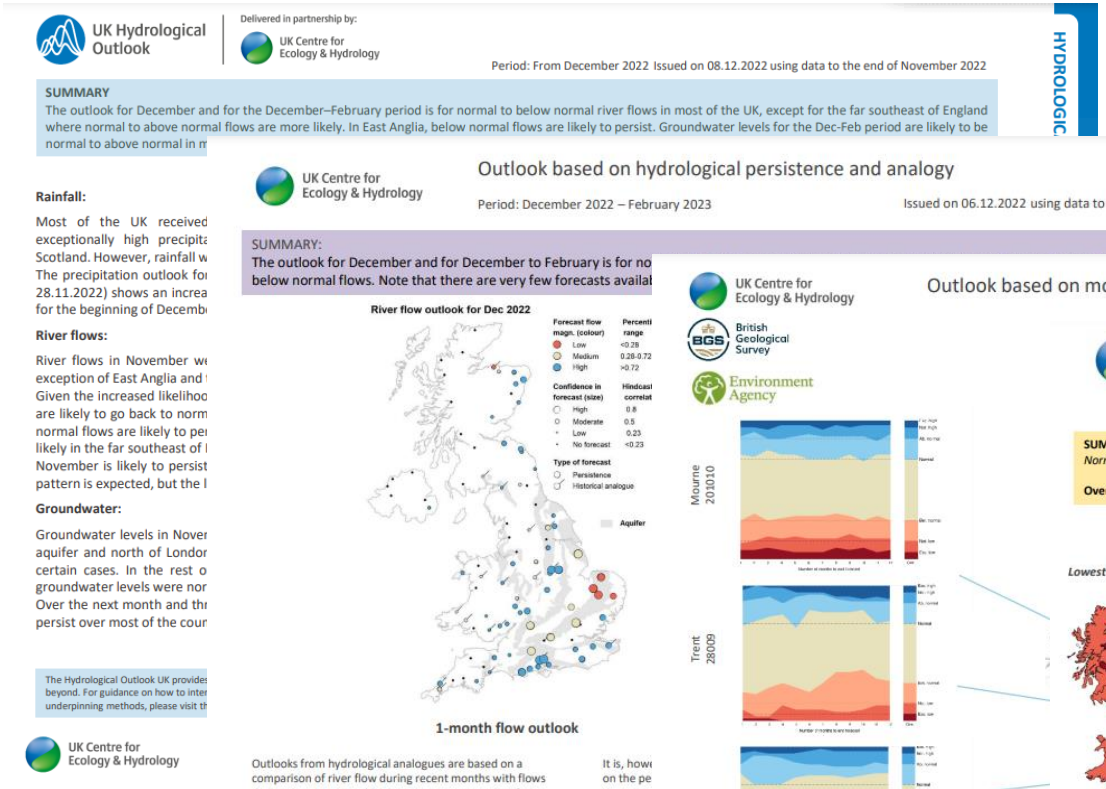


Summary of rainfall, river flows and groundwater levels over the previous month, plus high level summary of the Outlook

Pages summarising outputs from different forecast methods

UK Centre for Ecology & Hydrology

Hydrological Outlook UK


UK Hydrological Outlook

Delivered in partnership by: UK Centre for Ecology & Hydrology

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UK Centre for Ecology & Hydrology

UK Centre for Ecology & Hydrology

Outlook based on hydrological persistence and analogy

Overview

Period: December 2022 – February 2023

Issued on 06.12.2022 using data to the end of November 2022

RIVER FLO

SUMMARY:

The outlook for December and for December to February is for no below normal flows. Note that there are very few forecasts availal

River flow outlook for Dec 2022

Forecast flow magn. (colour) Low Medium High

Percenti range <0.28 0.28-0.72 >0.72

Confidence in forecast (size) High Moderate Low No forecast

Hindcast correlat 0.8 0.5 0.23 <0.23

Type of forecast Persistence Historical analogue

Aquifer

1-month flow outlook

Outlooks from hydrological analogues are based on a comparison of river flow during recent months with flows during the same months in previous years at a set of approximately 90 sites from across the UK. These sites are depicted on the two maps. Years with observed flows that most closely resemble current conditions are identified as the best analogues and the outlook is based on extrapolating from current conditions based on these analogues.

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The Hydrological Outlook UK provides an outlook for the water situation for the UK ov description of underpinning methods, please visit the website: www.hydoutuk.net

UK Centre for Ecology & Hydrology

British Geological Survey

Environment Agency

Outlook based on modelled flow from historical climate

Overview

RIVE

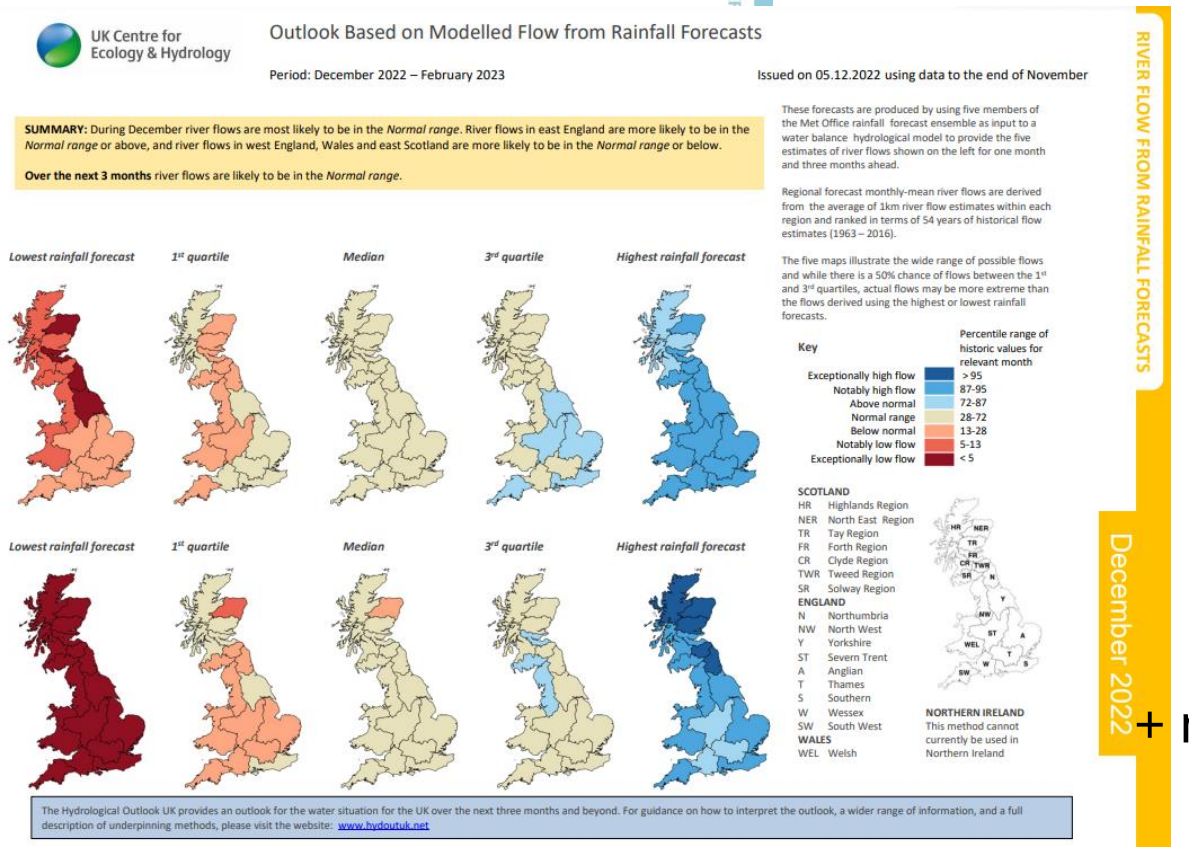
Mourne 201010

Trent 28009

Severn 54032

This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evapotranspiration) that form input to a hydrological model. The outputs are probabilistic simulations of the average river flow over the forecast period (1 to 12 months ahead), at each location. The simulations are generated by the GR4J conceptual rainfall-runoff model from IRSTEA (France) calibrated on observed or naturalised flows.

The Hydrological Outlook UK provides an outlook for the water situation fo description of underpinning methods, please visit the website: www.hydou


UK Centre for Ecology & Hydrology

Outlook Based on Modelled Flow from Rainfall Forecasts

Period: December 2022 – February 2023

Issued on 05.12.2022 using data to the end of November

SUMMARY: During December river flows are most likely to be in the *Normal range*. River flows in east England are more likely to be in the *Normal range* or above, and river flows in west England, Wales and east Scotland are more likely to be in the *Normal range* or below.

Over the next 3 months river flows are likely to be in the *Normal range*.

These forecasts are produced by using five members of the Met Office rainfall forecast ensemble as input to a water balance hydrological model to provide the five estimates of river flows shown on the left for one month and three months ahead.

Regional forecast monthly-mean river flows are derived from the average of 1km river flow estimates within each region and ranked in terms of 54 years of historical flow estimates (1963 – 2016).

The five maps illustrate the wide range of possible flows and while there is a 50% chance of flows between the 1st and 3rd quartiles, actual flows may be more extreme than the flows derived using the highest or lowest rainfall forecasts.

