Hydrological Outlook UK

Period: From February 2021

Issued on 09.02.2021 using data to the end of January 2021

HYDROLOGICAL OUTLOOK UK

February 2021

SUMMARY

Above normal to exceptionally high river flows are expected to persist in eastern and southern parts of the UK over the next three months. Elsewhere, river flows are likely to be within the normal range for February. Groundwater levels in northern aquifers are likely to be exceptionally high over the next three months, whilst levels in southern aquifers are likely to be normal to exceptionally high in February, and normal to notably high over the three month period February-April.

Rainfall:

Rainfall in January was slightly above average UK-wide, but fell with a very uneven distribution. The majority of England and Wales saw significantly above average rainfall, as high as 170% of average across large areas of north-eastern England, central England and East Anglia. Meanwhile, the majority of Scotland, and western parts of Northern Ireland received below average rainfall.

The rainfall outlook for February (issued by the Met Office on 25.01.21) shows the chance of wet conditions is slightly higher than the chance of dry conditions, and there is an increased likelihood of impacts from heavy rainfall. For February-March-April as a whole, there is a slightly higher-than-normal chance of dry conditions. The probability that UK-average precipitation for February-March-April will fall into the driest of five categories is around 25% and the probability that it will fall into the wettest of five categories is 15% (the 1981-2010 probability for each of these categories is 20%).

River flows:

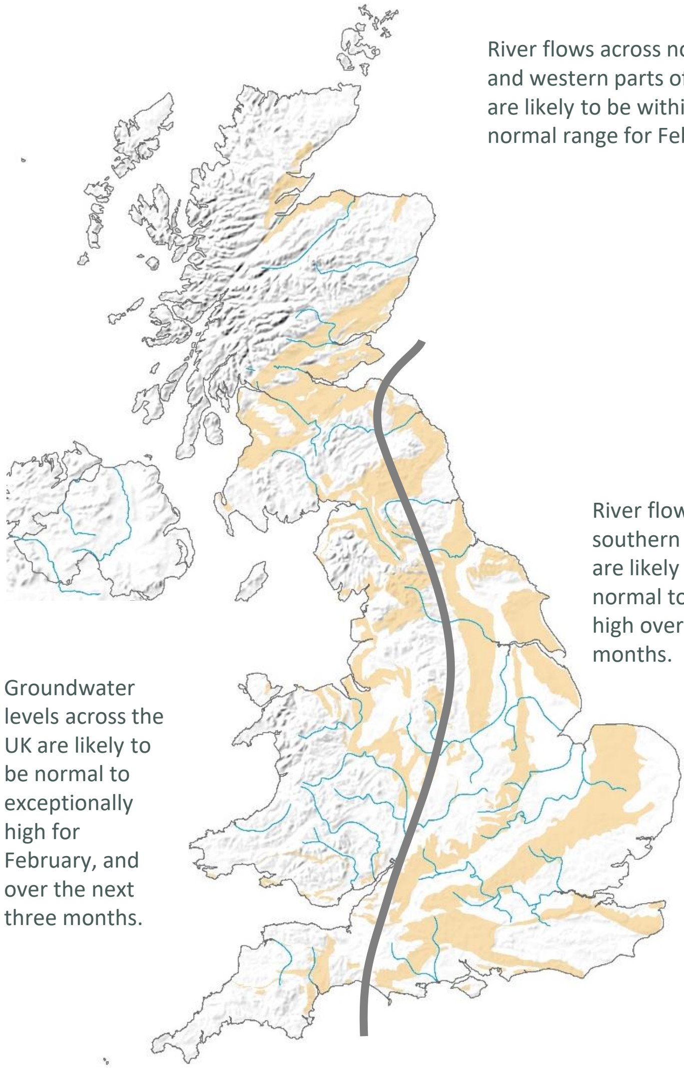
River flows in January were exceptionally high across the majority of England and Wales, with record breaking high flows seen in a large number of catchments in central England, including the Derwent and the Trent. Some river flows in parts of western England, South Wales and southern England remained within the normal range. Six month averaged flows have been above normal to notably high across the majority of England and Wales.

River flows in eastern and southern parts of the UK are expected to remain above normal to exceptionally high for February, and over the next three months, with some localised catchments expected to be within the normal range. River flows in northern and western parts of the UK are likely to be within the normal range for February.

Groundwater:

Groundwater levels in January were exceptionally high in many aquifers across England and Wales, particularly in the northern Permo-Triassic sandstone and Jurassic limestones where several boreholes reported record high groundwater levels. Levels in the southern Chalk were normal to notably high for January.

The outlook is for exceptionally high groundwater levels to persist in the Permo-Triassic sandstones, and the Devonian/Carboniferous aquifers of northern England over the next three months. Groundwater levels further south are likely to be normal to exceptionally high in February, and normal to notably high for the three month period February-April.



Shaded areas show principal aquifers

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UK Centre for Ecology & Hydrology | British Geological Survey | Department for Infrastructure An Roinn Bonneagair www.infrastructure-ni.gov.uk | Environment Agency | Met Office | Cyfoeth Naturiol Cymru Natural Resources Wales | SEPA Scottish Environment Protection Agency

Hydrological Outlook UK

About the Hydrological Outlook:

This document presents an outlook for the UK water situation for the next 1 – 3 months and beyond, using observational datasets, meteorological forecasts and a suite of hydrological modelling tools. The outlook is produced in a collaboration between the UK Centre for Ecology and Hydrology (UKCEH), British Geological Survey (BGS), the Met Office, the Environment Agency (EA), Natural Resources Wales (NRW), the Scottish Environment Protection Agency (SEPA), and for Northern Ireland, the Department for Infrastructure – Rivers (DfIR).

Data and Models:

The Hydrological Outlook depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged. Historic river flow and groundwater data are sourced from the UK National River Flow Archive and the National Groundwater Level Archive. Contemporary data are provided by the EA, SEPA, NRW and DfIR. These data are used to initialise hydrological models, and to provide outlook information based on statistical analysis of historical analogues.

Climate forecasts are produced by the Met Office. Hydrological modelling is undertaken by UKCEH using the Grid-to-Grid, PDM and CLASSIC hydrological models and by the EA using CATCHMOD. Hydrogeological modelling uses the R-groundwater model run by BGS and CATCHMOD run by the EA. Supporting documentation is available from the Outlooks website:
http://www.hydoutuk.net/methods

Presentation:

The language used in the summary presented overleaf generally places flows and groundwater levels into just three classes, i.e. below normal, normal, and above normal. However, the underpinning methods use as many as seven classes as defined in the graphic to the right, i.e. the summary uses a simpler classification than some of the methods. On those occasions when it is appropriate to provide greater discrimination at the extremes the terminology and definitions of the seven class scheme will be adopted.

	Colour	Percentile range of historic values for relevant month
Exceptionally high flow	black	> 95
Notably high flow	blue	87-95
Above normal	cyan	72-87
Normal range	green	28-72
Below normal	yellow	13-28
Notably low flow	orange	5-13
Exceptionally low flow	red	< 5

Disclaimer and liability:

The Hydrological Outlook partnership aims to ensure that all Content provided is accurate and consistent with its current scientific understanding. However, the science which underlies hydrological and hydrogeological forecasts and climate projections is constantly evolving. Therefore any element of the Content which involves a forecast or a prediction should not be relied upon as though it were a statement of fact. To the fullest extent permitted by applicable law, the Hydrological Outlook Partnership excludes all warranties or representations (express or implied) in respect of the Content.

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From April 2018 the Hydrological Outlook is supported by the Natural Environment Research Council funded UK-SCAPE and Hydro-JULES Programmes.

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Further information:

For more detailed information about the Hydrological Outlook, and the derivation of the maps, plots and interpretation provided in this outlook, please visit the Hydrological Outlook UK website.

The website features a host of other background information, including a wider range of sources of information which are used in the preparation of this Outlook.

Contact:

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t: 01491 692371 e: enquiries@hydoutuk.net

Reference for the Hydrological Outlook:

Hydrological Outlook UK, 2021, February, UK Centre for Ecology and Hydrology, Oxfordshire UK, Online, http://www.hydoutuk.net/latest-outlook/

Other Sources of Information:

The Hydrological Outlook should be used alongside other sources of up-to-date information on the current water resources status and flood risk.

Environment Agency Water Situation Reports: provides summary of water resources status on a monthly and weekly basis for England:
https://www.gov.uk/government/collections/water-situation-reports-for-england

Flood warnings are continually updated, and should be consulted for an up-to-date and localised assessment of flood risk:
Environment Agency: https://flood-warning-information.service.gov.uk/map
Scottish Environment Protection Agency: http://www.sepa.org.uk/flooding.aspx

Hydrological Summary for the UK: provides summary of current water resources status for the UK:
https://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk

UK Met Office forecasts for the UK:
www.metoffice.gov.uk/public/weather/forecast/#?tab=regionalForecast

UK Water Resources Portal: monitor the UK hydrological situation in near real-time including rainfall, river flow, groundwater and soil moisture from COSMOS-UK:
https://eip.ceh.ac.uk/hydrology/water-resources/

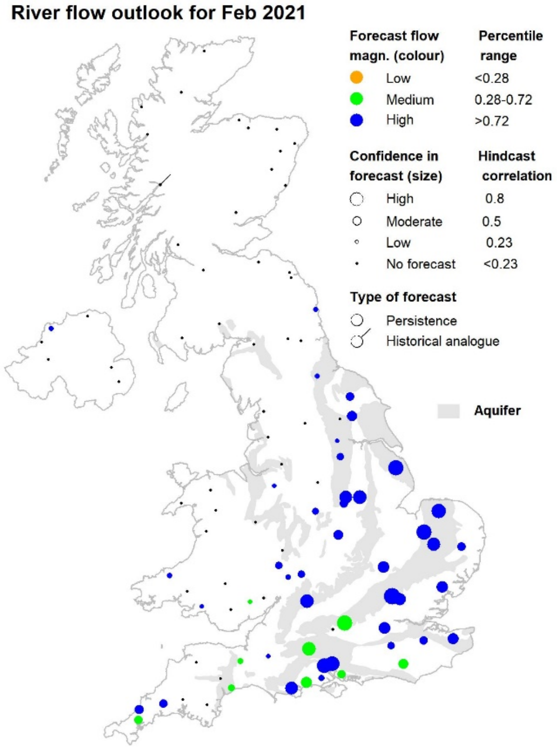
UK Centre for Ecology & Hydrology

Outlook based on hydrological persistence and analogy

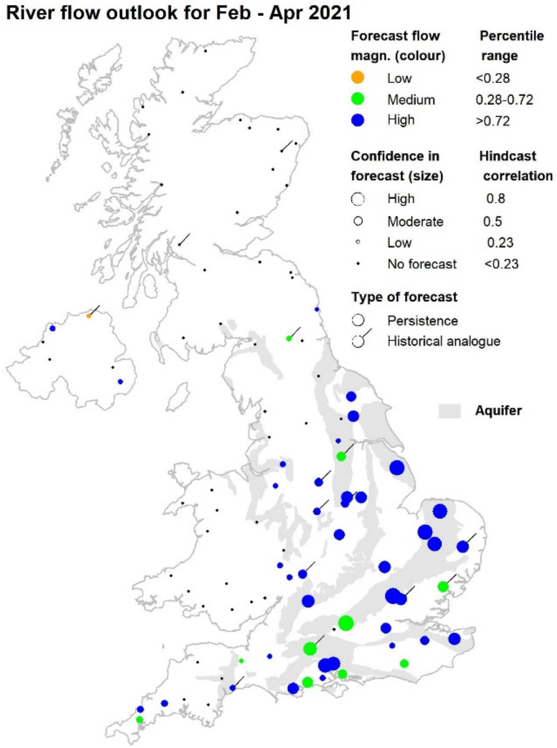
Period: February – April 2021

Issued on 05.02.2021 using data to the end of January 2021

SUMMARY
The outlooks for February and for February-April are for normal to above normal flows in south, central and eastern England, with hardly any forecasts available for the rest of the UK.



