Hydrological Summary

for the United Kingdom

March 2023

General

The start of March was settled, continuing the dry conditions established in February. This was followed by notably wet conditions across much of England and Wales. Rainfall anomalies were greatest in the south of England, with up to three times the average in places. River flows responded correspondingly from well below average at the start of the month, and for March as a whole were above normal to exceptionally high in the south and west. Soils wetted across the country through March, and soil moisture deficits were eliminated in almost all regions despite the drier than average February. The early onset groundwater level recessions seen in many sites last month ended, and recharge was observed in the more responsive aquifers. Levels were predominantly in the normal range across the UK by month-end. Reservoir stocks for England & Wales were near average for March, with most stocks marginally above average. Although stocks at Colliford and Roadford remained substantially below average, they increased relative to average. With above average rainfall continuing into early April, and a late pulse in winter recharge expected, the outlook is for river flows and groundwater levels to be in the normal range or above normal across much of the UK over the coming months. However, long-term rainfall deficits remain in East Anglia, meaning that as the recharge season draws to a close vigilance may be needed as we head into the spring and summer.

Rainfall

High pressure conditions continued into the start of March, however, wintery weather prevailed from the 6th as air masses moved in from the Arctic. This brought snow to the UK resulting in school closures and travel disruption from the 7th to the 10th (32cm of snow was recorded in Buxton, Derbyshire, on the 10th). From the 11th, milder and wetter conditions prevailed, and persisted to month-end. On the 12th, many sites recorded totals exceeding 50mm, including 119mm at Honister Pass (Cumbria). Total March rainfall for the UK was 155% of average but this masks regional variability. Nearly three times the average was recorded in a band across southern England from the Severn to East Anglia and in parts of Kent, whilst north of a line from the Mersey to the Humber estuary, rainfall ranged from 110-150% of average. It was the third wettest March for both Northern Ireland and England (in series from 1836) with almost 175% and around 200% of average, respectively. Regions in the Midlands and south of England received well over twice the average, including 270% of average in Thames region where it was the second wettest March on record in a series from 1836. In contrast, north-west Scotland received between 40 and 90% of average and only Highland region received below average rainfall (80%). Since the start of the autumn (September-March), above average rainfall was registered across much of the UK, with more than 130% of average along the south-east coast of England. However, over the longer term in the 12 months since April 2022, deficits remain in central and eastern areas of England, including Anglian region with 88% of average.

River Flows

Recessions established in February continued into the first half of March, with only small interruptions in the first week. Flows were well below average and new daily minima established across the country, including the first 11 days on the Bervie (in a series from 1979). At the end of the second week, flow responses to rainfall and snow melt across the country approached or encroached into the high flow envelope, with new daily flow maxima set on the 13th/14th across Scotland, Wales and northern England. Flow responses were also seen in the more slowly responding groundwater dominated catchments in south-east England. Further responses to rainfall occurred in the second half of the month, including new daily flow maxima in south Wales, and south and east England in the last three days, whilst in Scotland and north-east England flows ended the month near- or below-average. Outflows from the UK rose sharply in the first week from daily outflow minima to well above average by month-end. March average flows were above normal to notably high across Wales, Northern Ireland and much of England. Some exceptionally high flows were also recorded in west Wales and south-west England where flows approached or exceeded 180% of average, including the Erch and Tywi (both their second highest March flows in series from 1973 and 1959, respectively) and the Dart (its third highest March flow, in a series from 1959). In contrast, flows were mostly below average but in the normal range across Scotland and the east of England, with several catchments registering below-normal flows. Since the start of September flows were mostly in the normal range across the UK, with above normal to notably high flows in parts of southern Scotland, northern England and across southern Wales and the south coast of England. Below normal flows were recorded in northern Scotland and eastern England where flows were around half the average.

Soil Moisture and Groundwater

Soil moisture increased from the low levels of the previous month, reflecting the high precipitation, and at month-end soils were at or above field capacity across the UK, enabling recharge to resume in many locations. Groundwater levels in the Chalk were falling at many sites in the early part of the month, but by late March levels were rising at all but three sites. At Chilgrove House the period of recession that commenced in mid-January ended in late March, causing the level to remain in the normal range. Recharge occurred at Killyglen throughout much of March, leading to notably high levels. Levels rose in the highly responsive Jurassic limestones with levels recovering at Ampney Crucis from below normal to a record high (for March, in a series from 1959). Low frequency data (single monthly values) for the sites in the Magnesian Limestone indicated a gentle decline in groundwater levels. The Carboniferous Limestone also responded rapidly to the rainfall, and levels rose across the aquifer. A record high value was recorded at Pant y Lladron (for March, in a series from 1996) and levels recovered from a February record low at Greenfield Garage to the normal range. Levels were fairly stable in the Permo-Triassic Sandstones, at Lime Kiln Way in the Upper Greensand and in the Devonian and Carboniferous sandstones. Levels at the majority of sites in these aquifers remained in the normal range. At Feddan Junction (Devonian sandstone) levels continued to be below normal.

National Hydrological Monitoring Programme | UK Centre for Ecology & Hydrology | BGS British Geological Survey

Rainfall . . . Rainfall . . .

Met Office

Rainfall accumulations and return period estimates

Percentages are from the 1991-2020 average.