Lowest rainfall forecast *1st quartile* *Median* *3rd quartile* *Highest rainfall forecast*

Lowest rainfall forecast *1st quartile* *Median* *3rd quartile* *Highest rainfall forecast*

Key — Percentile range of historic values for relevant month

Exceptionally high flow	> 95
Notably high flow	87-95
Above normal	72-87
Normal range	28-72
Below normal	13-28
Notably low flow	5-13
Exceptionally low flow	< 5

SCOTLAND
HR Highlands Region
NER North East Region
TR Tay Region
FR Forth Region
CR Clyde Region
TWR Tweed Region
SR Solway Region

ENGLAND
N Northumbria
NW North West
Y Yorkshire
ST Severn Trent
A Anglian
T Thames
S Southern
W Wessex
SW South West

WALES
WEL Welsh

NORTHERN IRELAND
This method cannot currently be used in Northern Ireland

The Hydrological Outlook UK provides an outlook for the water situation for the UK over the next three months and beyond. For guidance on how to interpret the outlook, a wider range of information, and a full description of underpinning methods, please visit the website: www.hydoutuk.net

RIVER FLOW FROM RAINFALL FORECASTS

December 2022

Summary of rainfall, river flows and groundwater levels over the previous month, plus high level summary of the Outlook

Pages summarising outputs from different forecast methods

+ more!

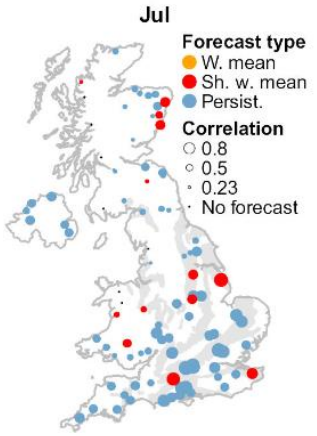
UK Centre for Ecology & Hydrology

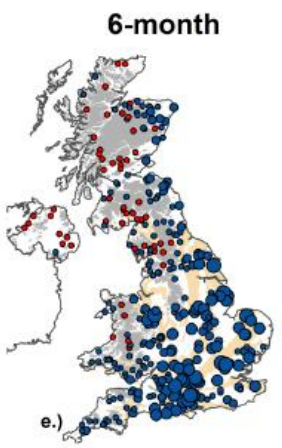
Q. Why use different methods? 1. Data requirements

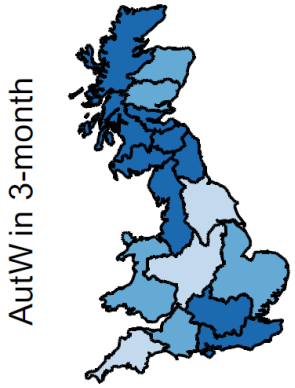
Method	Data needed to set up methodology	Data needed to run forecasts each month	UK Reference
1. Persistence and analogy	• Historic river flow data	• Updated river flow data	Svensson (2016)
2. Ensemble Streamflow Prediction (ESP)	• Historic river flow data • Historic rainfall data • Historic potential evapotranspiration data	• Updated river flow data (for initial conditions) • Updated rainfall data • Updated potential evapotranspiration data	Harrigan et al. (2018)
3. Flows modelled using dynamic rainfall ensemble	• Historic precipitation data • Historic potential evapotranspiration data • Landcover/soil type data • Slope data • Historic river flow data (calibration/validation)	• Updated rainfall data • Update PE data • Rainfall forecasts	Bell et al. (2017)

Q. Why use different methods? 2. Variable forecast skill

Method	UK best skill (seasons)	UK best skill (location)	UK Reference	Example skill maps
1. Persistence and analogy	At 1 to 3mn lead time, most skilful for **Summer**	South and East	Svensson (2016)	
2. Ensemble Streamflow Prediction (ESP)	At 3 to 12mn lead time, most skilful for **Autumn/Winter** At 1mn lead time, most skilful for **Summer**	South and East	Harrigan et al. (2018)	
3. Flows modelled using dynamic rainfall ensemble	At 1 to 3mn lead time, most skilful for **Autumn/Winter**	North and West	Bell et al. (2017)	



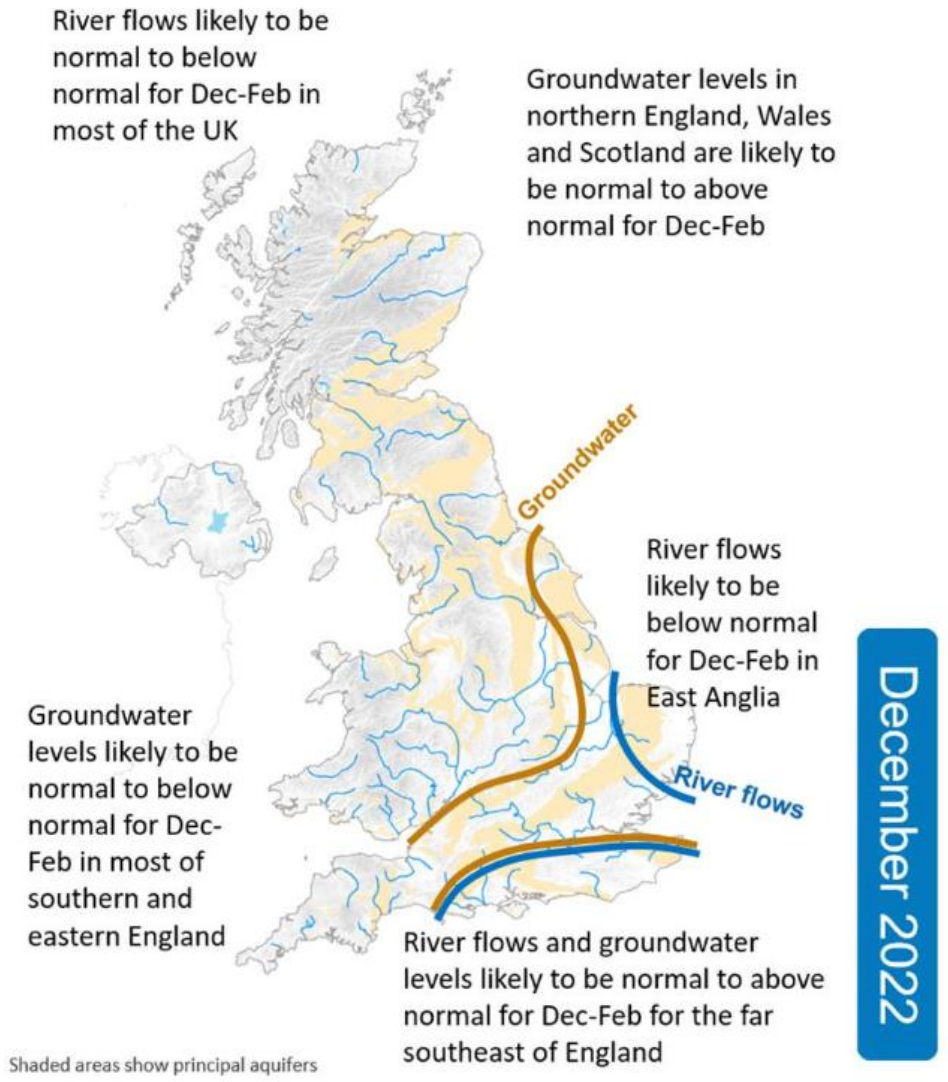




Note: maps use different metrics and hindcast periods, but **darker/larger symbols = more skilful**

Combining approaches

- Multiple approaches to capitalise on strengths of different methods in space and time
- It can be challenging to combine outputs over different spatial and temporal scales
- Monthly discussion forum with all modelling teams in the room to identify the signals emerging across all approaches

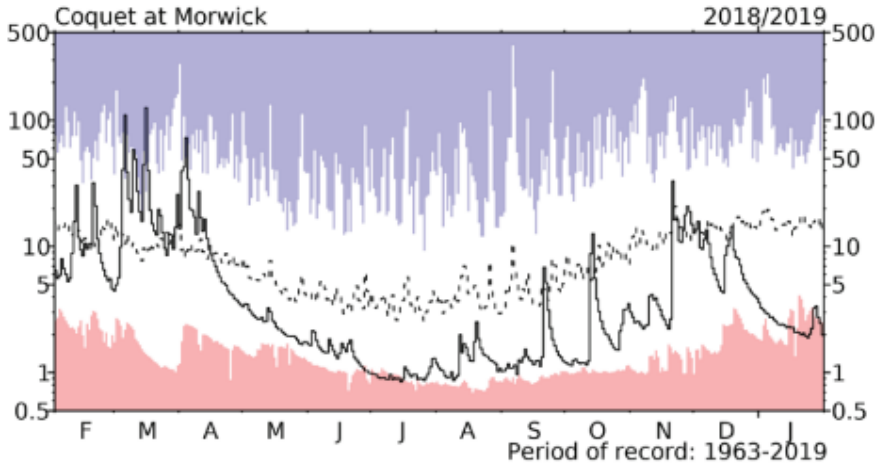


Summary map presents key messages for the forecast

1. Persistence and analogue: Method

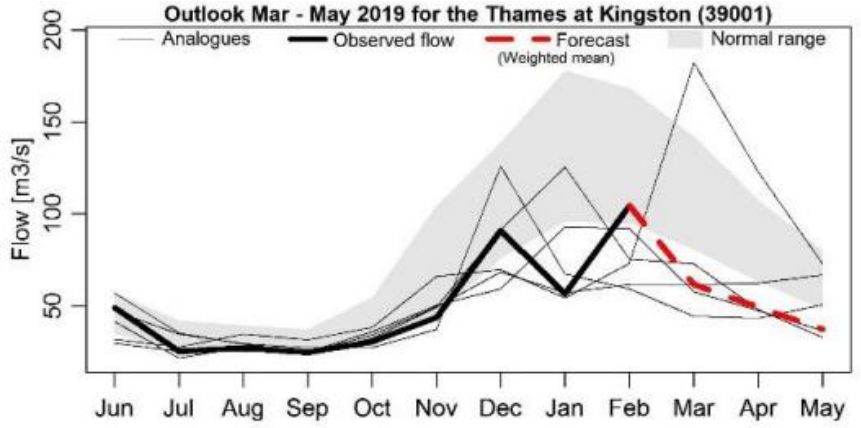
Persistence

- Calculate anomalies from mean monthly streamflow observations
- Persist the streamflow anomaly from one month to the next
- Using standardised anomalies means that the seasonal cycle can be taken into account