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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Outlook based on hydrological persistence and analogy

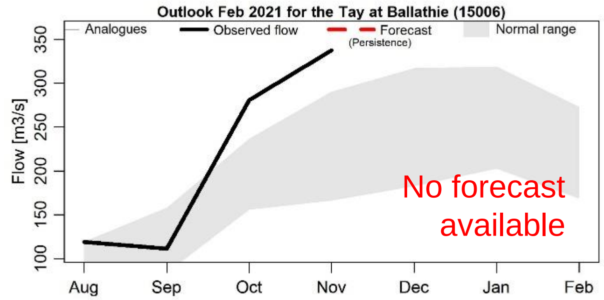
Site-based: 1 month outlook

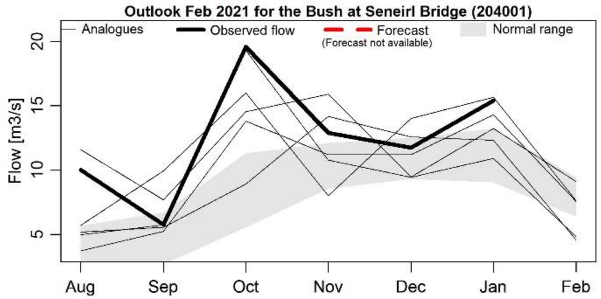
Period: February 2021

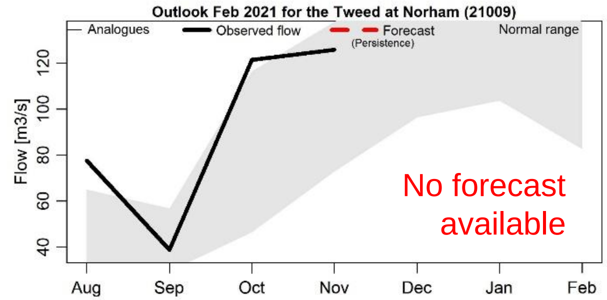
Issued on 05.02.2021 using data to the end of January 2021

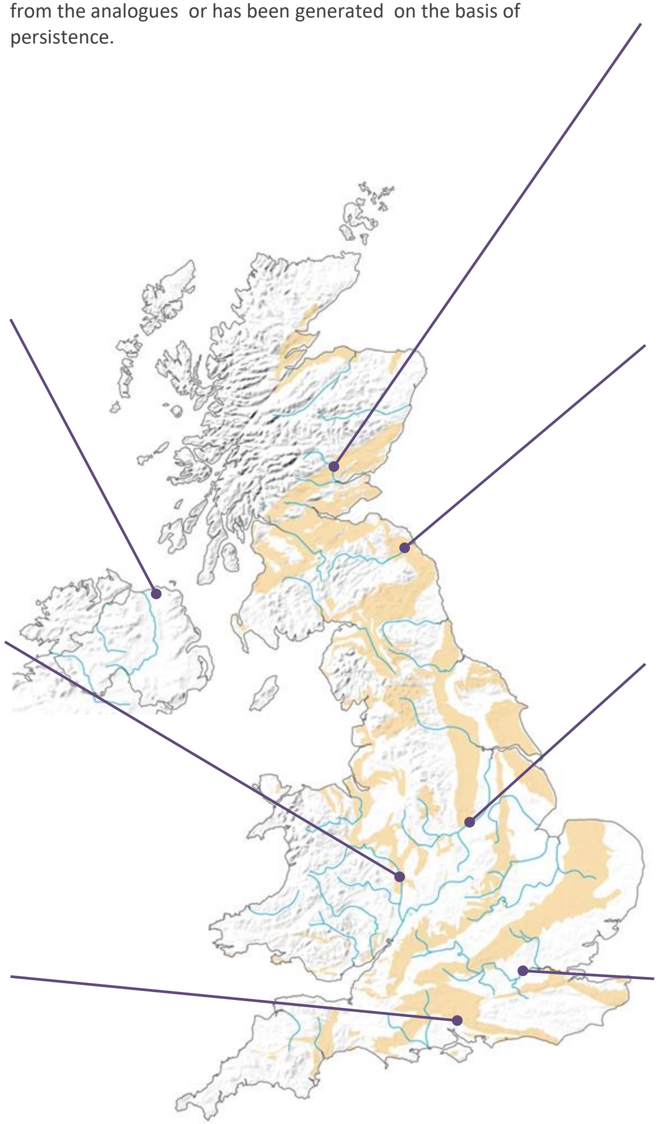
These figures provide insight into the hydrological analogue methodology for a set of sites from across the UK.

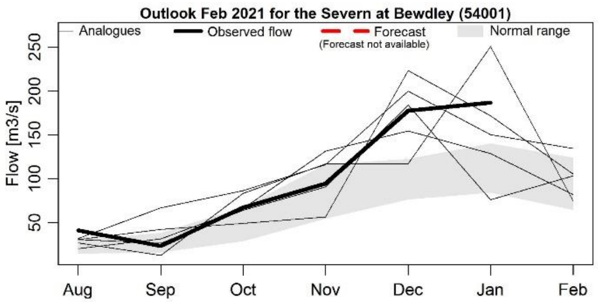
In each of the time series graphs the bold black line represents the observed flow during the past six months. The grey band indicates the normal flow range (the normal band includes 44% of observed flows in each month). The selected analogues are shown as thin lines and the trajectories that flows took in the following month are also shown. The forecast is shown as the dashed red line, and in each plot it states whether this has come from the analogues or has been generated on the basis of persistence.

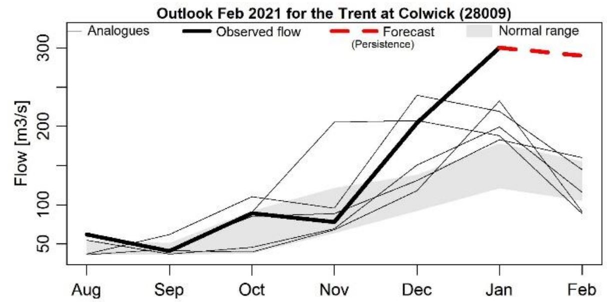


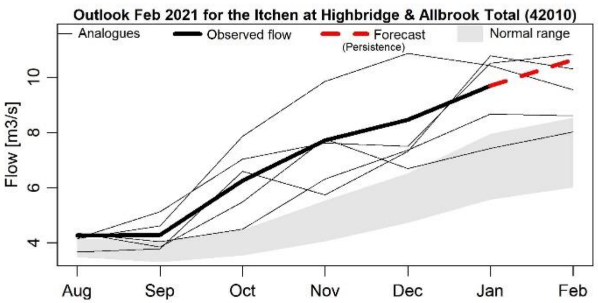


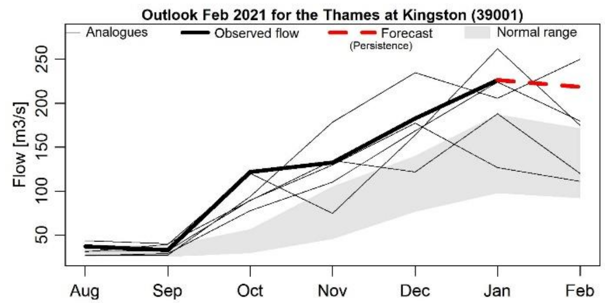












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Outlook based on hydrological persistence and analogy

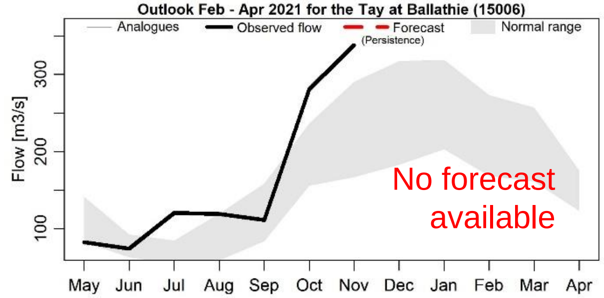
Site-based: 3 month outlook

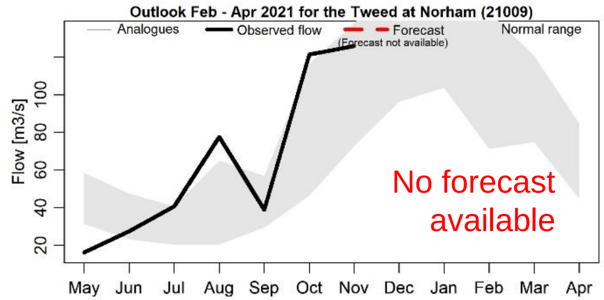
Period: February – April 2021

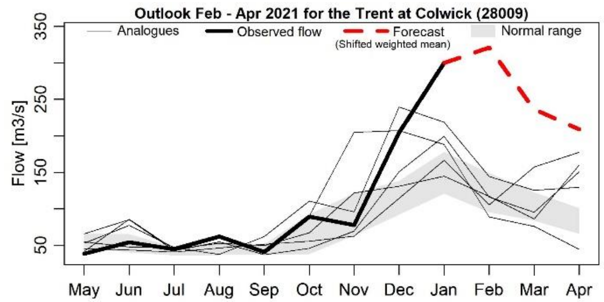
Issued on 05.02.2021 using data to the end of January 2021

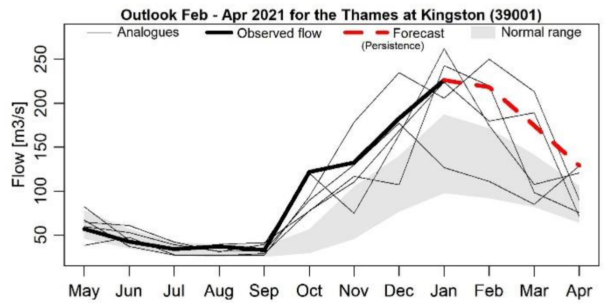
These figures provide insight into the hydrological analogue methodology for a set of sites from across the UK.

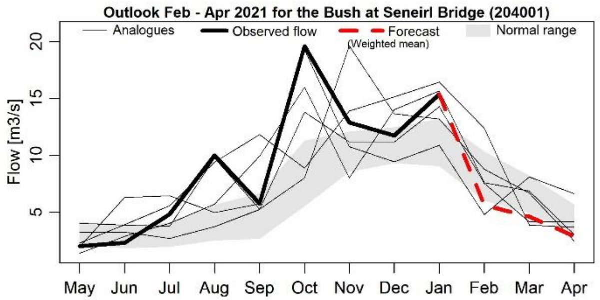
In each of the time series graphs the bold black line represents the observed flow during the past nine months. The grey band indicates the normal flow range (the normal band includes 44% of observed flows in each month). The selected analogues are shown as thin lines and the trajectories that flows took in the following three months are also shown. The forecast is shown as the dashed red line, and in each plot it states whether this has come from the analogues or has been generated on the basis of persistence.