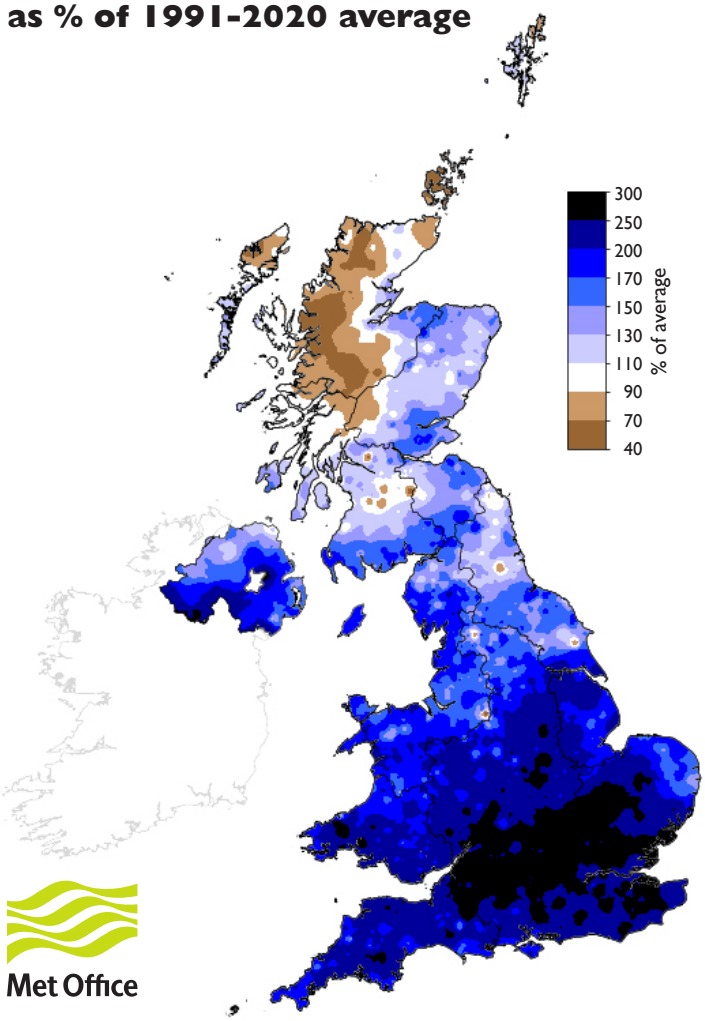
Region	Rainfall	Mar 2023	Feb23 – Mar23	RP	Dec22 – Mar23	RP	Sep22 – Mar23	RP	Apr22 – Mar23	RP
United Kingdom	mm	**132**	175		417		837		1126	
	%	**155**	97	2-5	97	2-5	110	8-12	97	2-5
England	mm	**119**	135		316		645		828	
	%	**204**	108	2-5	106	2-5	118	8-12	96	2-5
Scotland	mm	**130**	227		546		1091		1552	
	%	**104**	86	2-5	88	2-5	102	5-10	99	2-5
Wales	mm	**207**	233		599		1111		1395	
	%	**200**	104	2-5	109	2-5	113	5-10	96	2-5
Northern Ireland	mm	**151**	183		365		796		1132	
	%	**174**	102	2-5	88	2-5	108	5-10	98	2-5
England & Wales	mm	**131**	148		355		709		905	
	%	**203**	107	2-5	107	2-5	117	8-12	96	2-5
North West	mm	**150**	187		483		933		1260	
	%	**166**	95	2-5	103	2-5	111	8-12	99	2-5
Northumbria	mm	**84**	113		284		609		822	
	%	**134**	85	2-5	92	2-5	108	2-5	91	2-5
Severn-Trent	mm	**115**	125		266		556		731	
	%	**214**	112	2-5	101	2-5	114	5-10	92	2-5
Yorkshire	mm	**97**	119		288		601		790	
	%	**163**	92	2-5	97	2-5	112	5-10	91	2-5
Anglian	mm	**88**	96		194		413		548	
	%	**222**	117	2-5	102	2-5	112	2-5	88	2-5
Thames	mm	**125**	132		284		581		720	
	%	**270**	133	2-5	117	2-5	128	10-15	100	2-5
Southern	mm	**123**	131		351		753		896	
	%	**238**	114	2-5	119	5-10	138	15-25	110	2-5
Wessex	mm	**149**	160		398		764		927	
	%	**239**	122	2-5	123	5-10	129	10-20	103	2-5
South West	mm	**192**	214		531		1018		1233	
	%	**213**	109	2-5	110	2-5	119	8-12	99	2-5
Welsh	mm	**200**	225		573		1073		1348	
	%	**202**	105	2-5	109	2-5	114	5-10	96	2-5
Highland	mm	**124**	278		648		1199		1777	
	%	**80**	84	2-5	85	2-5	92	2-5	96	2-5
North East	mm	**91**	139		338		735		1050	
	%	**125**	92	2-5	96	2-5	110	5-10	99	2-5
Tay	mm	**120**	181		446		1035		1413	
	%	**112**	80	2-5	83	2-5	111	8-12	102	2-5
Forth	mm	**128**	186		447		908		1222	
	%	**133**	91	2-5	95	2-5	111	10-20	99	2-5
Tweed	mm	**111**	154		384		796		1044	
	%	**142**	92	2-5	98	2-5	114	15-25	96	2-5
Solway	mm	**182**	236		582		1197		1606	
	%	**152**	93	2-5	97	2-5	113	20-35	102	5-10
Clyde	mm	**163**	265		646		1302		1851	
	%	**108**	82	2-5	86	2-5	100	2-5	98	2-5

% = percentage of 1991-2020 average *RP = Return period*

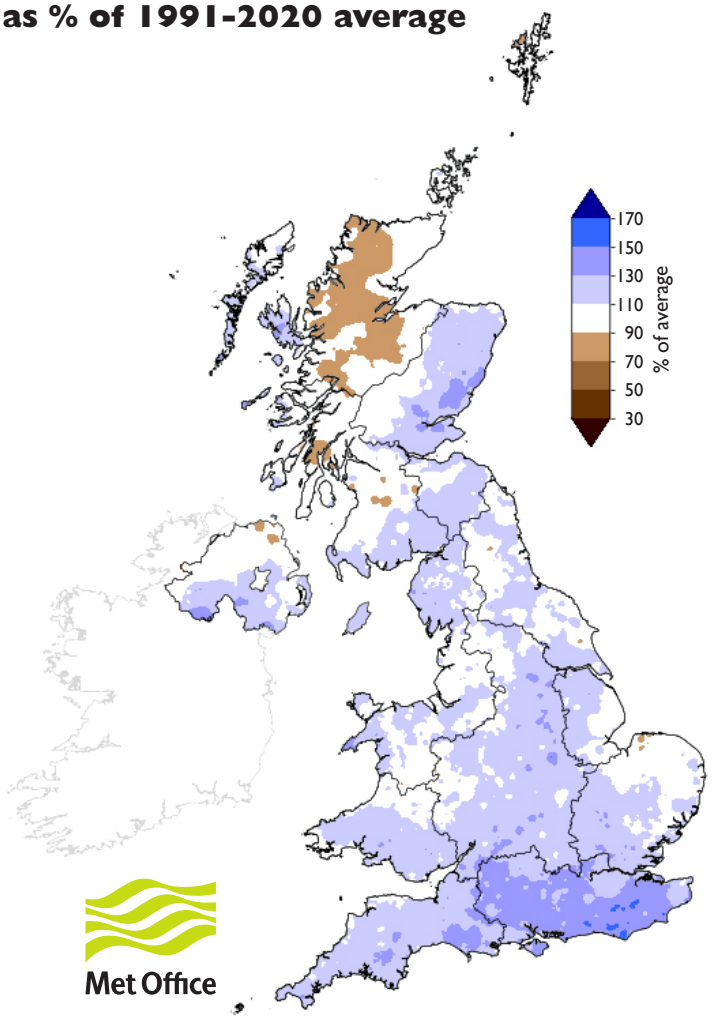
Important note: Figures in the above table may be quoted provided their source is acknowledged. Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic variability since 1836; they also assume a stable climate. The quoted RPs relate to the specific timespans only; for the same timespans, but beginning in any month the RPs would be substantially shorter. The timespans featured do not purport to represent the critical periods for any particular water resource management zone. For hydrological or water resources assessments of drought severity, river flows and/or groundwater levels normally provide a better guide than return periods based on regional rainfall totals. Note that precipitation totals in winter months may be underestimated due to snowfall undercatch. All monthly rainfall totals since January 2023 are provisional. Source: Data from HadUK-Grid dataset at 1km resolution v1.2.0.0.