Analogues

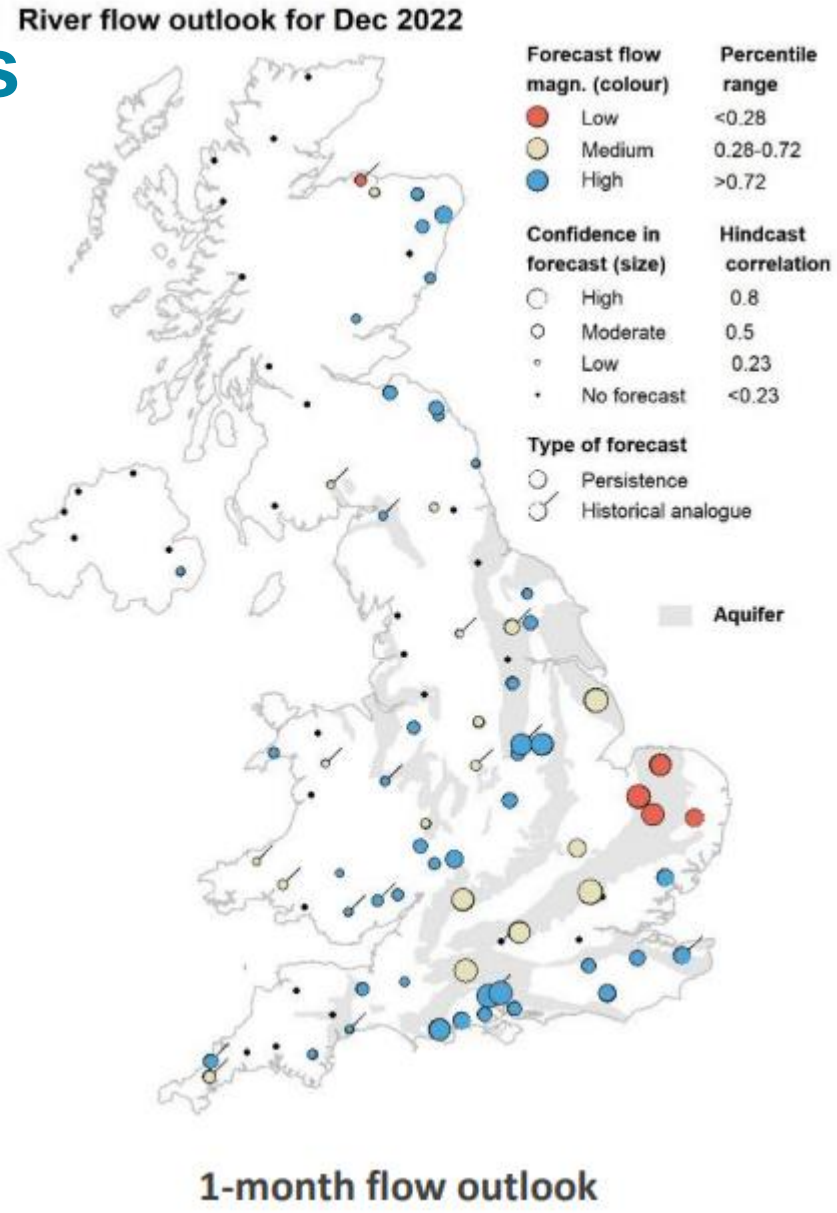
- Compare streamflow anomalies from the past 6 & 9 months with all possible historical sequences of anomalies
- Select **five** that are most similar to the recent past
- Assume streamflow patterns from the past will repeat in the future



1. Persistence and analogue: Outputs

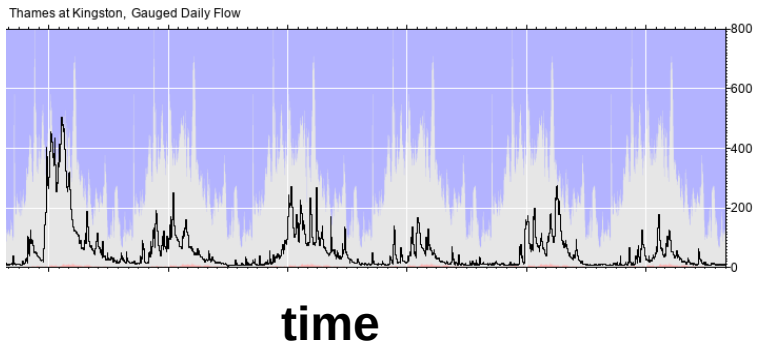
- Spatial output
- For each location and calendar month, use the method that has performed best in the past
- Colour represents flow magnitude

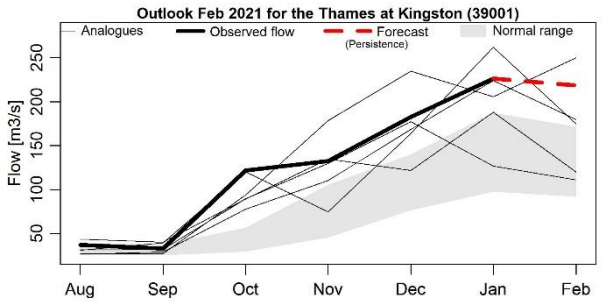
  (**high** / medium / **low**)
- Size represents confidence in the forecast:
  - **big circle = high confidence**

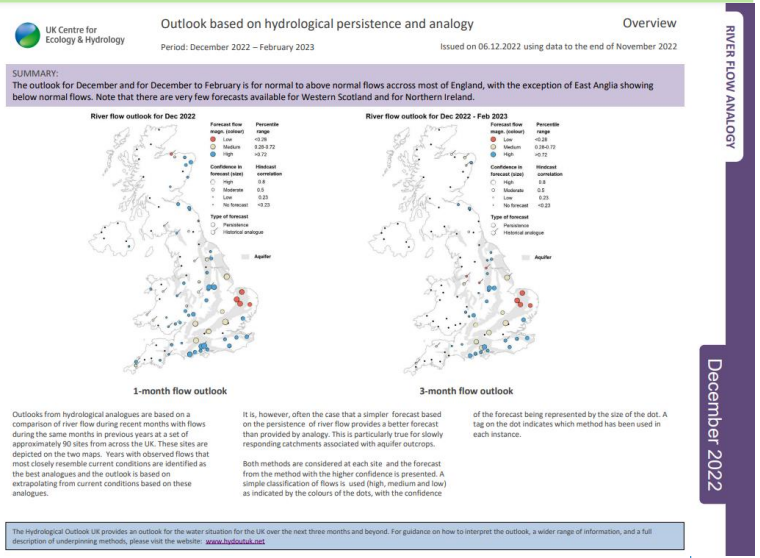


1. Persistence and analogue: Process

Data inputs	Method development steps	Operational requirements
For each catchment: • Historical streamflow time series	R Scripts to: • Identify five analogues from streamflow records • Create forecast using persistence and analogues • Visualise forecasts (timeseries and maps)	Each month: • Timely delivery of flow data • Run method • Run plotting script







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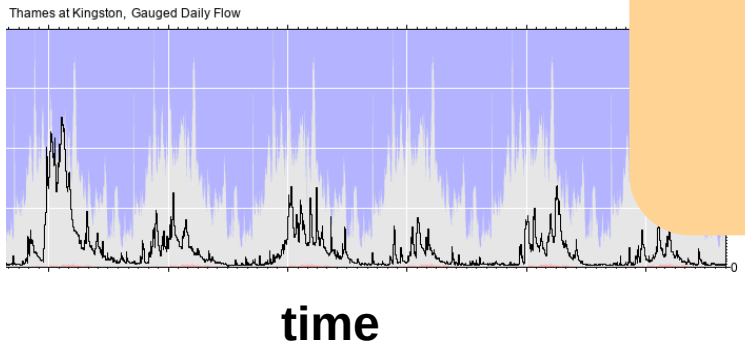
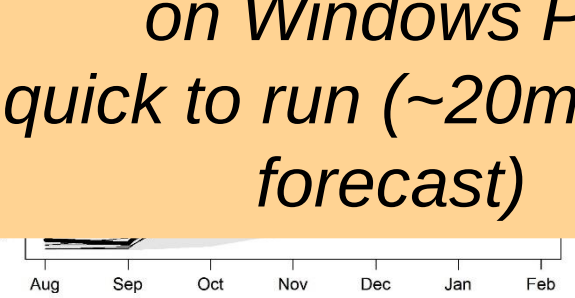
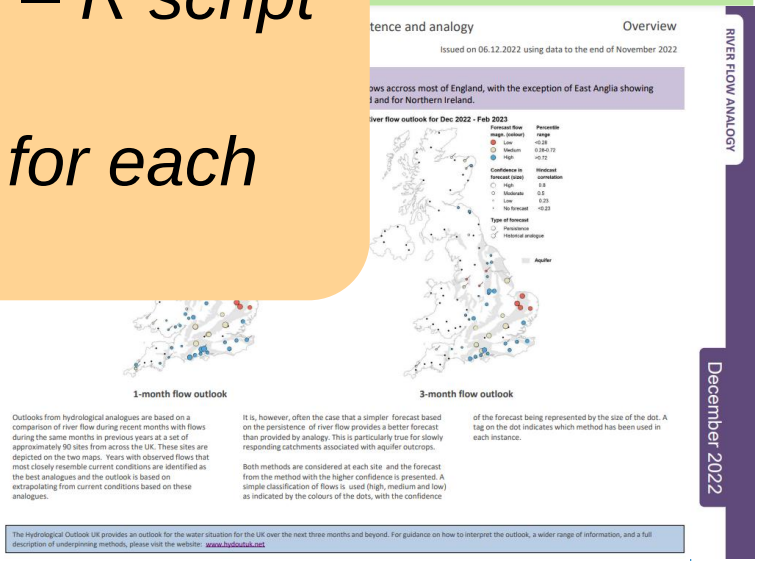
1. Persistence and analogue: Process