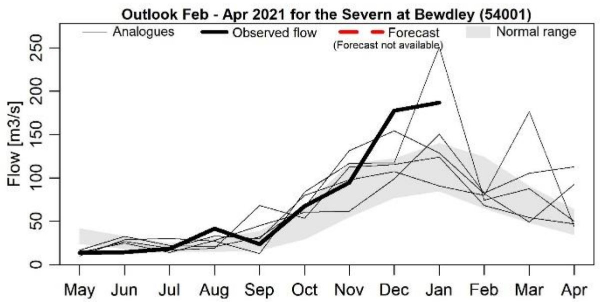


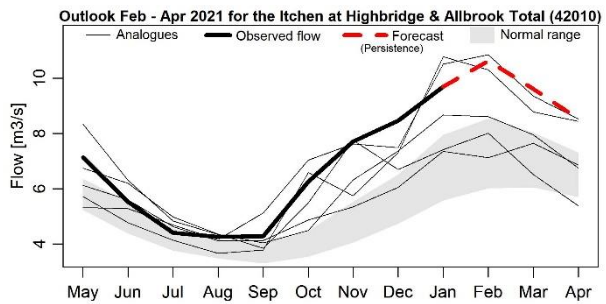


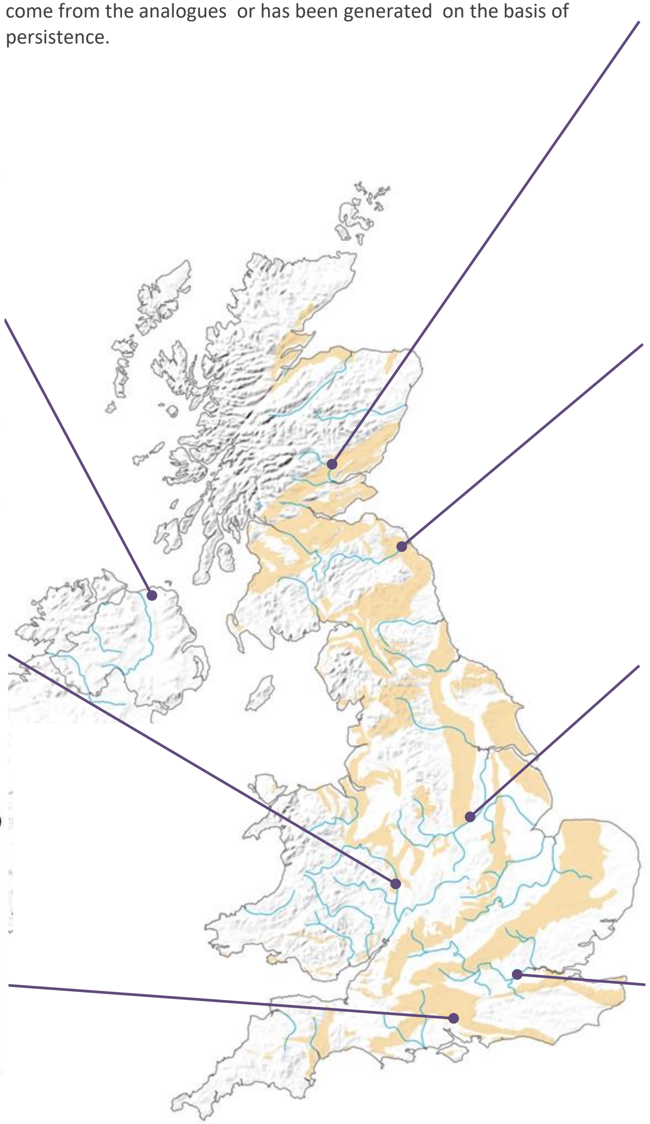












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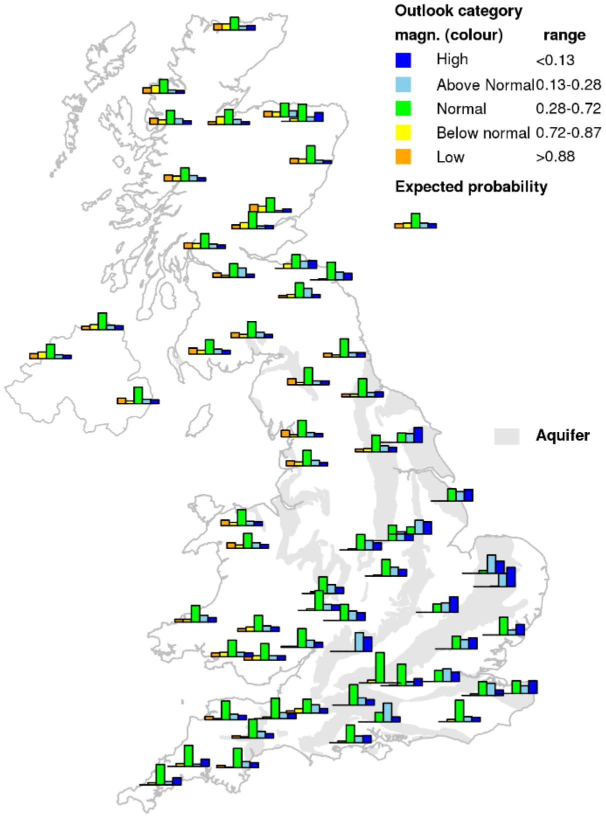
Outlook based on modelled flow from historical climate

Period: February 2021 – July 2021

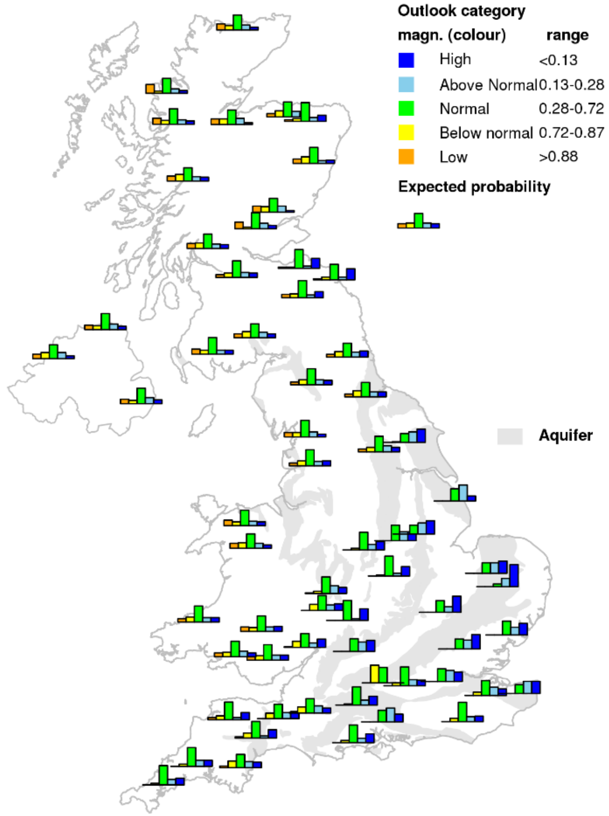
Issued on **05.02.2020** using data to the end of January 2021

River flows are likely above normal to high in East Anglia and normal to above normal elsewhere in the south and east of England in the next month. Elsewhere flows are likely to be within the normal range. Normal to above normal flows are likely to persist in the south and east for the next 3 months and remain normal elsewhere.

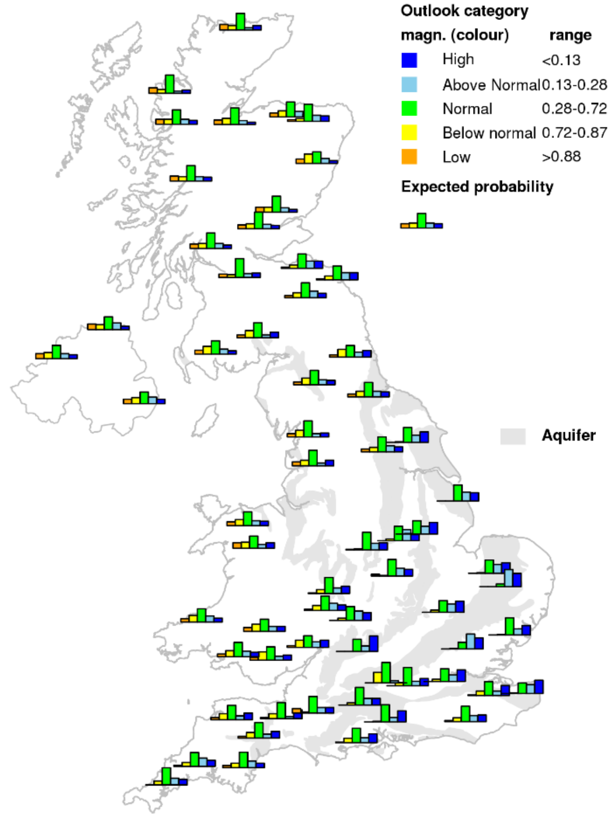
1-month river flow outlook starting Feb 2021



3-month river flow outlook starting Feb 2021



6-month river flow outlook starting Feb 2021



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 bar plot maps show the outlook distribution for 1, 3 and 6-month period for 64 catchments across England and Wales. Each bar plot represents the probabilistic distribution of the simulated river flow compared to the historical river flow, for the same n-month period. The probabilities fall within five categories, classified as: low, below normal, normal, above normal and high.

This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.

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UK Centre for Ecology & Hydrology

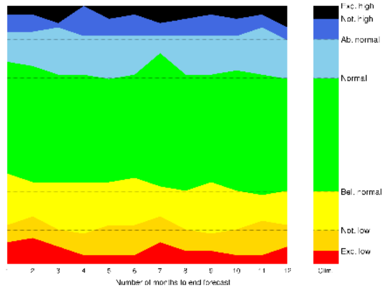
British Geological Survey

Environment Agency

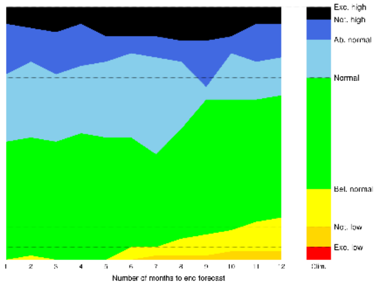
Outlook based on modelled flow from historical climate