Rainfall . . . Rainfall . . .

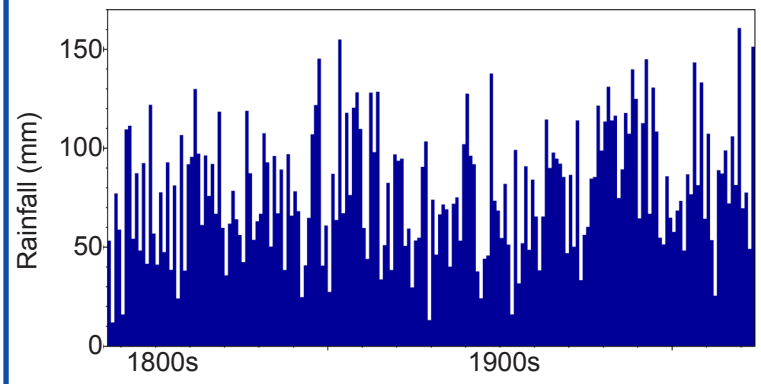
March 2023 rainfall
as % of 1991-2020 average



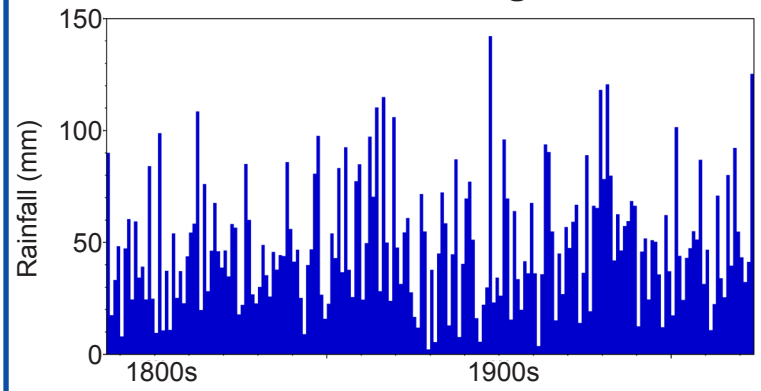
September 2022 - March 2023 rainfall
as % of 1991-2020 average



March rainfall for Northern Ireland



March rainfall for Thames region



UK Hydrological Outlook

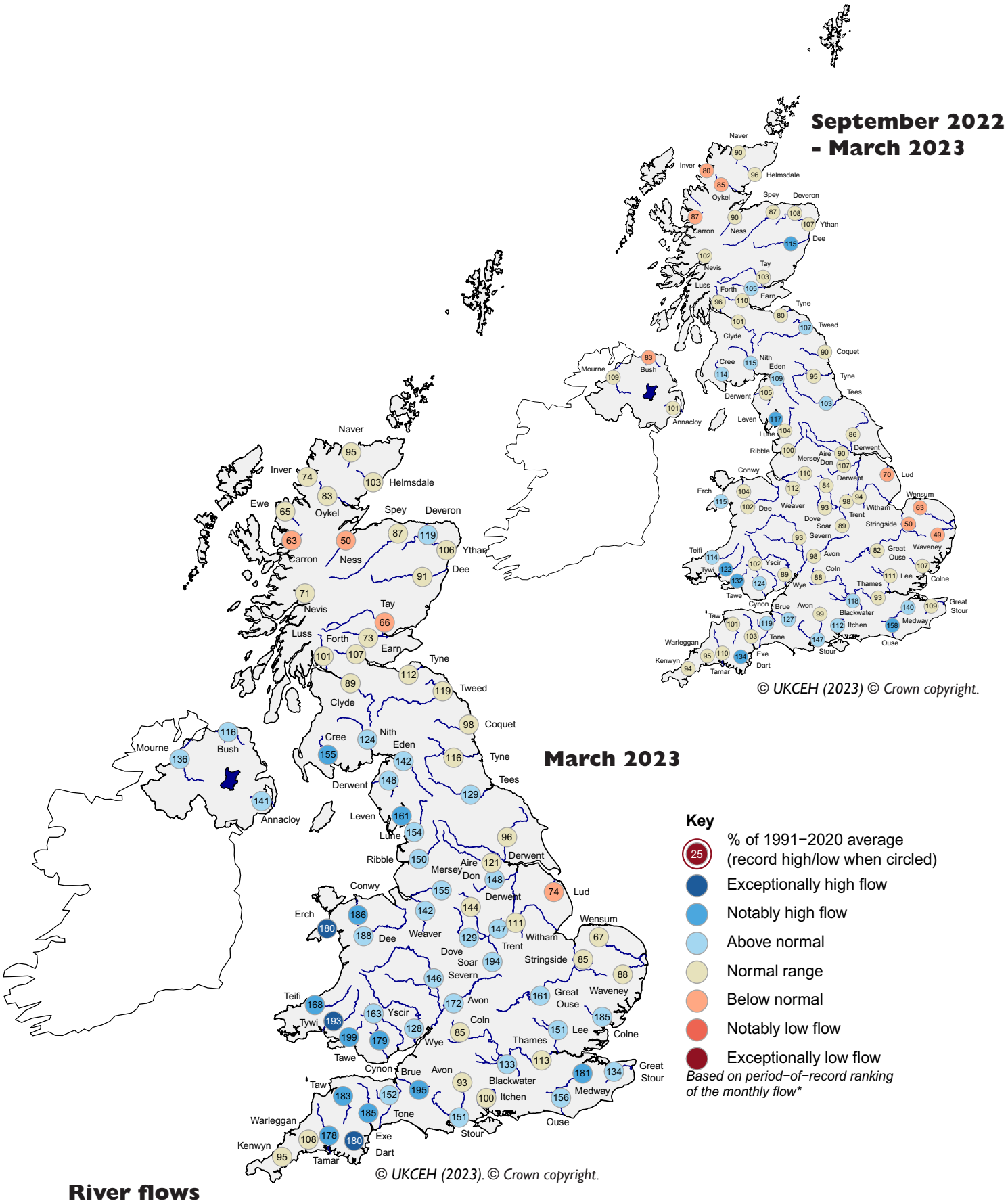
The Hydrological Outlook provides an insight into future hydrological conditions across the UK. Specifically it describes likely trajectories for river flows and groundwater levels on a monthly basis, with particular focus on the next three months.