Data inputs	Method development steps	Operational requirements
For each catchment: • Historical streamflow time series	R Scripts to: • Identify five analogues from streamflow records • Create forecast using persistence and analogues • Visualise forecasts (timeseries	Each month: • Timely delivery of flow data • Run method • Run plotting script

Small computational demand – R script on Windows PC
Very quick to run (~20mins for each forecast)







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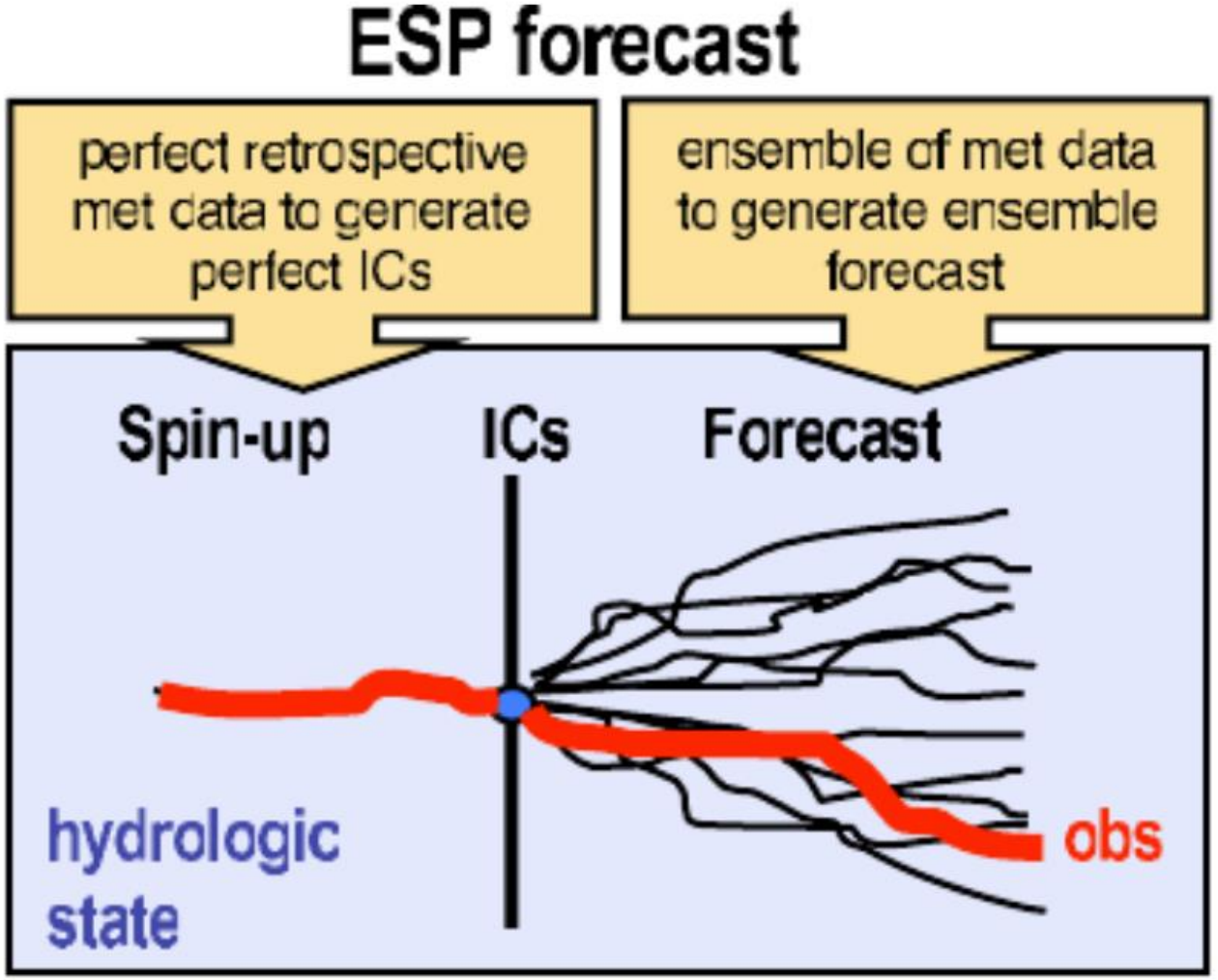
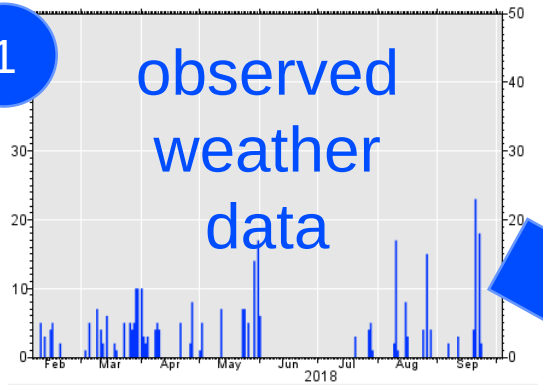
2. Ensemble Streamflow Prediction: Method

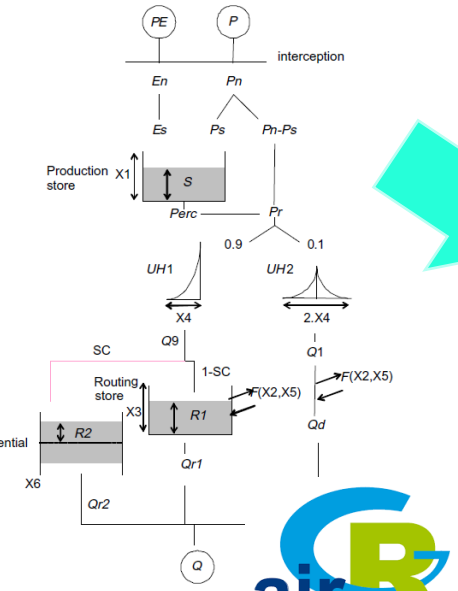


2. Ensemble Streamflow Prediction: Method

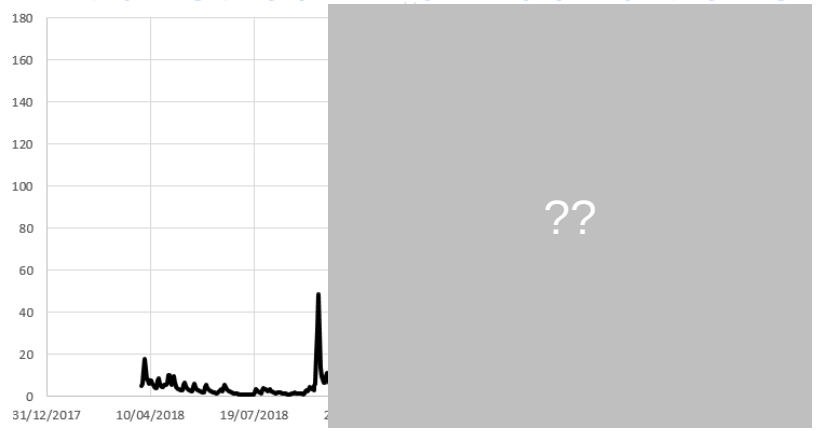
1



lumped catchment hydrological model



initial streamflow conditions



Each year of historic rainfall and PE

2

	PET	Rainfall
958	0.329908	0

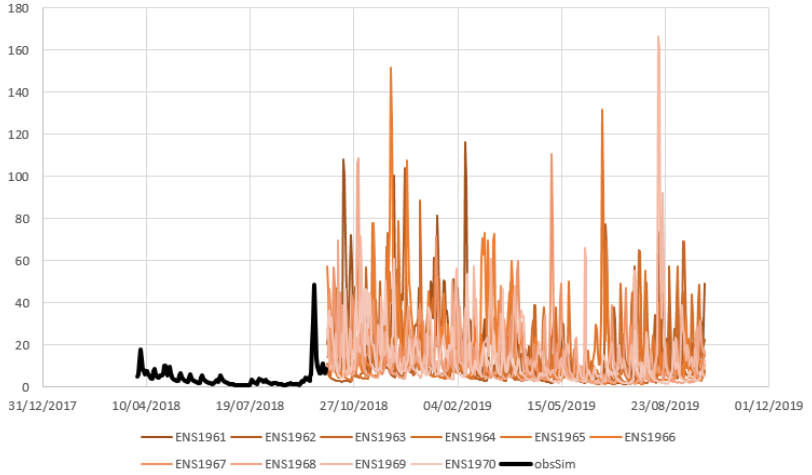
	A	B	C
	ATE	PET	Rainfall
	1/01/1959	0.329908	11.5067