Overview

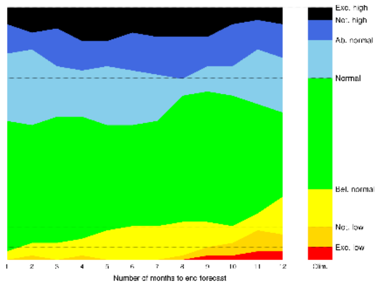
Mourne 201010

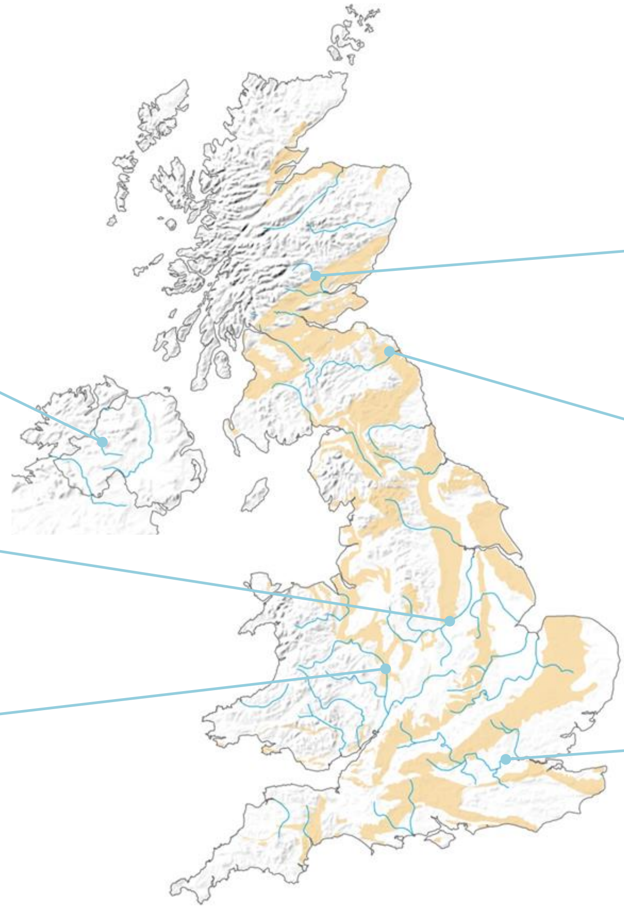


Trent 28009

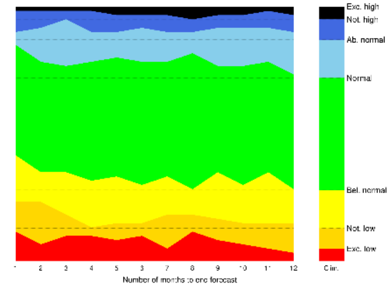


Severn 54032

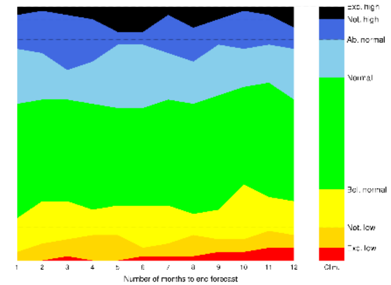




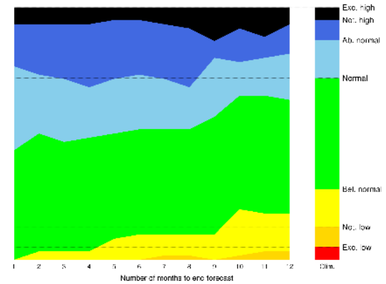
Tay 15006



Tweed 21009



Thames 39001



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 stack diagrams show the variation over time of the outlook distribution for a number of individual catchments. Each graph represents variation over time of the number of simulated river flows, in each month ensemble, that fall within each of seven categories: exceptionally low, notably low, below normal, normal, above normal, notably high and exceptionally high. The categories represent cumulative flow conditions, e.g. For 3-month, the simulated total 3-month flow compared to the historical 3-month flow distribution. The monthly variations can be compared to the long-term average distribution of river flows (shown as columns on the right of each timeline graph).

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UK Centre for Ecology & Hydrology
Met Office
Environment Agency

Outlook based on modelled flow from North Atlantic Oscillation historical climate analogues

New Winter NAO analogue forecasts – In Development

Period: February 2021 – April 2021
Issued on 07.02.2021 using data to the end of January

This page shows the results of the GR4J hydrological model run using historical climate analogues, resampled according to the forecast North Atlantic Oscillation (NAO) index. Please see the next page for details on the method.

Global weather patterns can affect UK weather during the coming season and their influence acts to shift the chances of the categories in the Outlook. For the early part of February-March-April, a mature La Niña is expected to increase the likelihood of westerly winds. However, the Sudden Stratospheric Warming (SSW) which occurred in early January, shifts westerly winds south of their normal position. When combined, these drivers reduce the likelihood of drier or wetter than average rainfall. Moving out of the winter period, the NAO signal for FMA is relatively weak compared to recent months.

Feb-Mar-Apr Precipitation anomaly (Northwest UK)

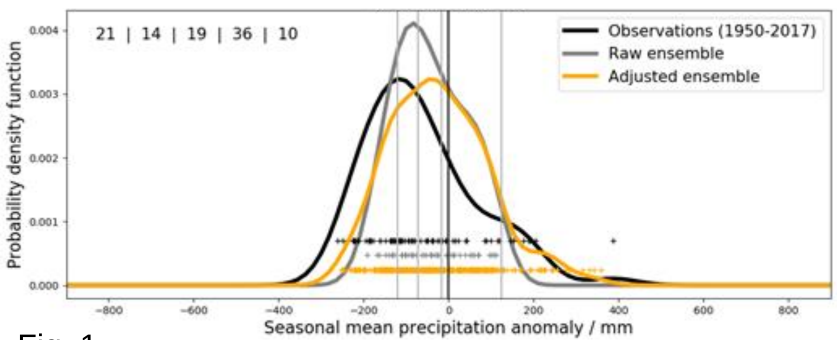

Fig. 1

River flows for February-March-April are likely to be above normal in East Anglia, and normal to above normal across central and southern England as well as parts of the north-east. Elsewhere flows are likely to be within the normal range. Due to the relatively weak signal of the NAO during this period, these NAO analogue forecast results are very similar to the traditional forecast from historical climate.

Feb-Mar-Apr 2021 NAO Driven River Flow Outlook

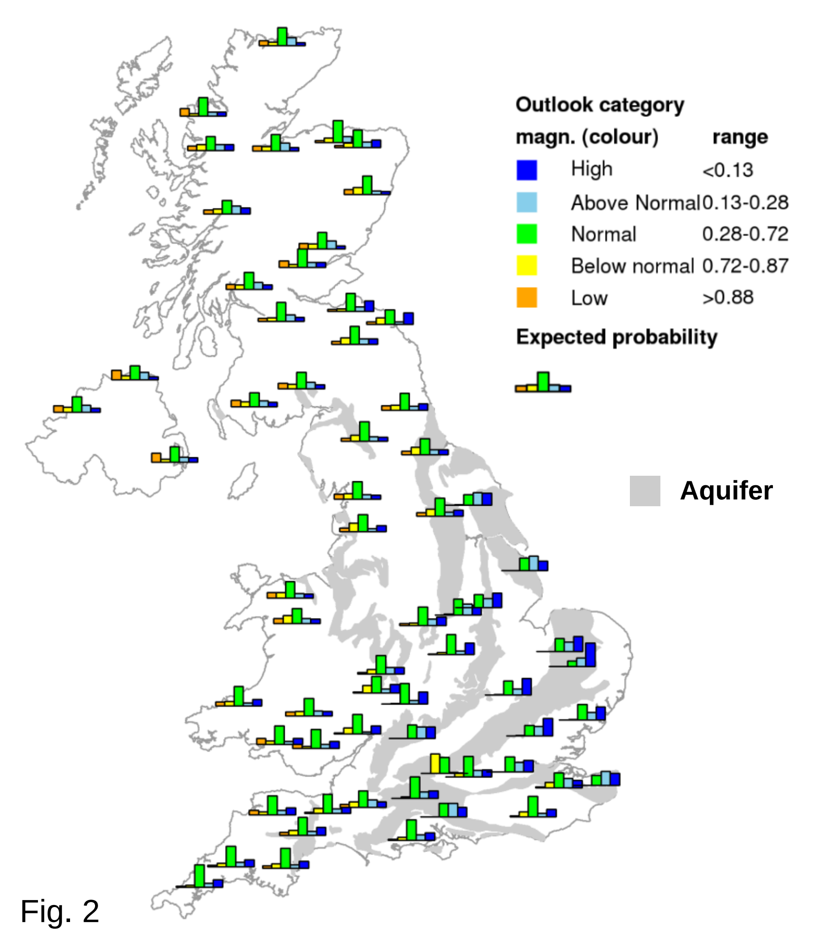

Fig. 2

This outlook is based on ensembles of historical sequences of observed climate (rainfall and potential evapotranspiration), resampled according to the NAO index, that form input to a hydrological model. The outputs are the likelihoods of different outcomes for the average river flow over the three month winter forecast period at each location. The simulations are generated by the GR4J conceptual rainfall-runoff model calibrated on observed flows.

Figure 1 shows the distribution of individual outcomes (shown as crosses) and the consequent likelihood of different amounts of precipitation in the Northwest UK (as a difference from the long-term average). The black line shows the likelihood based only on past climate, using observations from 1950-2017. The grey line shows the output from the Met Office GloSea long-range prediction system. The orange line shows the GloSea outputs adjusted to correct for known under-prediction of the size of weather signals. The numbers in the top left represent the percentage of adjusted outcomes that fall into five categories that are equally likely based on the observational climate distribution (shown by the vertical grey lines on the graph).

Figure 2 shows the outlook distribution for 64 catchments across the UK. Each bar plot represents the likelihood of the simulated river flow compared to the historical river flow, for the same n-month period. The probabilities fall within five categories, classified as: low, below normal, normal, above normal and high.

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UK Centre for Ecology & Hydrology

Met Office

Environment Agency

Outlook based on modelled flow from North Atlantic Oscillation historical climate analogues

The North Atlantic Oscillation (NAO) is a measure of the strength and frequency of westerly winds across the UK and can be a strong driver of winter precipitation, especially in the north and western parts of the UK. This directly influences river flows in the highly responsive catchments in this area. Including the NAO forecast in winter hydrological predictions significantly improves the skill of the forecast in many UK catchments.

NAO historical climate analogues Method

Rescale 42 NAO forecasts to correct under-prediction of NAO variability

Take each adjusted forecast value of FMA average NAO

Find a non-consecutive FMA sequence where average observed NAO = forecast value

e.g. February 1992, March 2003, April 1965

Repeat 10 times per NAO forecast = 420 analogue date sequences

Extract catchment averaged rainfall and PET for each sequence

Run each data sequence through GR4J as a FMA forecasts

Continuous Ranked Probability Skill Score (CRPSS) for February-March-April (FMA) flow hindcasts

compared to a flow climatology baseline

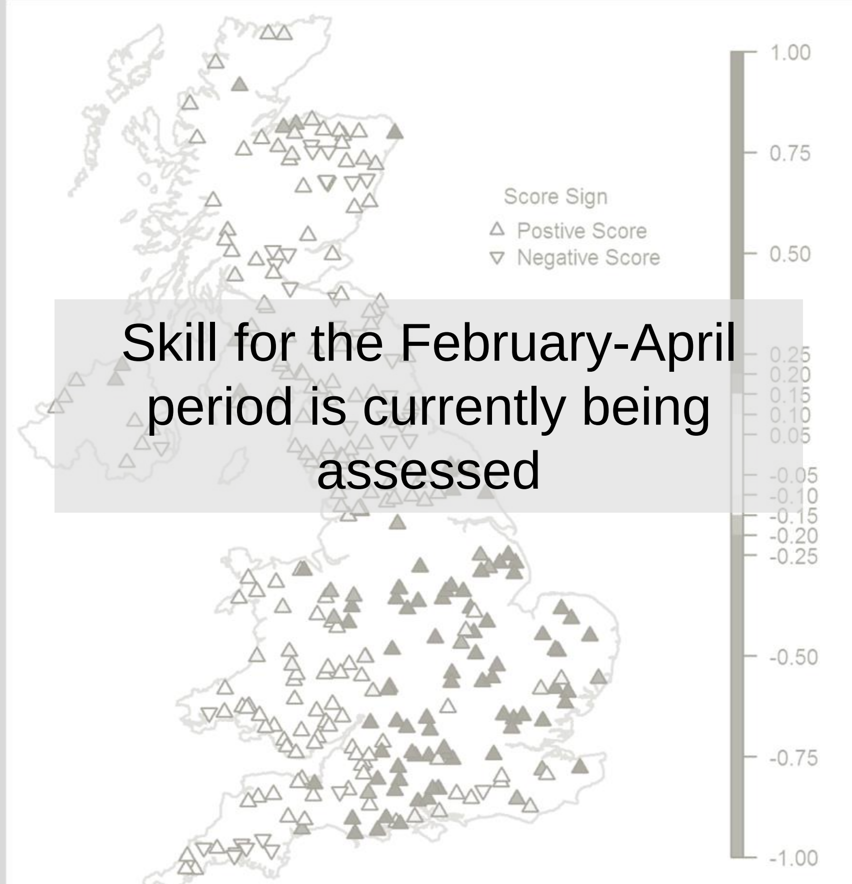


Fig. 3

The NAO analogue forecasts are run in a very similar way to the historical climate forecasts, however they make use of North Atlantic Oscillation forecasts. NAO forecasts are extracted from the Met Office GloSea long-range prediction system and are rescaled to correct known under-prediction of NAO variability. Ten sets of non-consecutive historic months with similar NAO index values are then sought for each climate forecast member (daily sequences within individual months are retained). See Stringer et al., 2020 for further detail. https://doi.org/10.1175/JAMC-D-19-0094.1).