The complete version of the Hydrological Outlook UK can be found at: www.hydoutuk.net/latest-outlook/

Period: **from April 2023**
Issued: **12.04.2023**
using data to the end of March 2023

The outlook for April and for the April–June period is for normal to above normal river flows in southern England and southern Wales, and normal for the rest of the country. Groundwater levels are expected to be mostly normal, except in the eastern South Downs Chalk and the Devonian and Northern Fell Sandstone of Scotland and NE England where they are likely to be above normal.

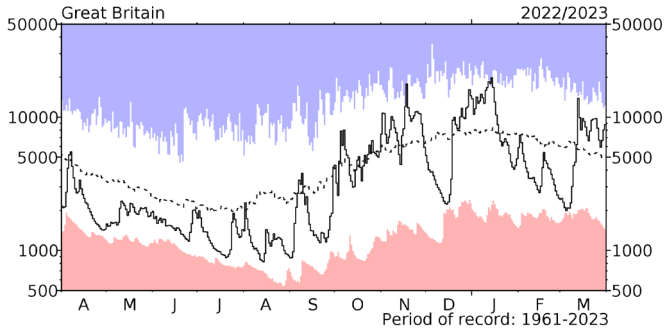
River flow . . . River flow . . .

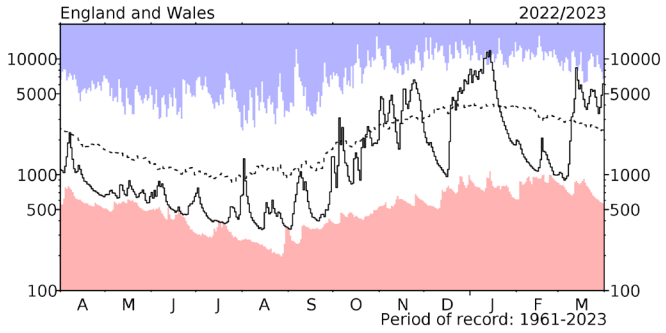


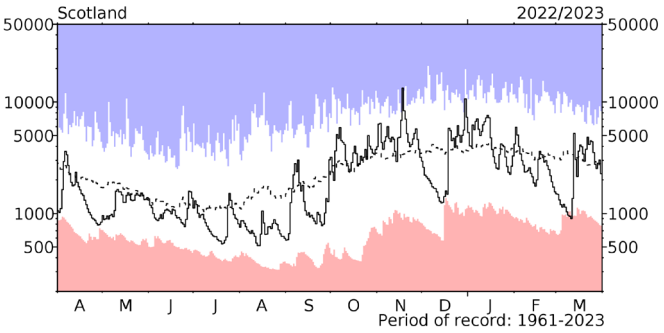
River flows

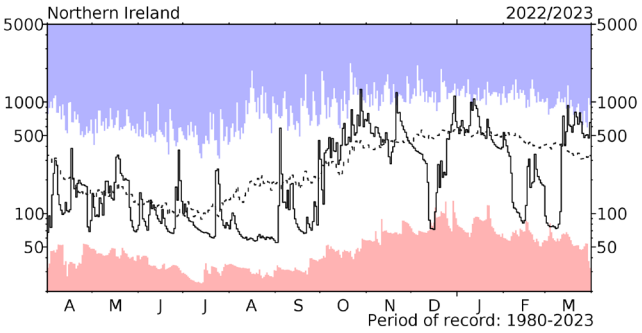
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much greater. The categories of the spots are based on the full period-of-record data whereas the percentages are based on the 1991-2020 averaging period for consistency between rainfall and river flows. Percentages may be omitted where flows are under review.

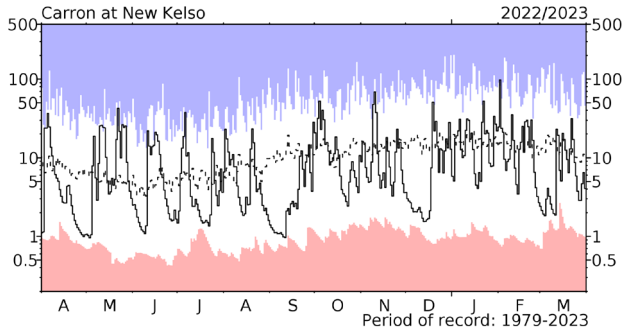
River flow . . . River flow . . .