	A	B	C
1	DATE	PET	Rainfall
732	01/01/1960	0.329908	0

	A	B	C
1	DATE	PET	Rainfall
1098	01/01/1961	0.329908	0.889701

	A	B	C
1	DATE	PET	Rainfall
1463	01/01/1962	0.096792	0.020927
1464	02/01/1962	0	0.002141
1465	03/01/1962	0.023837	1.036616
1466	04/01/1962	0.337444	1.532983
1467	05/01/1962	0	6.524311
1468	06/01/1962	0.36599	3.996156
1469	07/01/1962	0.021316	1.480379
1470	08/01/1962	0.259197	6.162475
1471	09/01/1962	0.340038	8.16346
1472	10/01/1962	0.442007	6.092088
1473	11/01/1962	0.080435	3.673692
1474	12/01/1962	0.137007	20.15883

ensemble of streamflow forecasts



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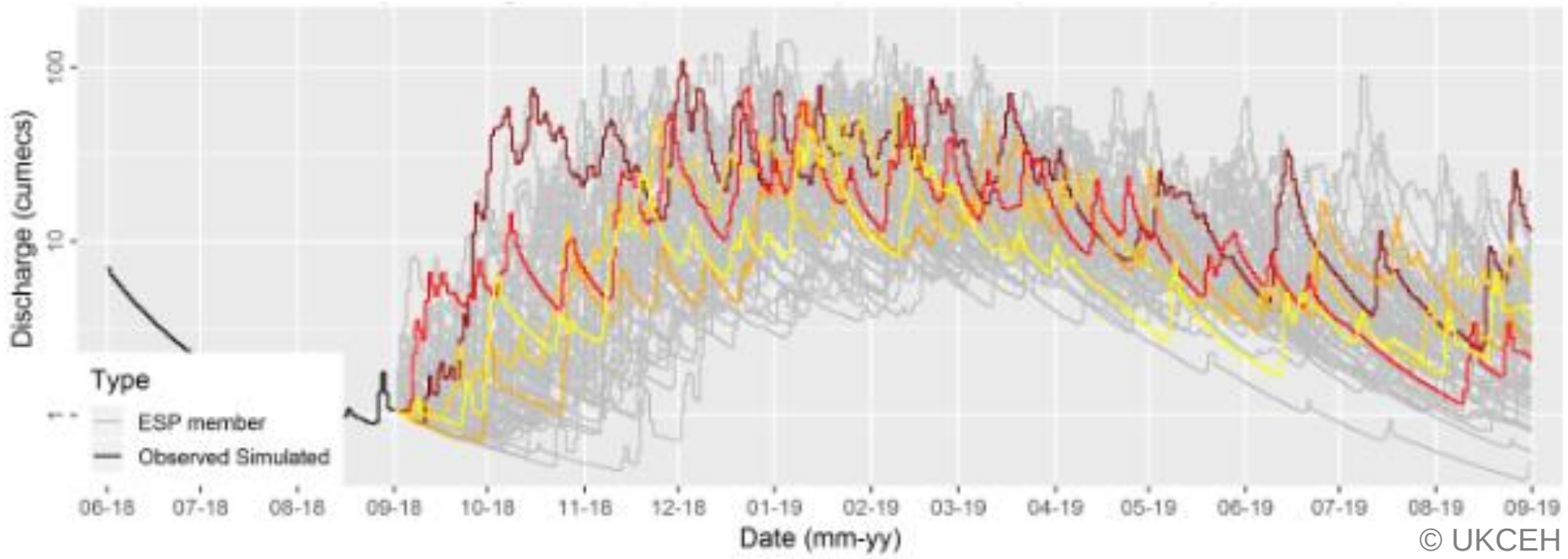
2. Ensemble Streamflow Prediction: Method

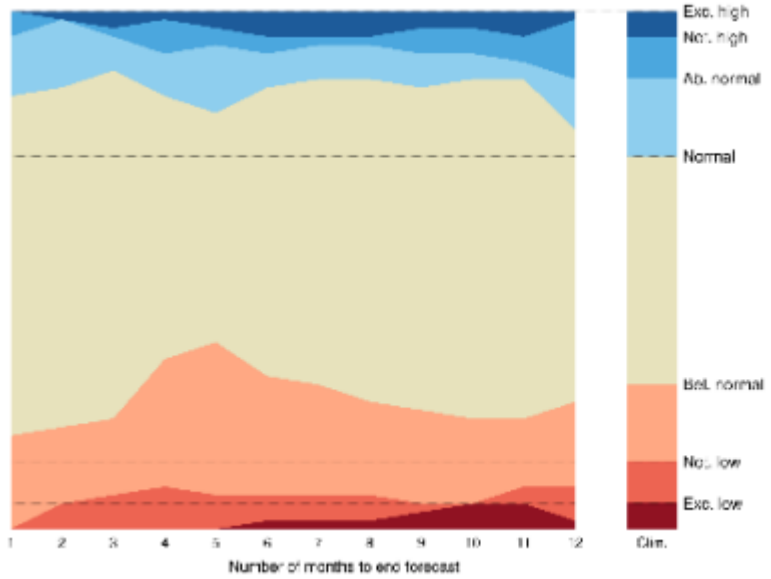
Historical rainfall data are used in the hydrological model to forecast what may happen over the coming months from the initial conditions (which are modelled using observed rainfall)

Each year of historical rainfall run through the model provides an ensemble member

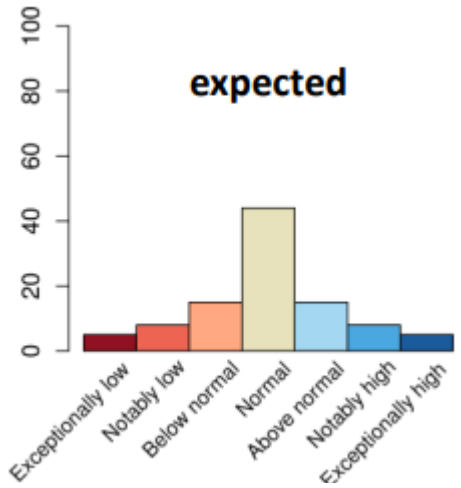


2. Ensemble Streamflow Prediction: Outputs

We can then summarise the forecast for each gauge using the category most of the ensemble members fall into

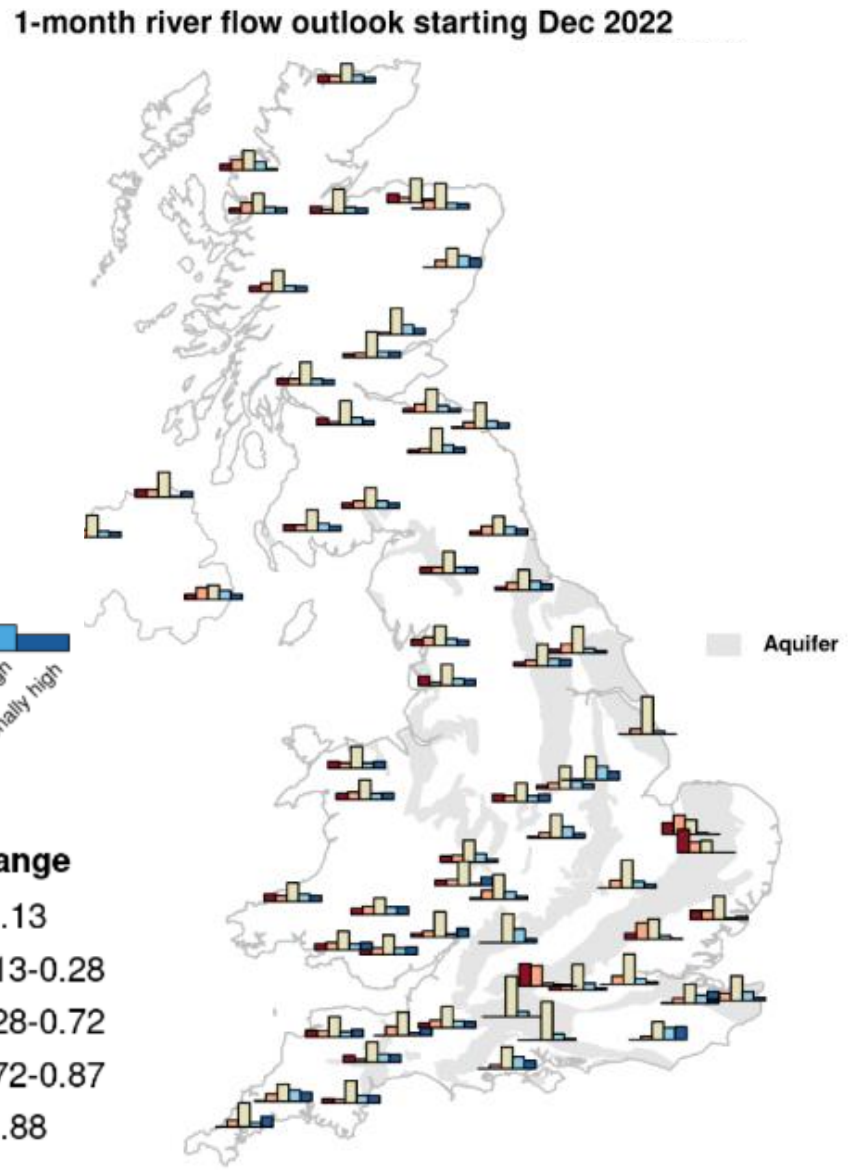


Thames
39001



Outlook category

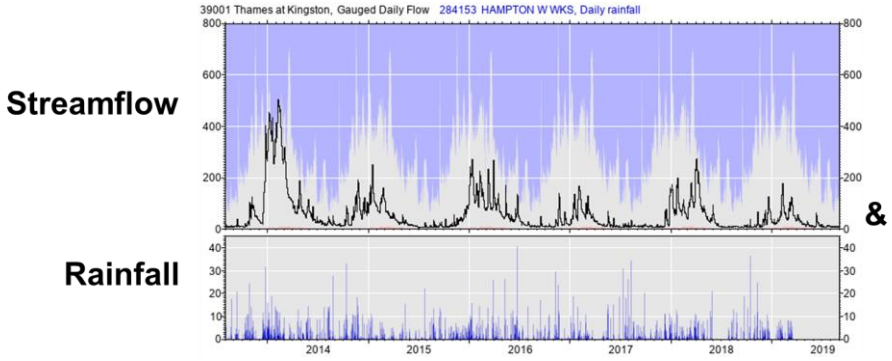
magn. (colour)	range
High	<0.13
Above Normal	0.13-0.28
Normal	0.28-0.72
Below normal	0.72-0.87
Low	>0.88