The GR4J hydrological model is run using observational precipitation and potential evapotranspiration data up to the point of initialisation. Rather than using each historic year as climate input, as with the historical climate forecasts, the non-sequential date sequences identified using the NAO index forecasts are instead used to extract non-sequential historic precipitation and potential evapotranspiration data. These data are then used as input to the hydrological model to run in forecast mode.

Figure 3 shows the continuous ranked probability skill score (CRPSS) in the NAO analogue river flow hindcasts when compared to observations, calculated over the hindcast period 1994-2016. Blue arrows pointing upward show improvement in forecast skill when compared to a flow climatology baseline. Skill in the south-east is known to be due to the persistence of flows, and is seen in the standard historical climate forecasts. Skill in the north and west shown on this map however, is additional skill achieved by utilising the NAO index forecasts.

Current Daily Simulated Subsurface Water Storage Conditions

Based on subsurface water storage estimated for 31st January 2021

Issue date: 03.02.2021

These maps are based on Grid-to-Grid (G2G) hydrological model simulated subsurface water storage, expressed as an anomaly from the historical monthly mean. To highlight areas that are particularly wet or dry, the storage anomaly is presented here using a colour scale highlighting water storage relative to historical extremes. The maps below show relative wetness.

These maps do not provide a flood forecast and are not maps of soil moisture. Instead they indicate areas where subsurface water storage approaches or exceeds its historical maximum. Rainfall in the high 'relative wetness' areas could result in flooding.

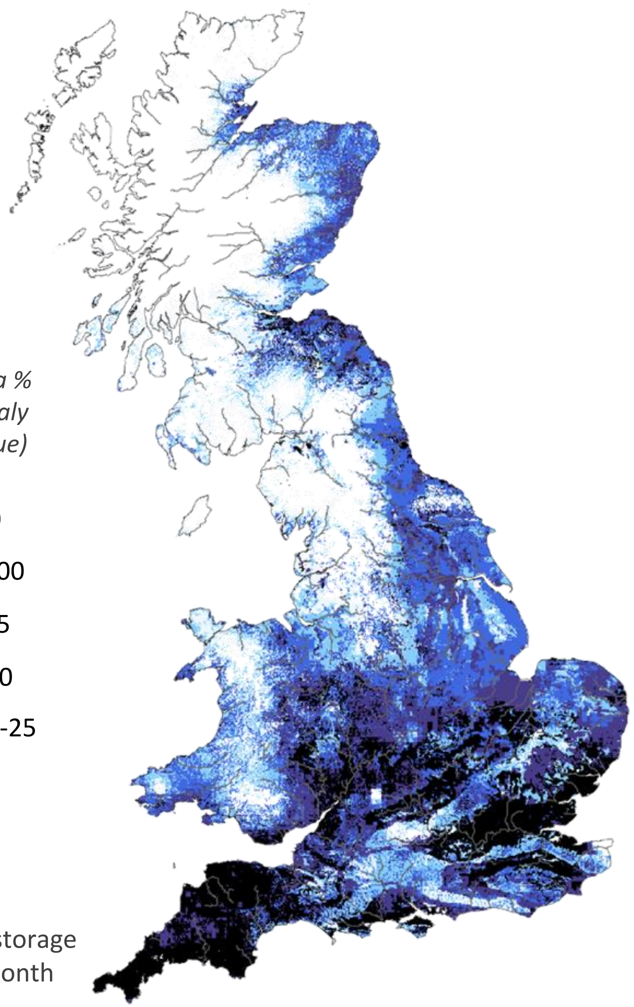
SUMMARY: At the end of January, subsurface water levels across much of the country were higher than expected for this time of year, including most of Wales and Central England (medium to high relative wetness) and eastern regions of North England and Scotland (medium relative wetness).

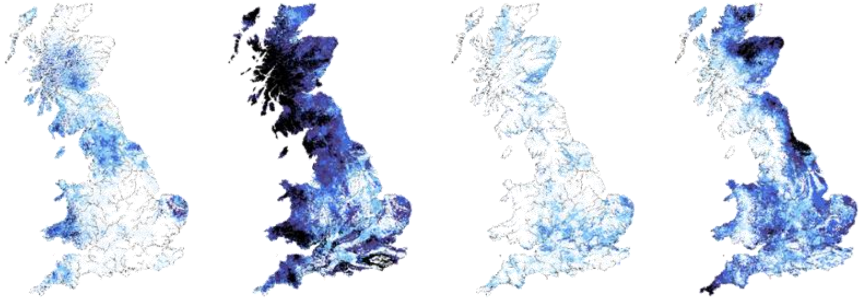
Relative Wetness

Water storage anomaly as a % of maximum storage anomaly (zero indicates average value)

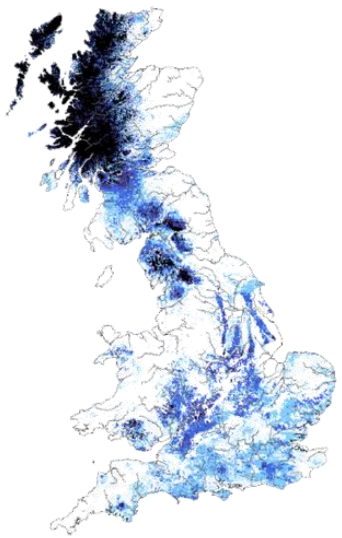
High (very wet)	■	>100
	■	75-100
Medium	■	50-75
	■	25-50
Low	■	0.01-25
(No wetness)	□	<0
Main rivers		

Labels refer to estimated storage on *final day* of named month





September October November December



January 2020

October 2000*

*Example month displaying extreme relative wetness

February 2021

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Current Daily Simulated Subsurface Water Storage Conditions

Based on subsurface water storage estimated for 31st January 2021

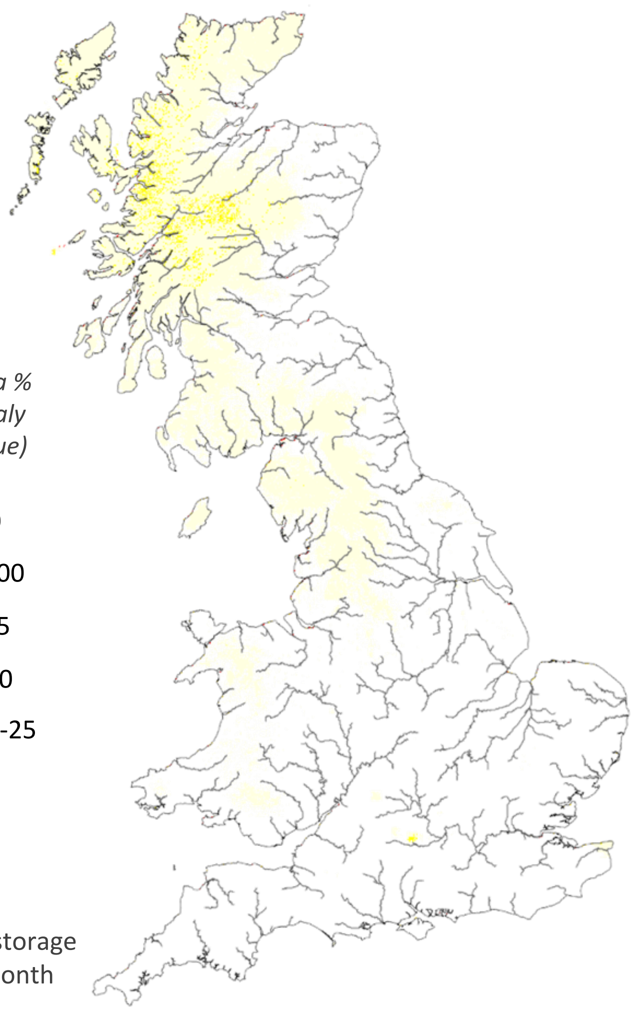
Issue date: 03.02.2021

These maps are based on Grid-to-Grid (G2G) hydrological model simulated subsurface water storage, expressed as an anomaly from the historical monthly mean. To highlight areas that are particularly wet or dry, the storage anomaly is presented here using a colour scale highlighting water storage relative to historical extremes. The maps below show relative dryness.

These maps do not provide a drought forecast and are not maps of soil moisture. Instead they indicate areas where subsurface water storage approaches or exceeds its historical minimum. A lack of rainfall in the high 'relative dryness' areas could lead to (or prolong) a drought.

SUMMARY: At the end of January, subsurface water levels across much of the country were higher than expected for this time of year, reflected in very low levels of relative dryness. Areas of exception include western regions of Scotland, which have subsurface water levels slightly higher than average for this time of year.

Relative Dryness



Water storage anomaly as a % of minimum storage anomaly (zero indicates average value)

High (very dry) >100

75-100

Medium 50-75

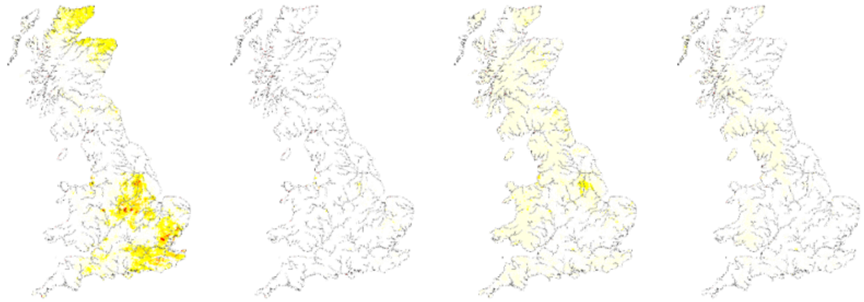
25-50

Low 0.01-25

(No dryness) <0

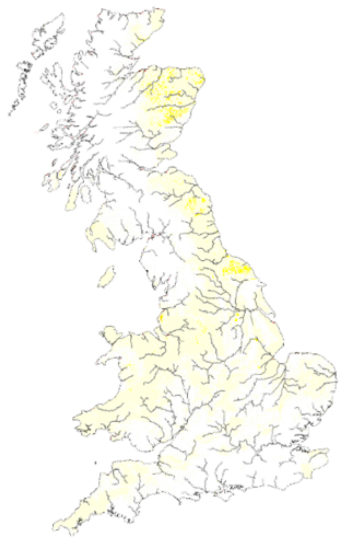
Main rivers

Labels refer to estimated storage on *final day* of named month

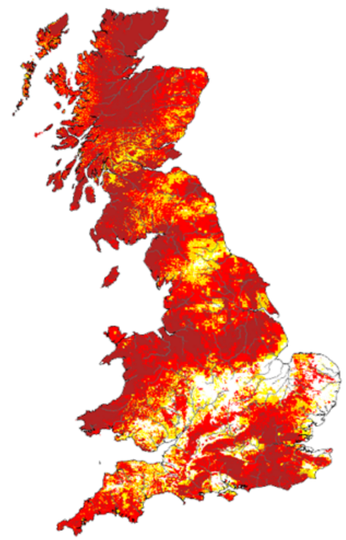


September October November December

January 2020



August 1976*



*Example month displaying extreme relative dryness

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Relative Dryness

- The relative dryness map highlights areas where current estimates of **subsurface water storage** (from the G2G hydrological model, calculated for the last day of last month) are particularly ***low***.
- The map indicates areas where the ground is dry compared to the monthly **average** storage (for the period 1981 to 2010), and shows this relative to the historical **minimum** storage level (for 1971 to 2010).
- Relative dryness calculation: $R_d\ (\%) = \frac{(S_{average} - S)}{(S_{average} - S_{min})} \times 100$

$$= \frac{\text{(average storage for this month - storage at end of last month)}}{\text{(average storage for this month - historical minimum storage)}} \times 100$$

- A value of $\boldsymbol{R_d}$ **= 100** shows that a region is very dry, and indicates that the storage is as low as the minimum value ever estimated by the model for this month.
- A value of $\boldsymbol{R_d}$ **= 0** indicates that the storage in the region matches the monthly average value. *Negative relative dryness values will show up as part of the relative wetness map.*
- The map **does not provide a drought forecast**. A lack of rainfall in the high 'relative dryness' areas **could** lead to (or prolong) a drought.