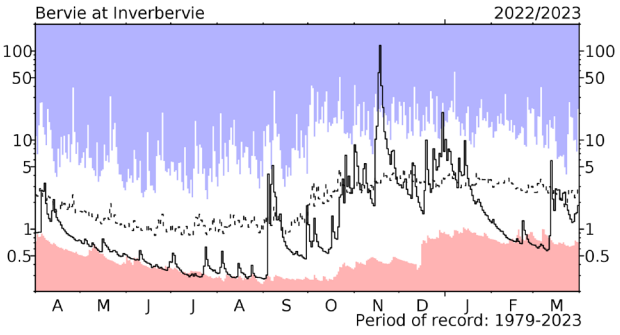


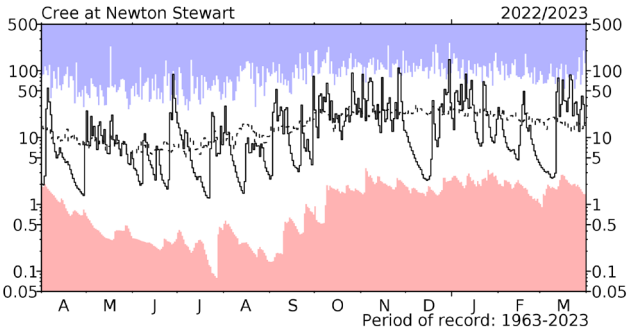


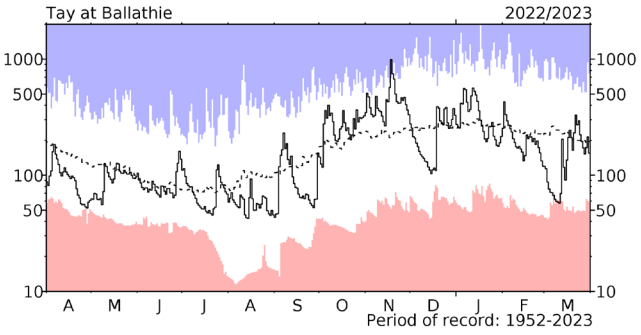


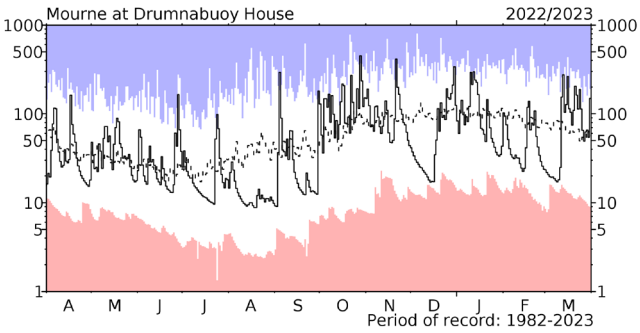


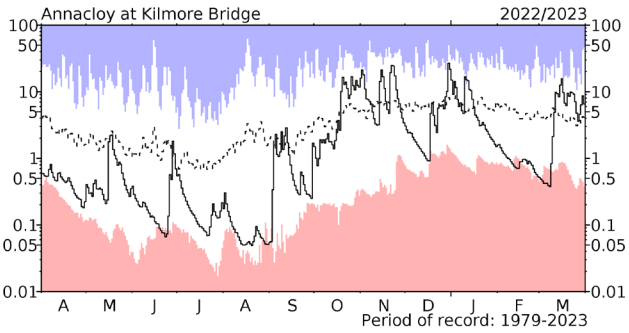








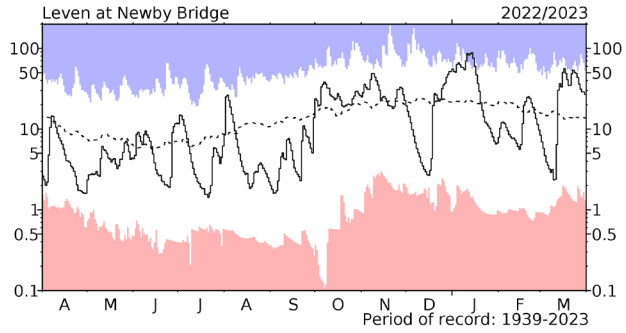


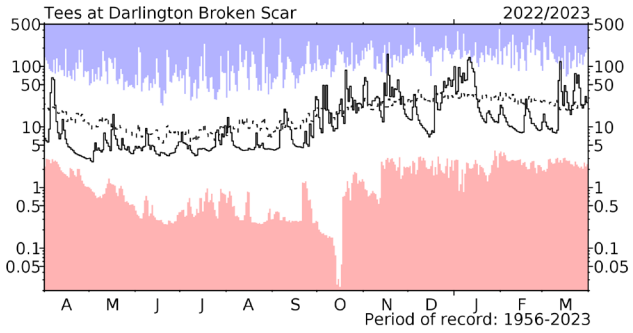


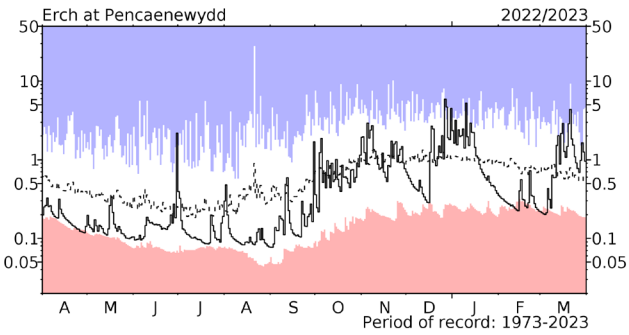
River flow hydrographs

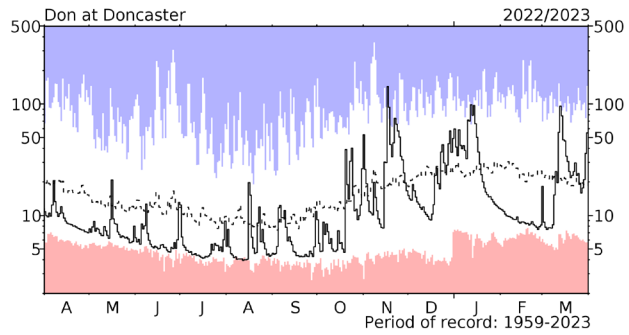
*The river flow hydrographs show the daily mean flows (measured in m^3s^{-1}) together with the maximum and minimum daily flows prior to April 2022 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed line represents the period-of-record average daily flow.

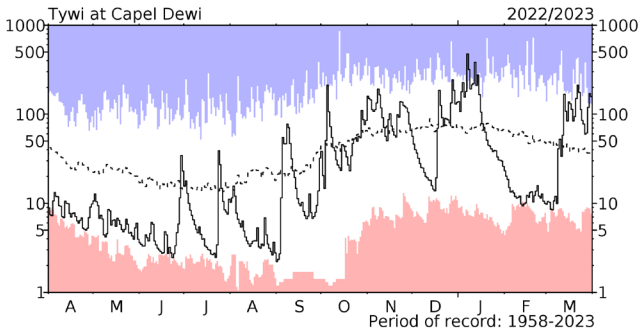
River flow . . . River flow . . .