UK Centre for Ecology & Hydrology

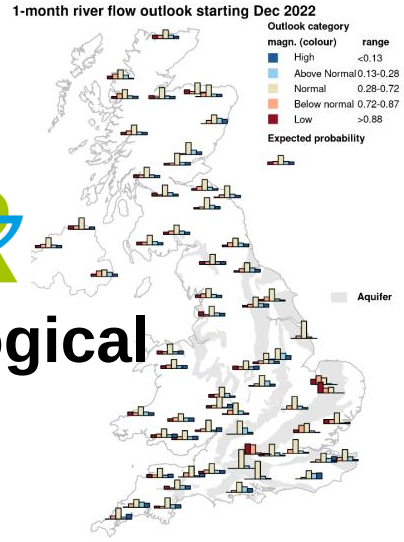
2. Ensemble Streamflow Prediction: Process

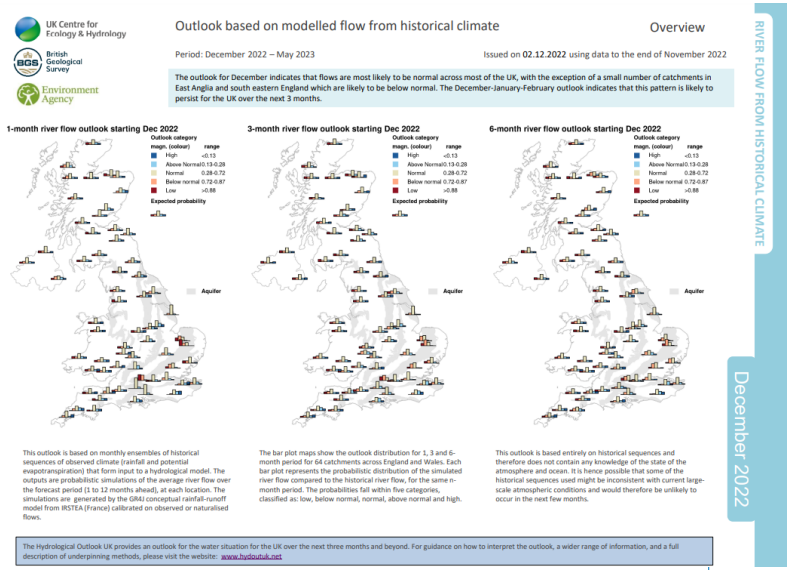
Data inputs	Method development steps	Operational requirements
For each catchment: • Historical catchment average rainfall and PE time series • Historical streamflow time series	Set up catchment hydrological model to use historical climate data • Calibrate and validate catchment model using historical streamflow time series • Script to run method and visualise forecasts	Each month: • Timely delivery of flow data • Run method • Run plotting script



& PE

Hydrological model

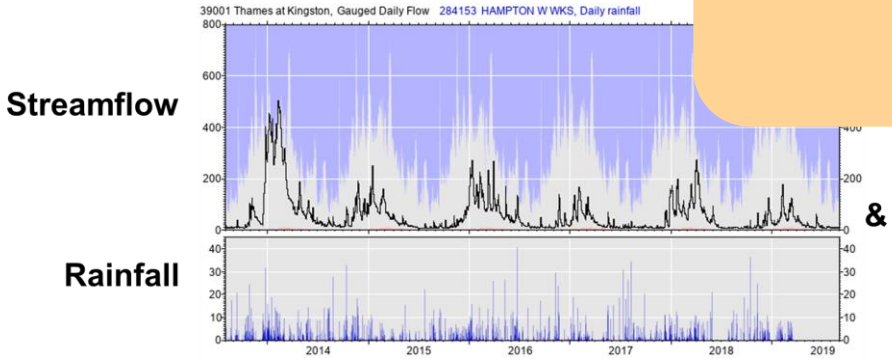




2. Ensemble Streamflow Prediction: Process

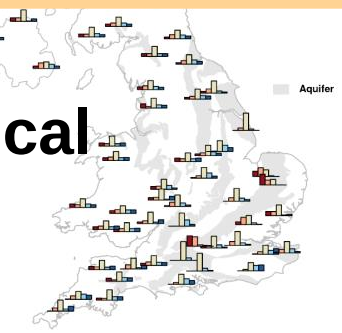
Data inputs	Method development steps	Operational requirements
For each catchment: • Historical catchment average rainfall and PE time series • Historical streamflow time series	Set up catchment hydrological model to use historical climate data • Calibrate and validate catchment model using historical streamflow time series	Each month: • Timely delivery of flow data • Run method • Run plotting script

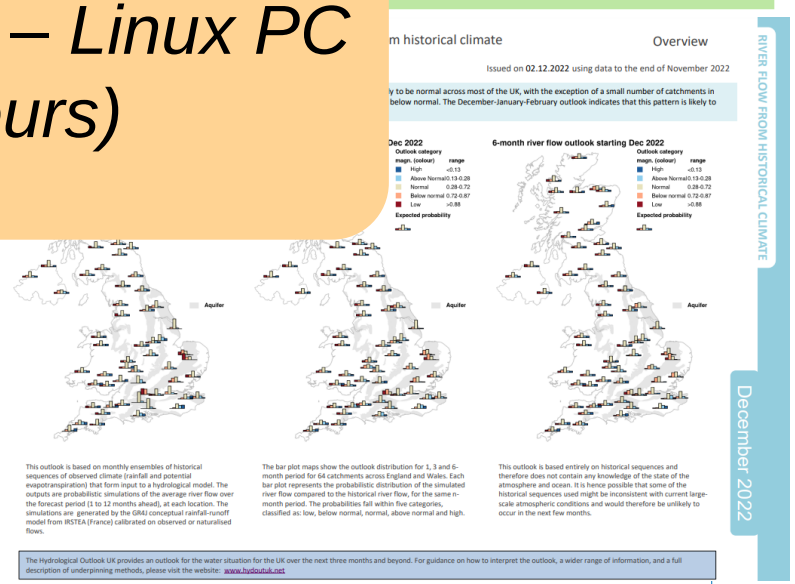
Small computational demand – Linux PC
Quick to run (a few hours)



& PE

Hydrological model



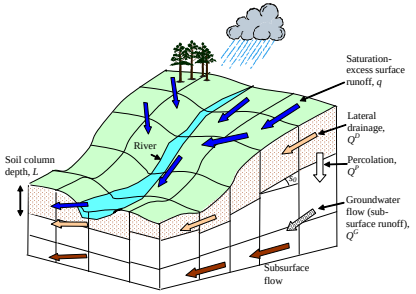


3. Dynamic rainfall forecasts: Method

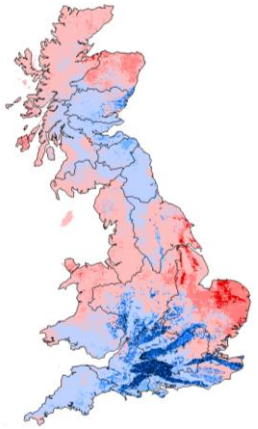
1

Observed weather data

High resolution national scale gridded model

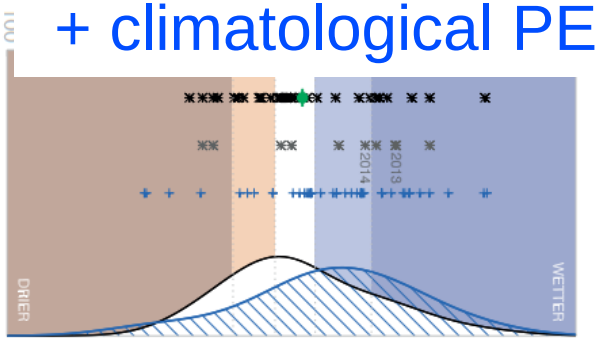


Hydrological initial conditions

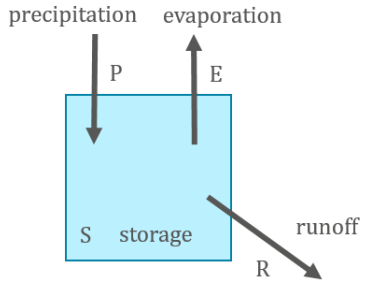


2

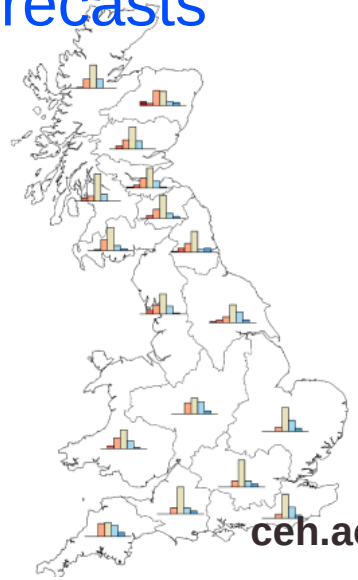
Ensemble of seasonal rainfall forecasts + climatological PE