Relative Wetness

- The relative wetness map highlights areas where current estimates of **subsurface water storage** (from the G2G hydrological model, calculated for the last day of last month) are particularly ***high***.
- The map indicates areas where the ground is wet compared to the monthly **average** storage (for the period 1981 to 2010), and shows this relative to the historical **maximum** storage level (for 1971 to 2010).
- Relative wetness calculation: $R_w\ (\%) = \frac{(S - S_{average})}{(S_{max} - S_{average})} \times 100$

$$= \frac{\text{(storage at end of last month - average storage for this month)}}{\text{(historical maximum storage - average storage for this month)}} \times 100$$

- A value of $\boldsymbol{R_w}$ **= 100** shows that a region is very wet, and indicates that the storage is as high as the maximum value ever estimated by the model for this month.
- A value of $\boldsymbol{R_w}$ **= 0** indicates that the storage in the region matches the monthly average value. *Negative relative wetness values will show up as part of the relative dryness map.*
- The map **does not provide a flood forecast**. Rainfall in the high 'relative wetness' areas **could** result in flooding.

UK Centre for Ecology & Hydrology

Return Period of Rainfall Required to Overcome Dry Conditions

Period: February 2021 – July 2021

Issue date: 03.02.2021

These maps show the **return period** of the rainfall required to overcome dry conditions simulated using the Grid-to-Grid (G2G) hydrological model. The maps are coloured according to the return period of accumulated rainfall required to overcome the estimated current subsurface water storage deficit over the next few months.

These maps do not provide a drought forecast. Instead they indicate the return period of rainfall required to overcome the dry conditions for the following 6 months based on current conditions.

SUMMARY: During February to July, Britain will not require particularly unusual rainfall (<5 year return periods) to return to average conditions for the time of year.

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

Feb

Mar

Apr

May

Jun

Jul

Rainfall amount / Probability		Colour	*Return period (years)*
Low (this rain is likely to occur)	> 20%		< 5
	< 20%		5 - 10
	< 10%		10 - 25
	< 4%		25 - 50
High (less likely)	< 2%		50 - 100
	< 1%		100 - 200
Extreme (unlikely but still possible)	< 0.5%		> 200

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Method

- These maps show the **return period** of the rainfall required to overcome dry conditions simulated using the Grid-to-Grid (G2G) hydrological model. The maps are coloured according to the return period of rainfall required to overcome the estimated current subsurface water storage deficit.

- For **dry areas** within a Hydrological Outlook region, i.e. where subsurface water storage anomaly < 0, we estimate ***regional average subsurface water storage deficit*** *(mm)* from the last day of the most recent G2G model run.

- For each region we also estimate the ***regional monthly average rainfall total*** *(mm)* (for the period 1971-2000).

- For each of the next 6 months, we estimate the rainfall total (including what is normally expected for each month) required to overcome the dry conditions.
  - To overcome the dry conditions by the end of month 1:
    rainfall required (mm) = regional monthly average rainfall for month 1 + regional average storage deficit
  - To overcome the dry conditions by the end of month 2 (more likely):
    rainfall required (mm) = regional monthly average rainfall for months 1 and 2 + regional average storage deficit
  - To overcome the dry conditions by the end of month *n* (likely):
    rainfall required (mm) = regional monthly average rainfall for months 1 to *n* + regional average storage deficit

- Using Tabony tables we estimate the return period of the ***rainfall required*** in each region and over the next 1 to 6 months to overcome the dry conditions.

- The return period results are displayed as regional maps with the colour scale based on the return period (years) of the rainfall required to replenish subsurface stores over the next 1, 2, .., 6 months ahead.

- Note: These maps do not provide a drought forecast. Instead they indicate the return period of rainfall required to overcome the dry conditions for the following 6 months based on current conditions.

Estimate of Additional Rainfall Required to Overcome Dry Conditions

Based on subsurface water storage estimated for 31st January 2021

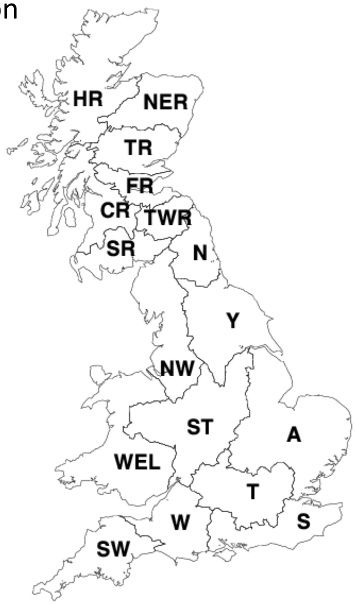
Issue date: 03.02.2021

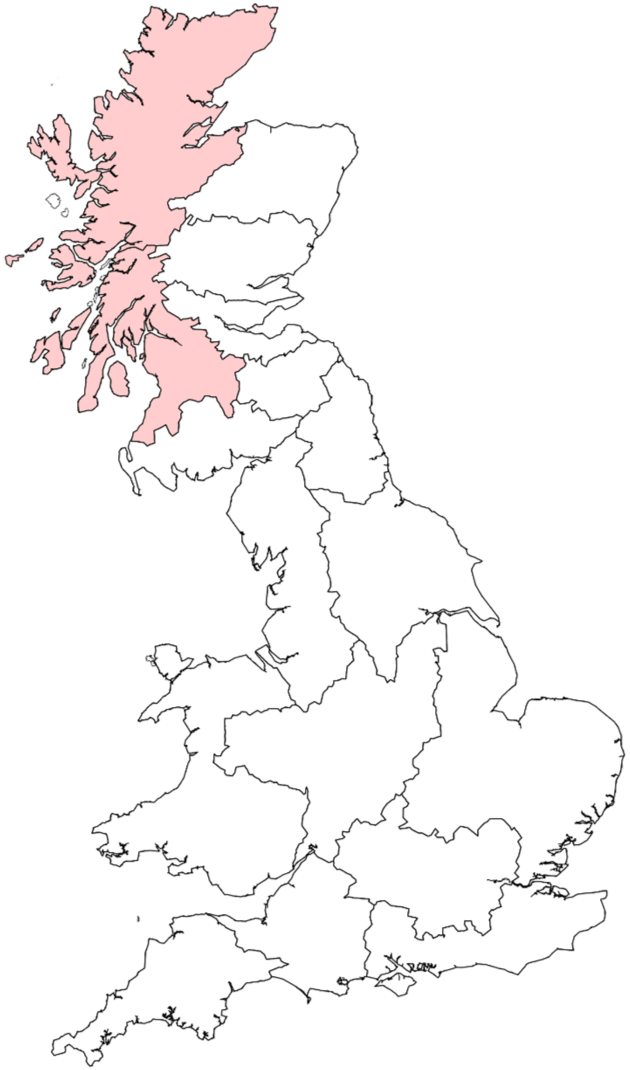
These maps show the Grid-to-Grid (G2G) hydrological model simulated subsurface water storage, expressed as an anomaly from the historical monthly mean (1981-2010), presented on a 1km grid and as regional means.
Subsurface storage deficits, i.e. where the subsurface water storage anomaly is less than zero, **are highlighted by the red/pink colours**.

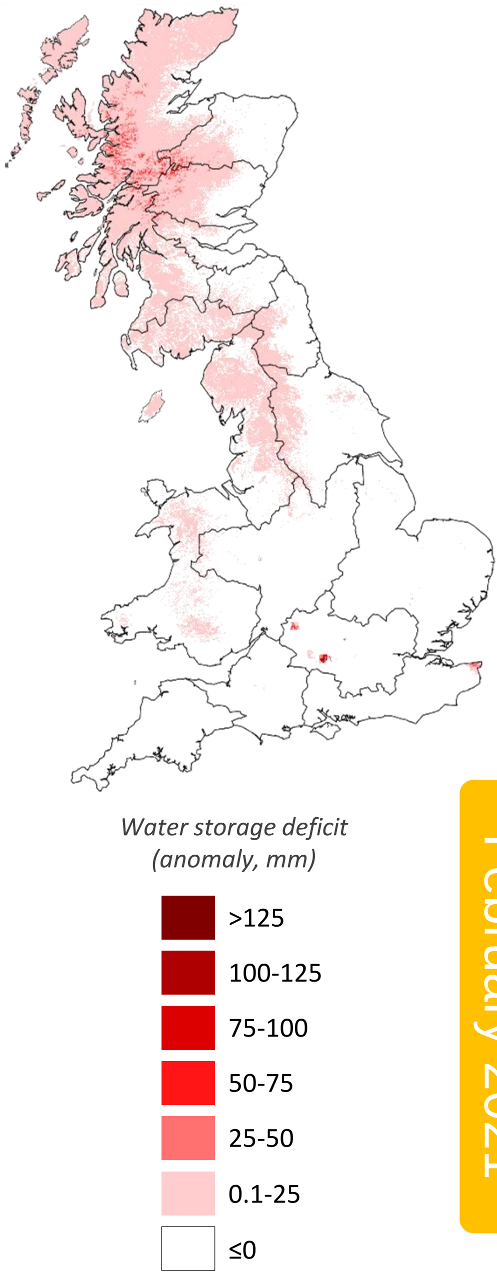
The **subsurface storage deficit (mm)** can be interpreted as an estimate of additional rainfall that would be required in future months to overcome dry conditions (i.e. rainfall in addition to what is expected on average). Regional mean values of additional rainfall required are provided in the table below.