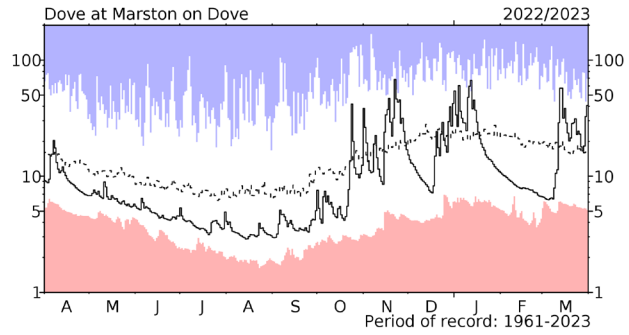


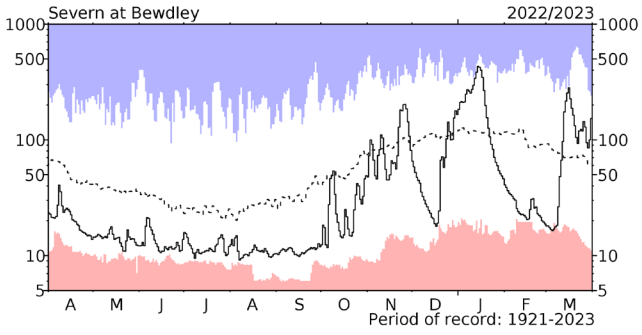


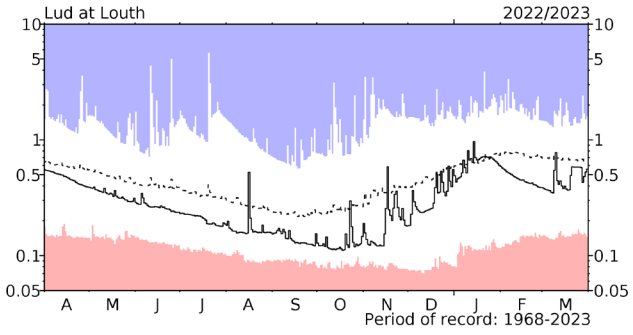


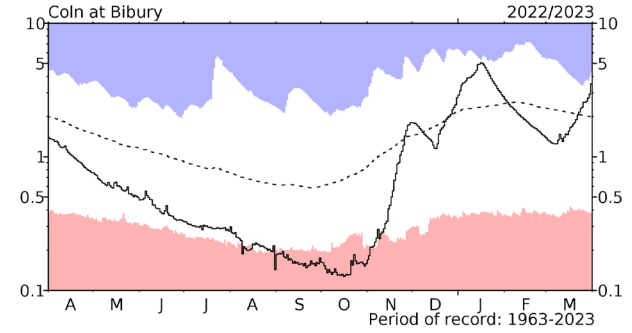


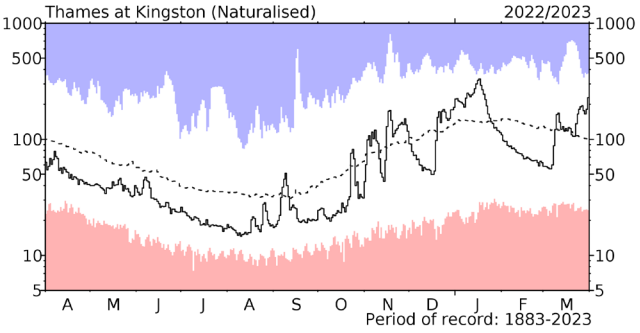


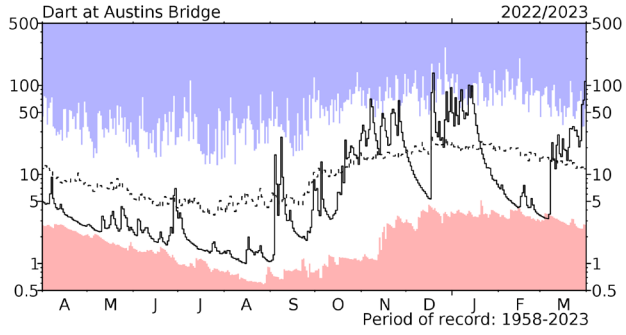


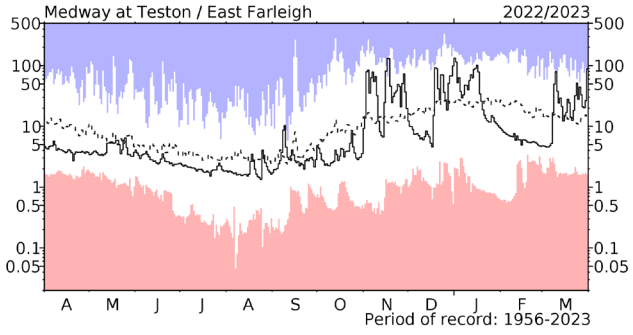




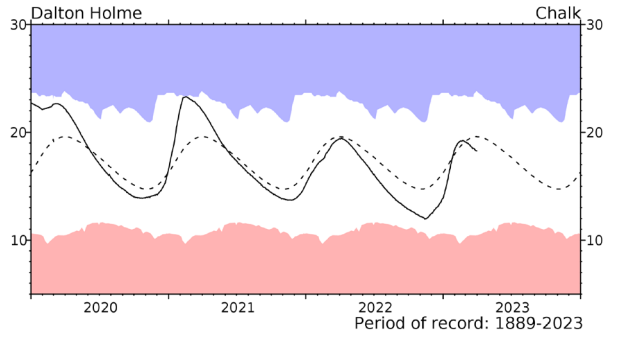


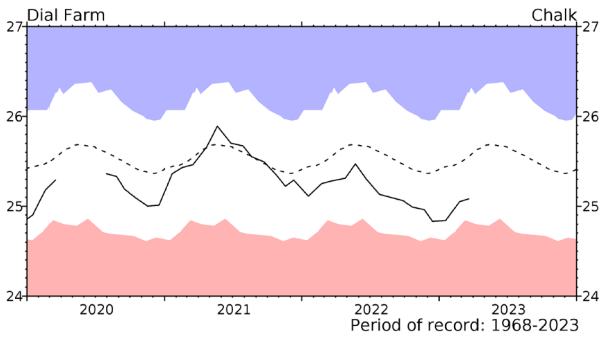


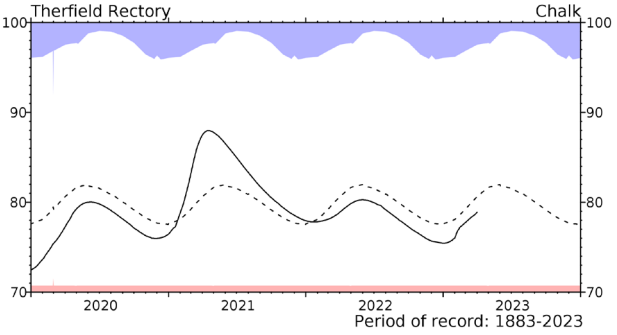


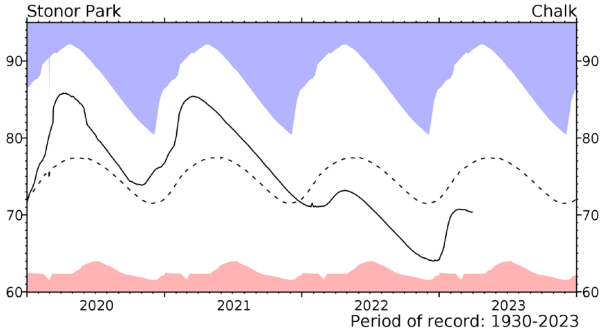


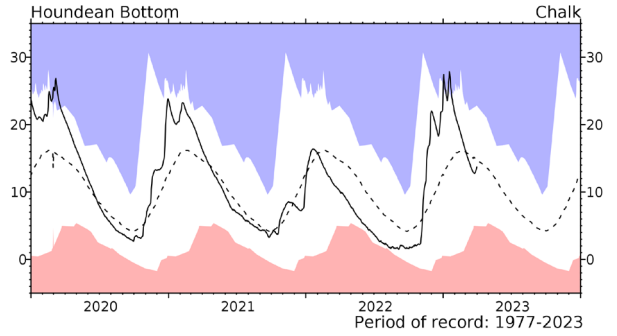
Groundwater…Groundwater

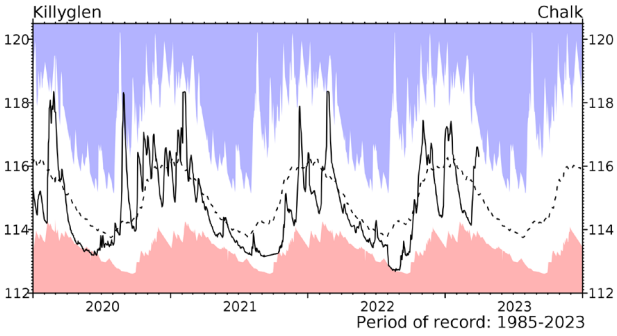


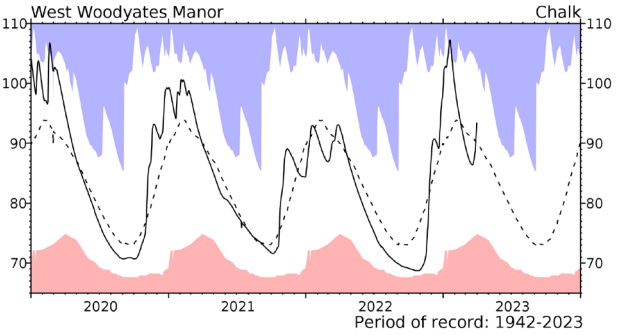


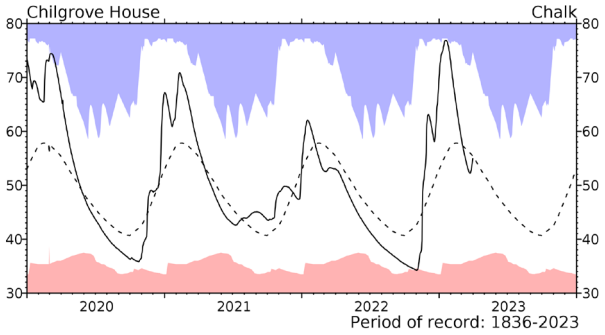