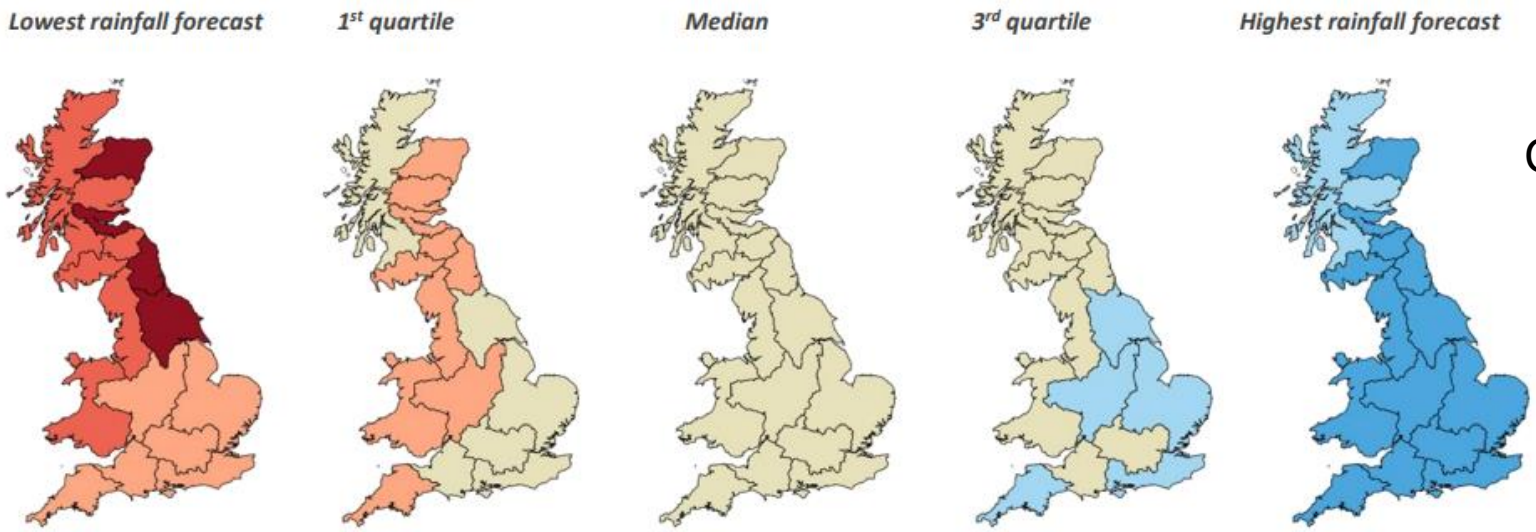
Simple water balance model



Streamflow forecasts

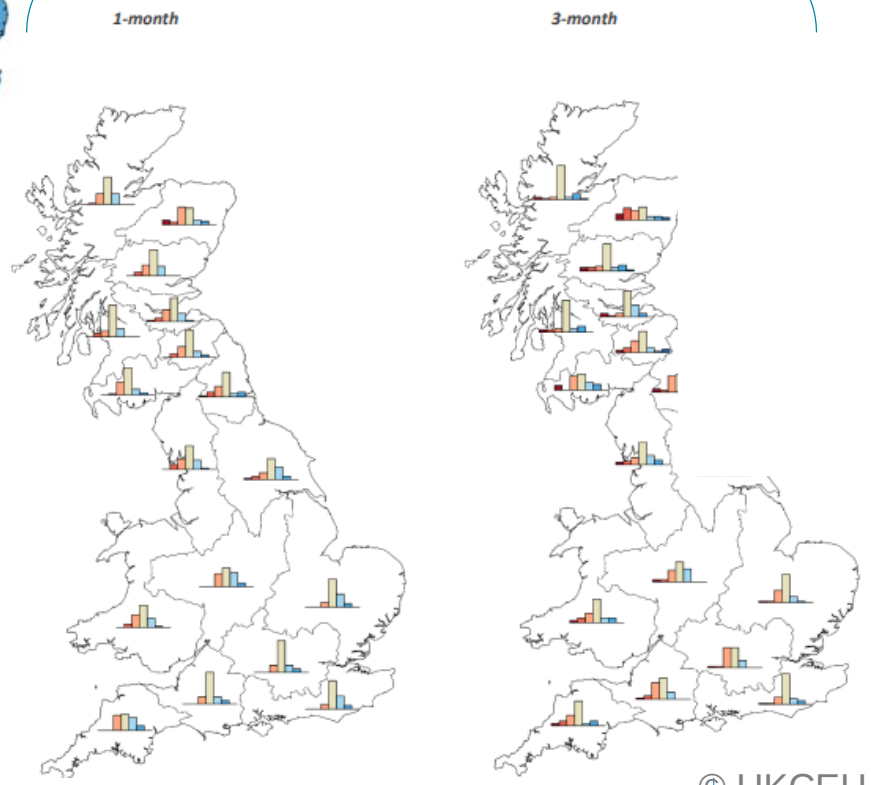


3. Dynamic rainfall forecasts: Outputs



1 month outlook based on 5 member rainfall forecast from UK Met Office

Considers all rainfall forecast ensemble members together showing % of ensemble in each category

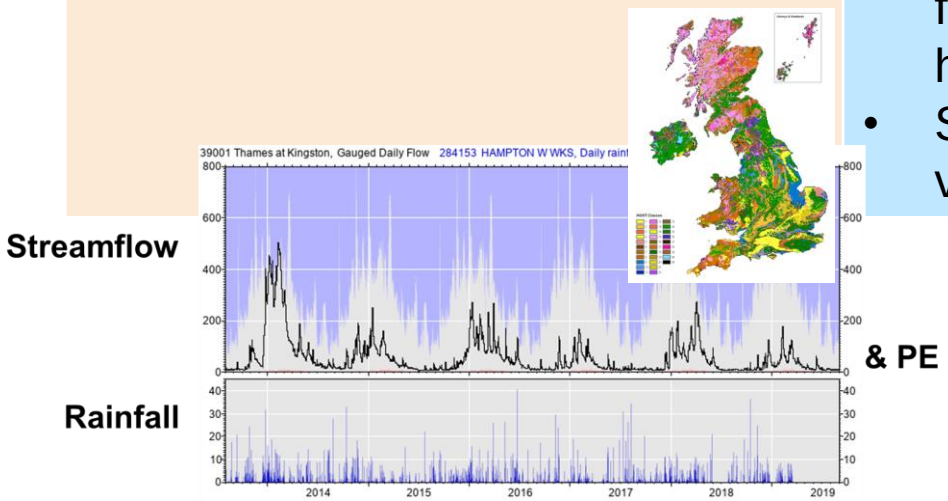


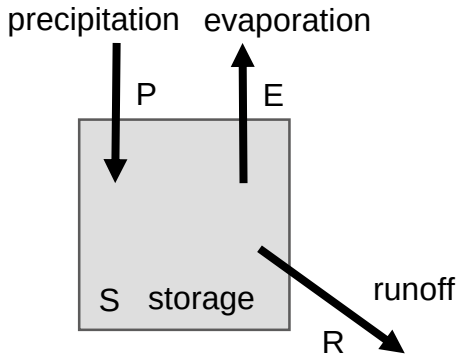
Key	Percentile range of historic values for relevant month
Exceptionally high flow	> 95
Notably high flow	87-95
Above normal	72-87
Normal range	28-72
Below normal	13-28
Notably low flow	5-13
Exceptionally low flow	< 5

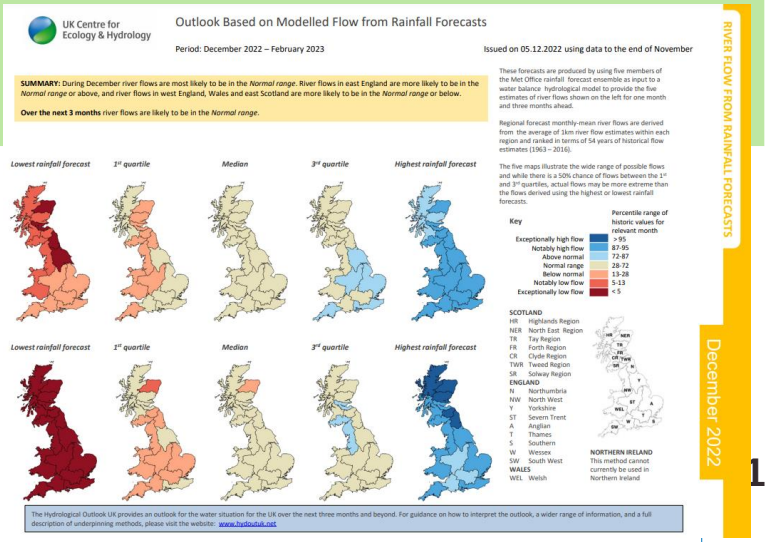
UK Centre for Ecology & Hydrology

3. Dynamic rainfall forecasts: Process

Data inputs	Method development steps	Operational requirements
• Historical rainfall and PE time series – initial conditions • Spatial datasets: Land cover/soil type, Slope • Historical streamflow time series – high-res model validation • Rainfall forecasts	• Set up gridded hydrological model to use historical climate data • Calibrate/validate gridded model using historical streamflow time series • Set up simple gridded water balance model to use rainfall forecasts and high resolution hydrological initial condition • Script to run method and visualise forecasts	Each month: Timely delivery of: • rainfall and PE data • rainfall forecasts Run method Run plotting script