Regional estimate of additional rainfall required (mm)

	SCOTLAND	
7	HR	Highlands Region
0	NER	North East Region
0	TR	Tay Region
0	FR	Forth Region
2	CR	Clyde Region
0	TWR	Tweed Region
0	SR	Solway Region
	ENGLAND	
0	N	Northumbria
0	NW	North West
0	Y	Yorkshire
0	ST	Severn Trent
0	A	Anglian
0	T	Thames
0	W	Wessex
0	S	Southern
0	SW	South West
	WALES	
0	WEL	Welsh







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Outlook Based on Modelled Flow from Rainfall Forecasts

Overview

Period: February 2021 – April 2021

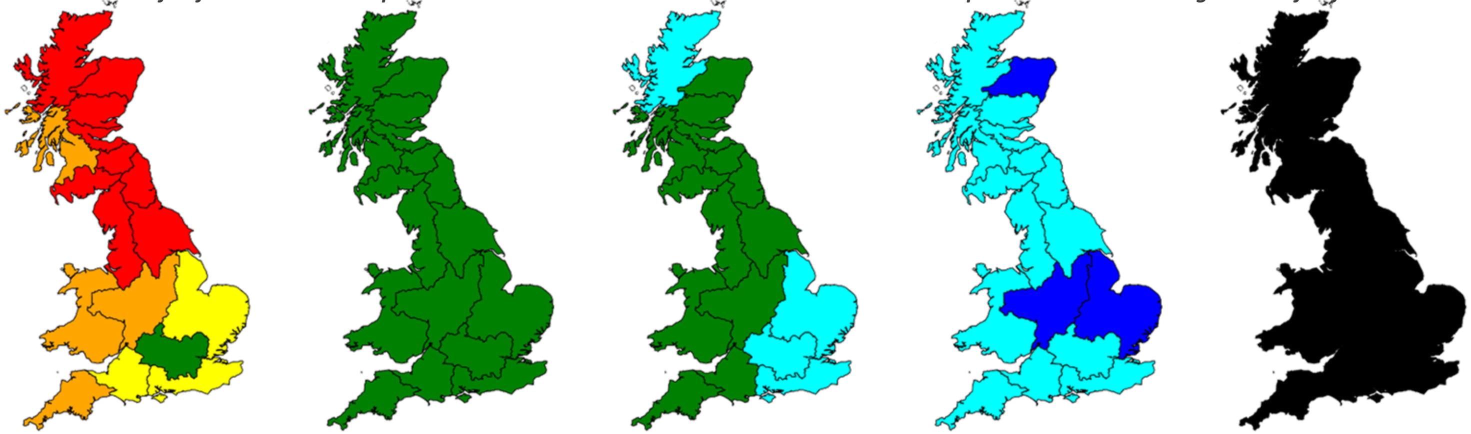
Issued on 05.02.2021 using data to the end of January

SUMMARY: During February, river flows across the majority of the country are most likely to be in the *Normal range* or above. River flows in the north of Scotland and the south east of England are most likely to be *Above normal*.

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

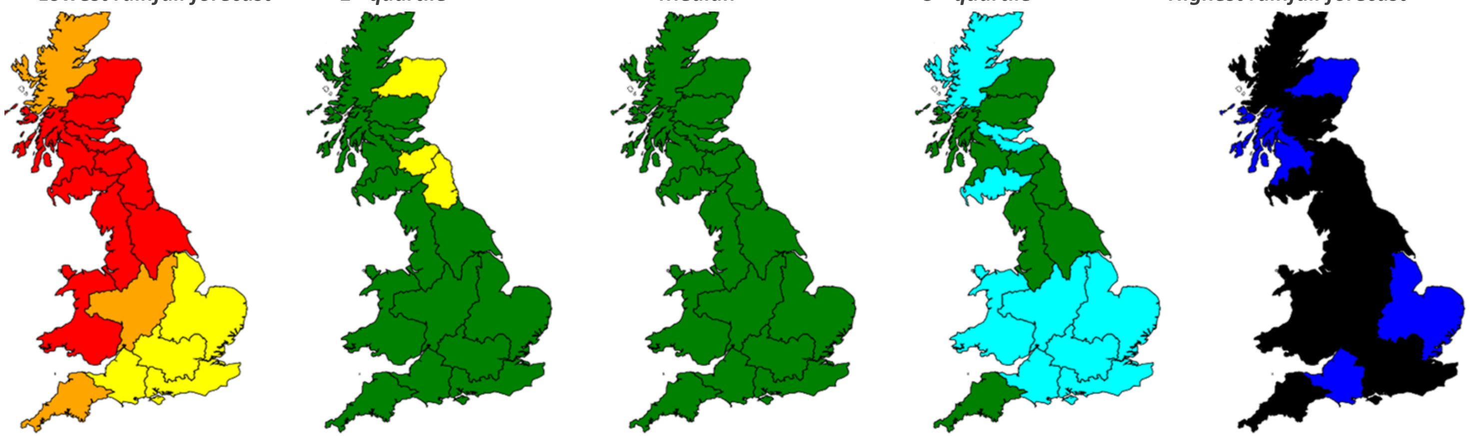
1-month flow outlook

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



3-month flow outlook

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



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.

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

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UK Centre for Ecology & Hydrology

Outlook Based on Modelled Flow from Rainfall Forecasts

1- and 3-month variability

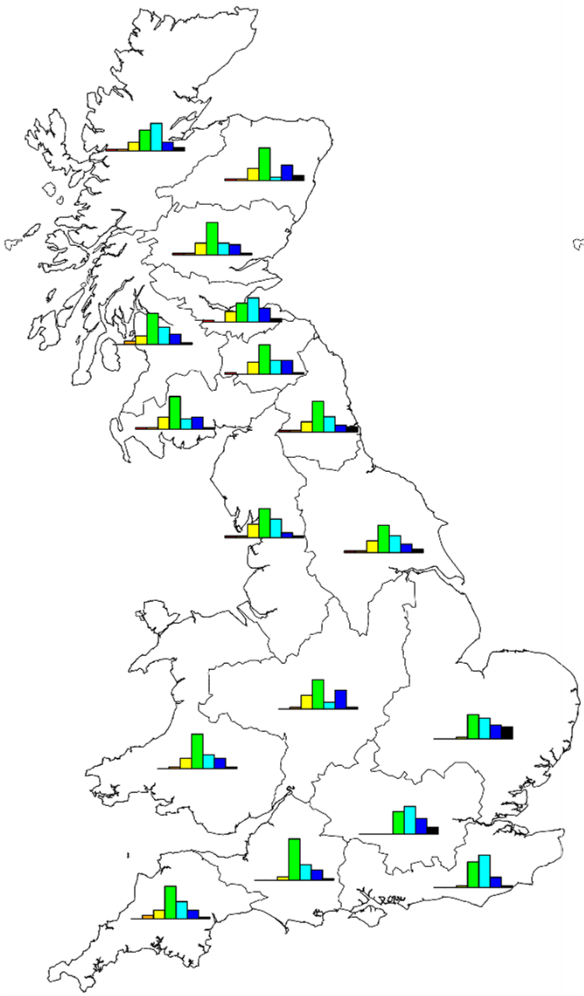
Period: February 2021 – April 2021

Issue date: 05.02.2021

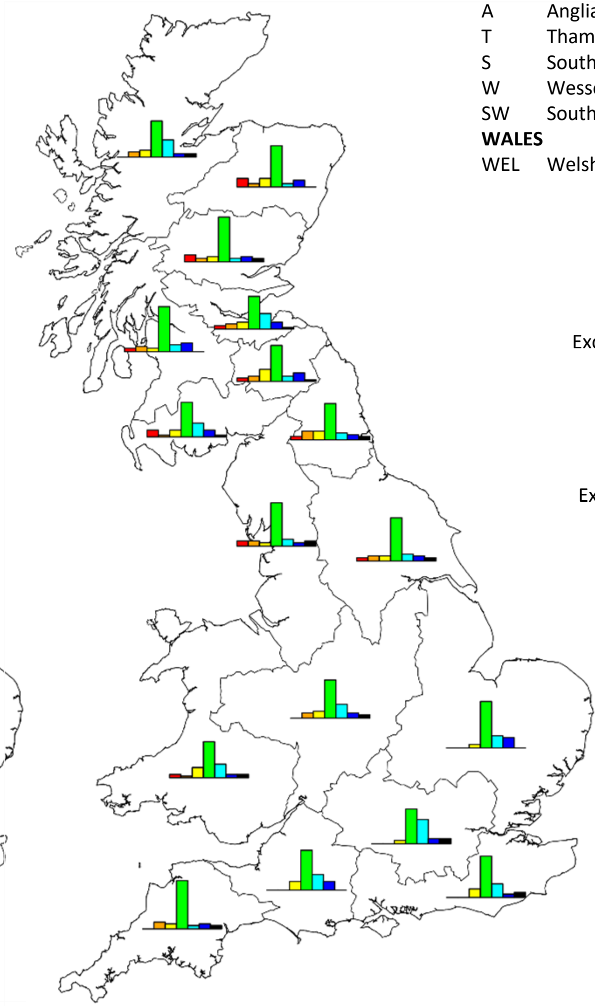
The regional maps illustrating the regional river flows for five members of the Met Office ensemble of rainfall forecasts give some indication of the range of possible river flows in the coming months. As noted previously, the actual flows could be more extreme than the flows generated by either the lowest or highest members of the rainfall ensemble.

The bar charts (below) give further insight into the range of river flow forecasts by considering all members of the forecast rainfall ensemble. The regional bar charts show the percentage of ensemble forecasts falling in each of the flow categories as generated by the monthly-resolution water-balance model. As before results are averaged by region then ranked in terms of 54 years of historical regional flow estimates (1963 – 2016).

1-month

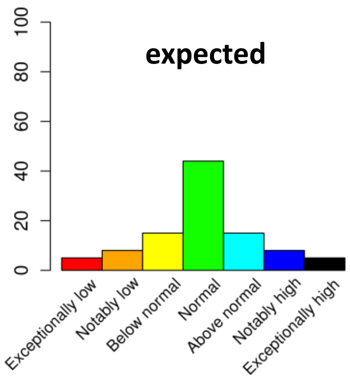


3-month



SUMMARY: During February, river flows across the majority of the country are most likely to be in the *Normal range* or above. River flows in the north of Scotland and the south east of England are most likely to be *Above normal*.

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



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

Percentile range of historic values for relevant month

	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

RIVER FLOW FROM RAINFALL FORECASTS

February 2021

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

UK Centre for Ecology & Hydrology

Outlook Based on Modelled Flow from Rainfall Forecasts

1- and 3-month variability

Period: February 2021 – April 2021

Issue date: 05.02.2021

The maps illustrating the regional river flows for five members of the Met Office ensemble of rainfall forecasts give some indication of the range of possible river flows in the coming months. As noted previously, the actual flows could be more extreme than the flows generated by either the lowest or highest members of the rainfall ensemble.

The tables below give further insight into the range of river flow forecasts by considering all members of the forecast rainfall ensemble. The numbers in the tables are the percentage of ensemble forecasts falling in each of the flow categories as generated by the monthly-resolution water-balance model. As before results are averaged by region then ranked in terms of 54 years of historical regional flow estimates (1963 – 2016).

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

SUMMARY: During February, river flows across the majority of the country are most likely to be in the *Normal range* or above. River flows in the north of Scotland and the south east of England are most likely to be *Above normal*.