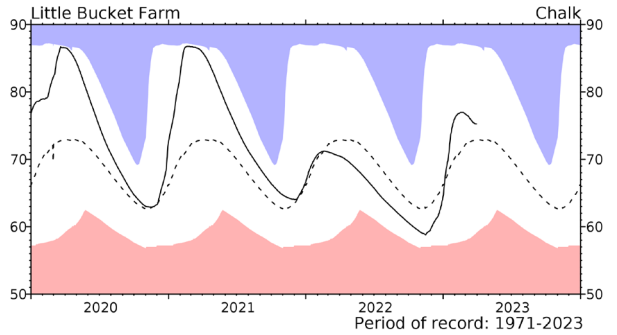


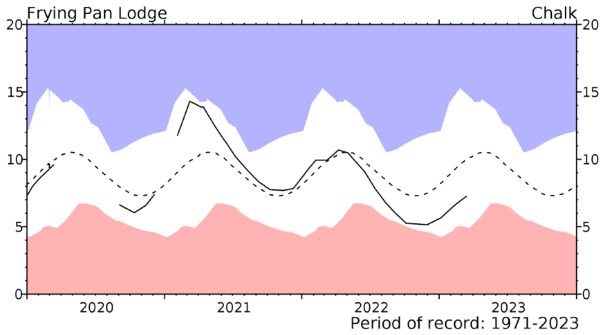






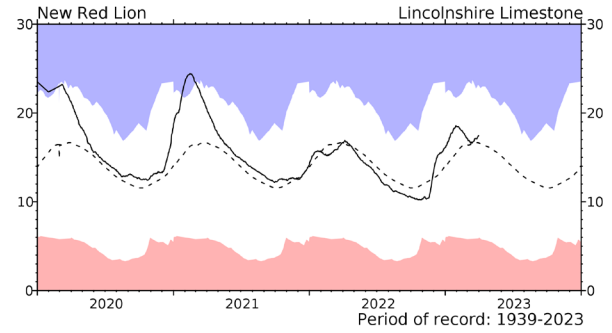


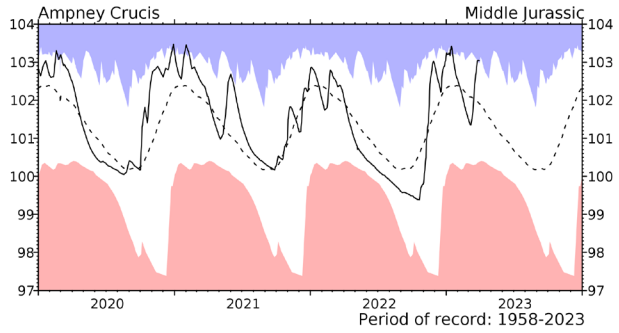


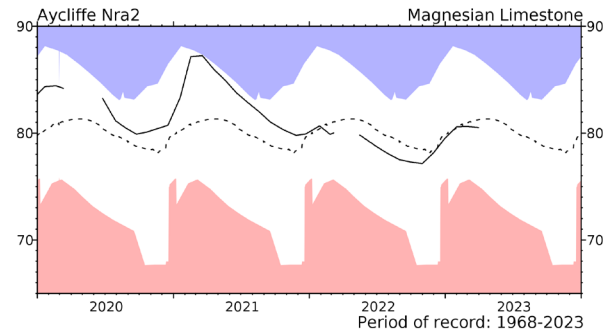


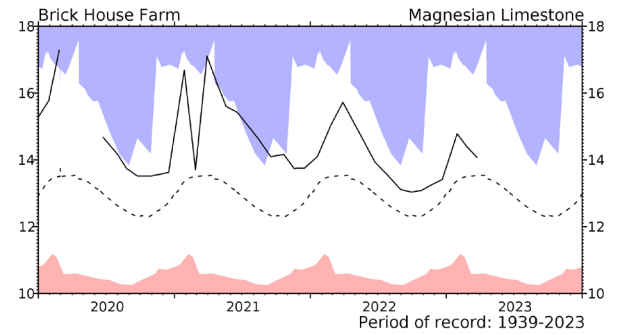
Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined below overlying impermeable strata. The monthly mean and the highest and lowest levels recorded for each month are calculated with data from the start of the record to the end of 2019. Note that most groundwater levels are not measured continuously and, for some index wells, the greater frequency of contemporary measurements may, in itself, contribute to an increased range of variation.