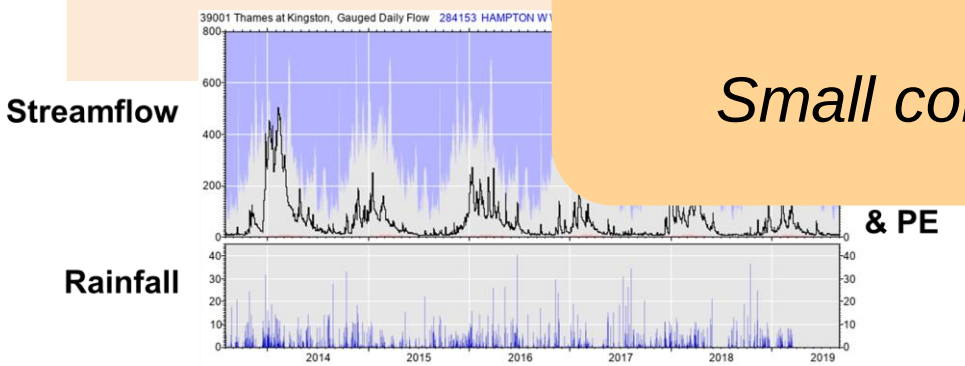




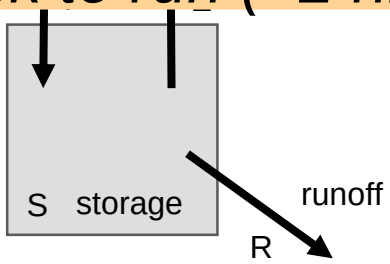
3. Dynamic rainfall forecasts: Process

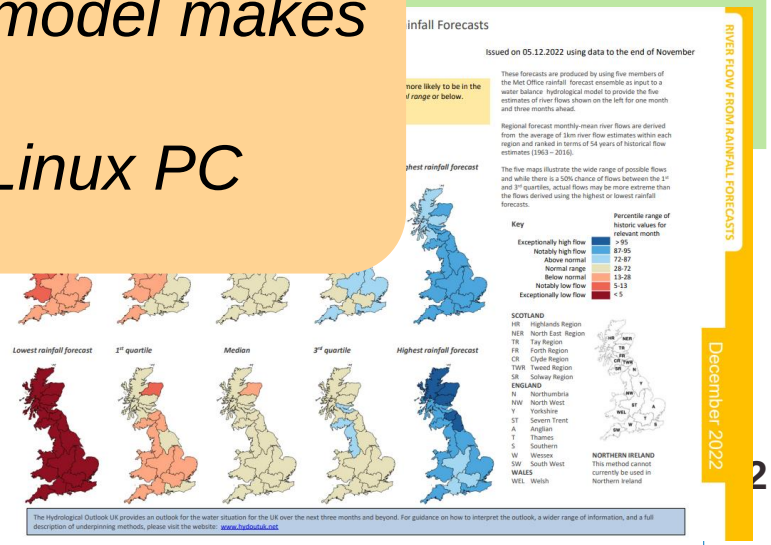
Data inputs	Method development steps	Operational requirements
• Historical rainfall and PE time series – initial conditions • Spatial datasets: Land cover/soil type, Slope • Historical streamflow time series – high-res model validation • Rainfall forecasts	• Set up gridded hydrological model to use historical climate data • Calibrate/validate gridded model using historical streamflow time series • Set up simple gridded water balance model to use rainfall	Each month: Timely delivery of: • rainfall and PE data • rainfall forecasts Run method Run plotting script

High resolution gridded model takes longer to run but monthly time step of forecasting model makes ensemble manageable
Small computational demand – Linux PC
Quick to run (~2 hrs)



& PE

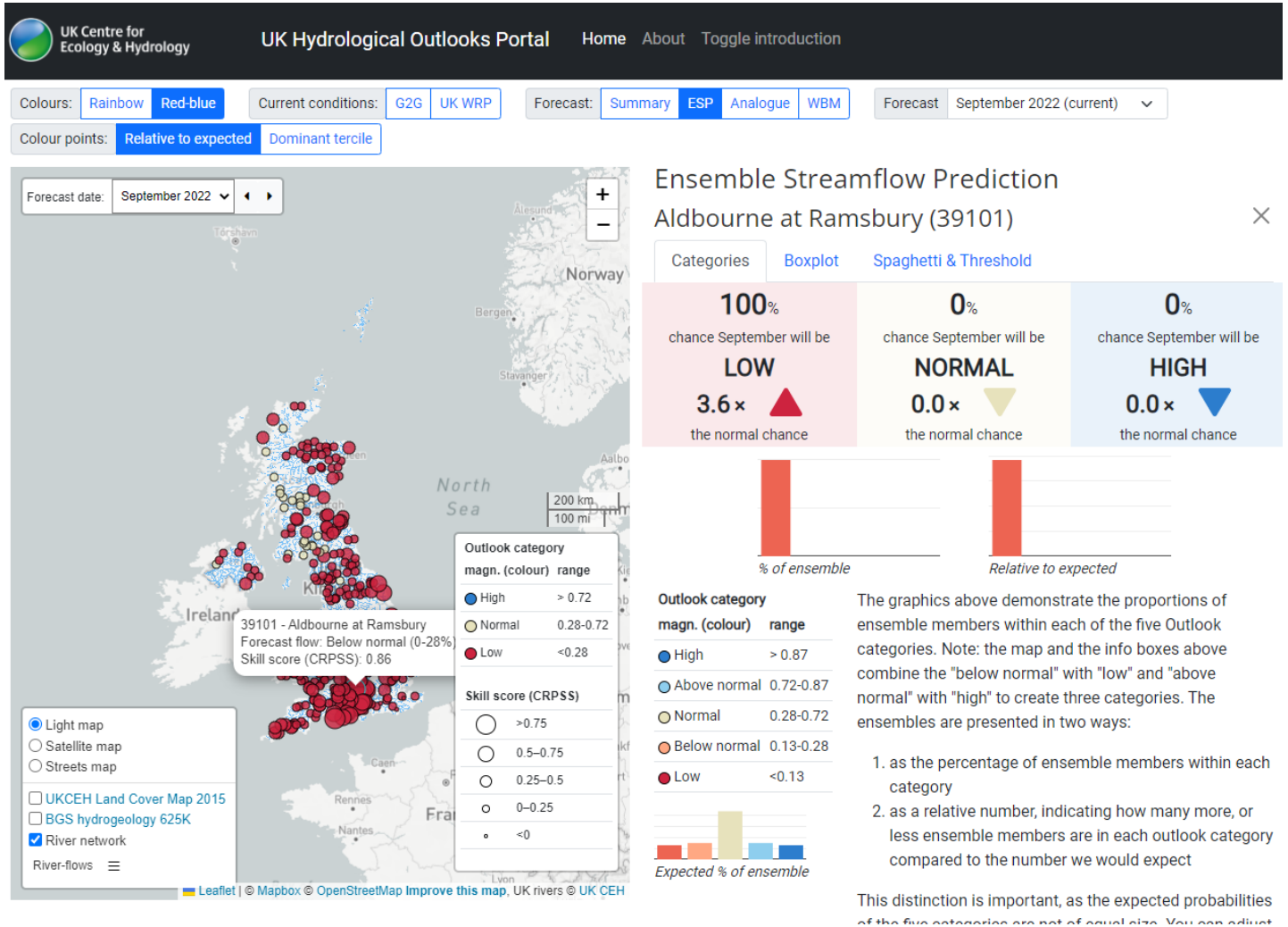




UK Hydrological Outlook: Methods summary

Method	UK best skill (seasons)	UK best skill (location)	UK Reference	Summary
1. Persistence and analogy	At 1 to 3mn lead time, most skilful for **Summer**	South and East	Svensson (2016)	**Simple, just needs past river flow data (no met. forecasts)**
2. Ensemble Streamflow Prediction (ESP)	At 3 to 12mn lead time, most skilful for **Autumn/Winter** At 1mn lead time, most skilful for **Summer**	South and East	Harrigan et al. (2018)	**Fairly simple – freely available, past climate and river flow data**
3. Flows modelled using dynamic rainfall ensemble	At 1 to 3mn lead time, most skilful for **Autumn/Winter**	North and West	Bell et al. (2017)	**Complex – needs weather forecasts, complex distributed model (but could use a simpler one)**

UK Hydrological Outlook Portal



An interactive web-based tool to explore UK seasonal river flow forecasts in more detail

https://eip.ceh.ac.uk/hydrology/outlooks/

Timelines

STATUS

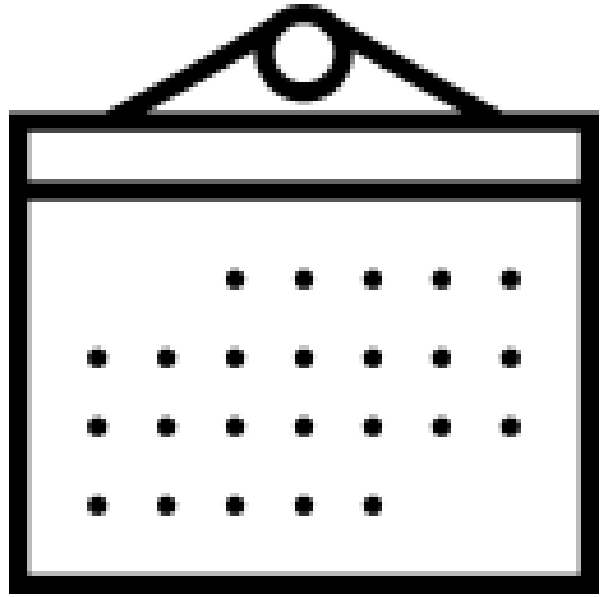
Hydrological Summary – published by 10th working day

- Depends on data provision, potential issues with data (drop outs, missing data etc.)

COSMOS-UK Summary – published by 2nd working day

UK Water Resources Portal – fully updated by 10th working day

- Can be impacted by data provision for status assessment



OUTLOOK

Hydrological Outlook – published by 5/6th working day

- Can be impacted by data provision for status assessment
- ESP forecasts can now be run mid-month with real-time rainfall data we are receiving from the Met Office

Some final thoughts…

- Data storage and update latency
- Consider locations for status assessment and outlooks – e.g. are they representative of the region and/or are they important for monitoring water supplies?
- Are records long enough to normalise data and categorise (e.g. normal range, above/below normal etc.)? Could modelled data be used to provide a longer data record?
- What outlook approach might be feasible based on data (historic and updated each month) and model availability and capacity?
- What skill do outlooks have and are they good enough for decision makers to trust?

Thank You

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November 2022
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UK Centre for
Ecology & Hydrology