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

1-month ahead	A	NW	N	ST	SW	S	T	Welsh	W	Y	CR	FR	HR	NER	SR	TR	TWR
Exceptionally high flow	17	2	7	2	2	2	10	2	2	5	2	5	5	7	2	2	2
Notably high flow	19	7	10	26	12	14	21	14	14	12	14	19	12	21	17	14	19
Above normal	29	26	21	10	24	45	38	19	21	24	24	33	38	5	14	17	19
Normal range	33	40	43	40	45	36	31	48	57	38	43	26	29	45	45	45	40
Below normal	2	19	14	19	12	2	0	14	5	17	12	14	12	17	17	17	17
Notably low flow	0	2	2	2	5	0	0	2	0	2	5	0	2	2	2	2	0
Exceptionally low flow	0	2	2	0	0	0	0	0	0	2	0	2	2	2	2	2	2

3-months ahead	A	NW	N	ST	SW	S	T	Welsh	W	Y	CR	FR	HR	NER	SR	TR	TWR
Exceptionally high flow	0	7	5	5	5	7	7	5	0	5	0	2	5	0	2	5	2
Notably high flow	14	5	7	7	7	5	7	5	12	7	12	10	5	10	10	7	12
Above normal	17	10	10	19	5	19	33	19	21	10	10	21	24	5	19	5	7
Normal range	64	60	50	52	67	57	48	50	55	60	62	45	50	57	48	62	50
Below normal	5	5	12	10	7	12	5	14	12	7	5	10	10	12	10	7	17
Notably low flow	0	7	12	7	10	0	0	2	0	7	7	7	7	5	2	5	7
Exceptionally low flow	0	7	5	0	0	0	0	5	0	5	5	5	0	12	10	10	5

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British Geological Survey

Outlook based on modelled groundwater level & climate forecast

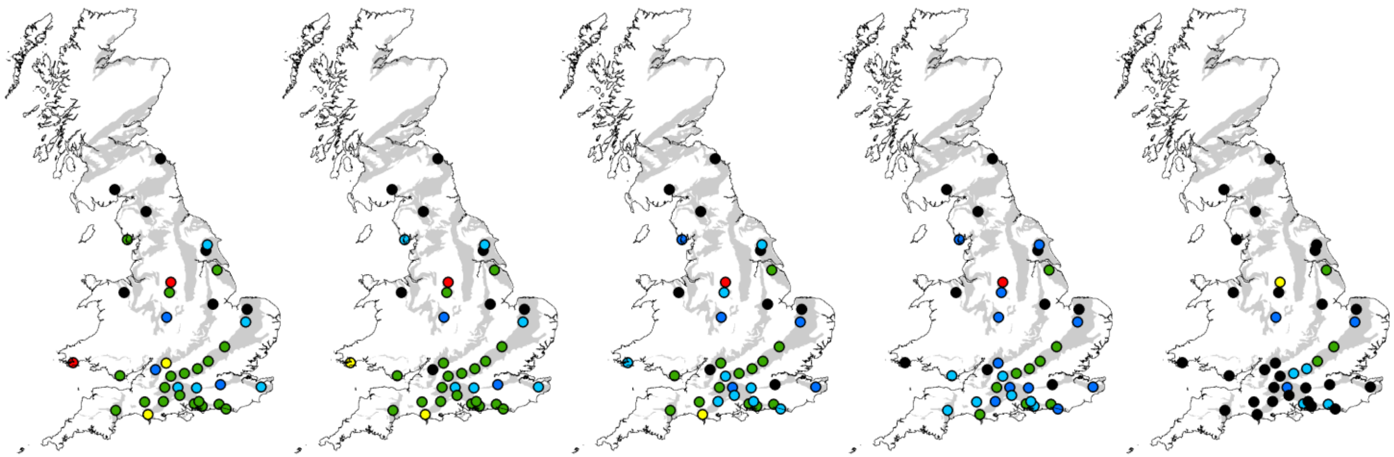
Overview

Period: February 2021–April 2021

Issued on 08. 02.2021 using data to the end of January

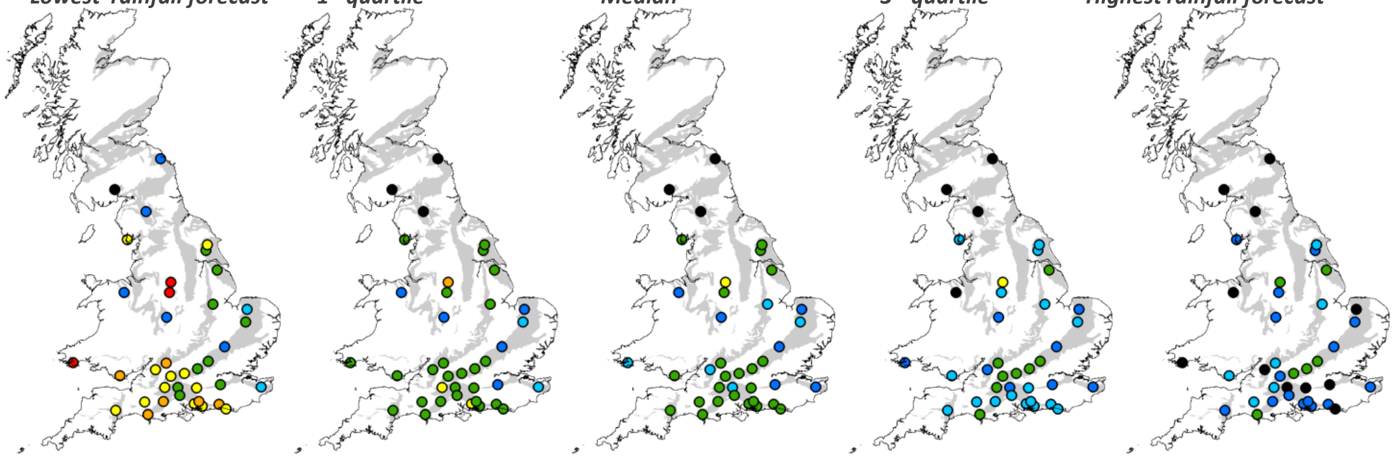
Generally above normal groundwater levels are predicted over the next month in England and Wales, with levels becoming more normal in the 3-month forecast. Groundwater levels in the Chalk of the East and South East are estimated to be above normal to notably high in the 1-month forecast, with notably high to exceptionally high levels in the other major aquifers. Exceptionally high levels are predicted under all rainfall scenarios at the Newbridge and Skirwith (Permo-Triassic sandstone), and Royalty Observatory (Fell Sandstone) sites in the 1-month and 3-month forecasts. Over 3 months the levels across the UK are predicted to range from normal to exceptionally high, with exceptionally high levels predicted at sites in every major aquifer. Note there are a reduced number of modelled sites. This is due to Covid-19 restrictions on access to sites in England and IT issues in Scotland.

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



1-month outlook

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

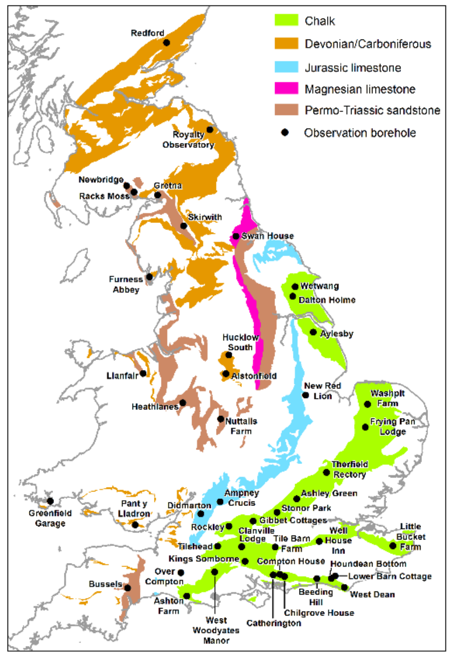


3-month outlook

These forecasts are produced by running five members of the Met Office ensemble climate forecast through groundwater models of observation borehole hydrographs at 42 sites across the country. The sites are distributed across the principal aquifers.

Based on the distribution of observed historical groundwater levels in a given month, seven categories have been derived for each site: very low, low, below normal, normal, above normal, high, and very high. The forecast groundwater level is assigned to one of these seven categories depending on where it falls within the distribution of the historically observed values.

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



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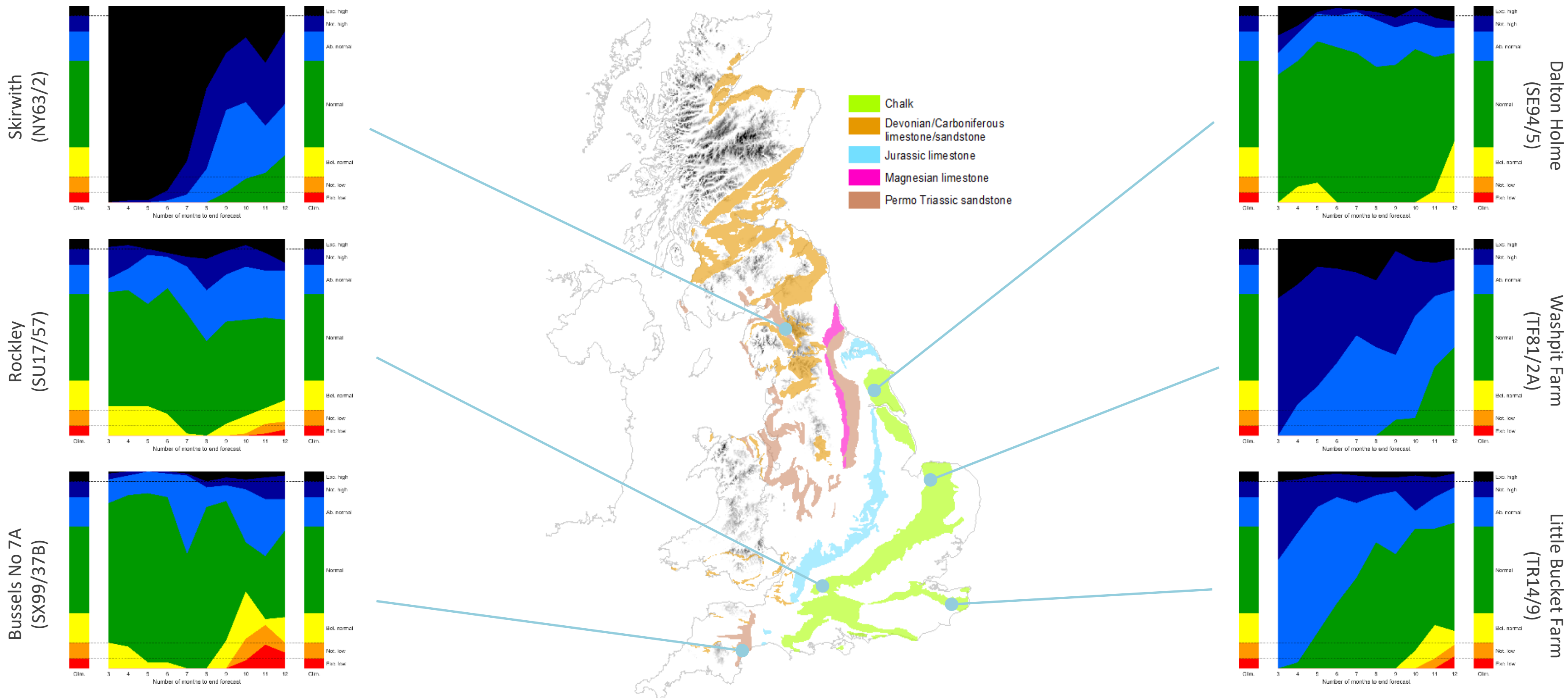
Outlook based on modelled groundwater from historical climate

Period: February 2021 – January 2022

Issued on 08.02.2021 using data to the end of January

Notably high to exceptionally high levels are predicted in the Permo-Triassic sandstone at Skirwith in North West England over the next 12 months. In the Chalk at Washpit Farm and Little Bucket Farm, above normal levels are predicted for the next six months. Elsewhere, levels are predicted to be normal to above normal throughout the period, where above normal levels dominate the next 6 months in the Chalk of the South-East of England.



This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evpotranspiration) that form input to hydrological models. The outputs are probabilistic simulations of the average groundwater level over the forecast horizon (3 to 12 months ahead), at each location.

The graphs show variation over time of the number of simulated groundwater levels in each monthly ensemble, that fall within each the seven categories: exceptionally low, notably low, below normal, normal, above normal, notably high and exceptionally high. The monthly variations can be compared to the long-term average distribution of levels, which are shown as columns on the left and right of each graph.

This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.

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