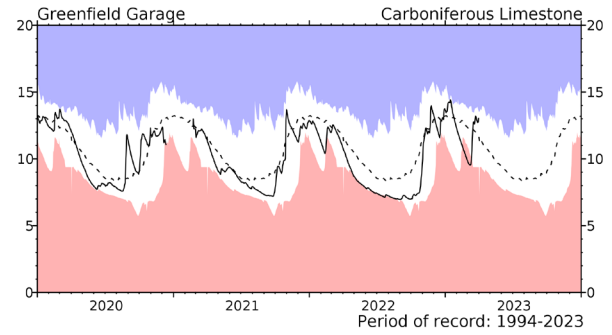
Groundwater… Groundwater

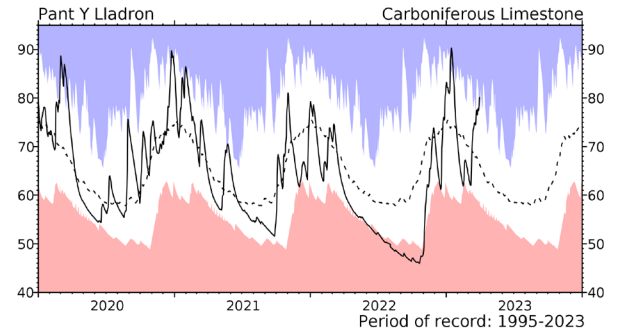


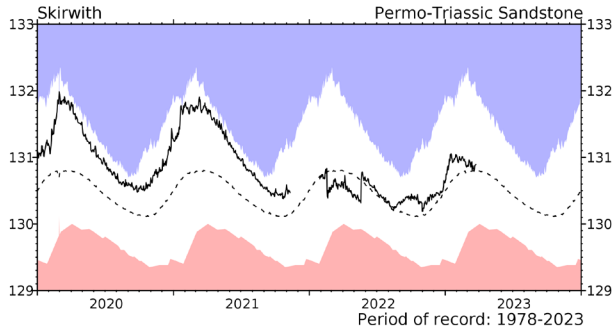


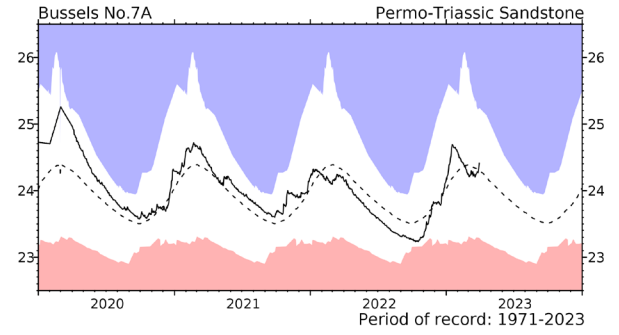


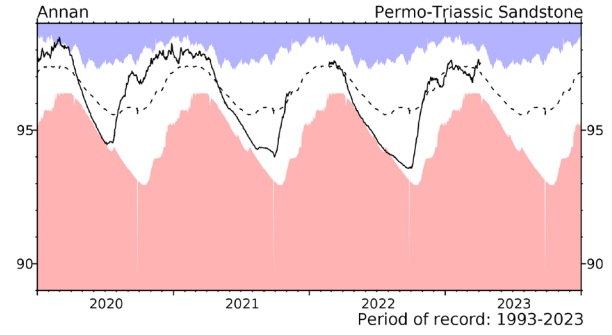


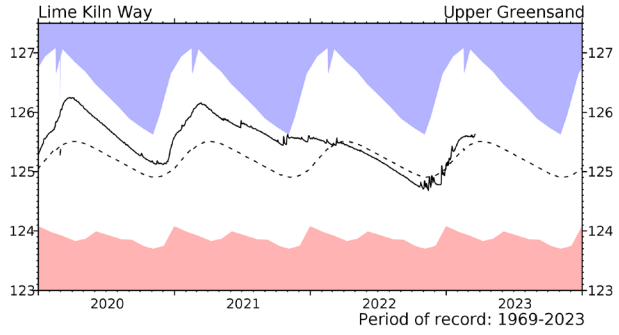


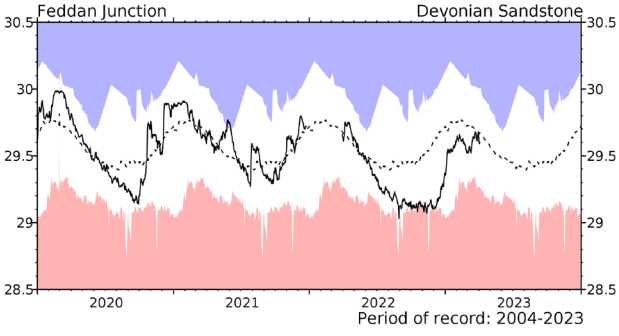


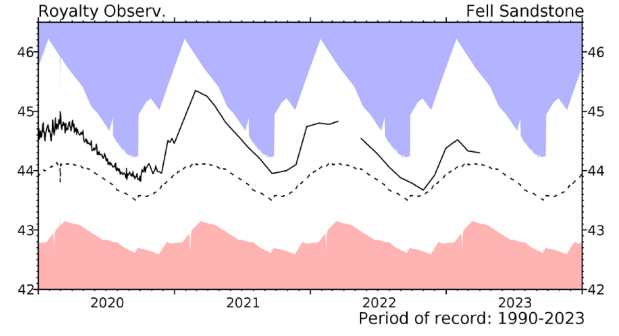










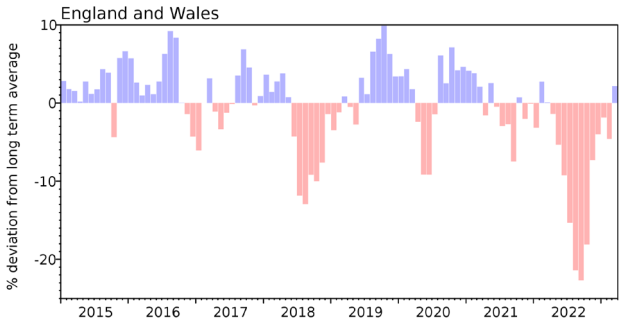


Groundwater levels - March 2023

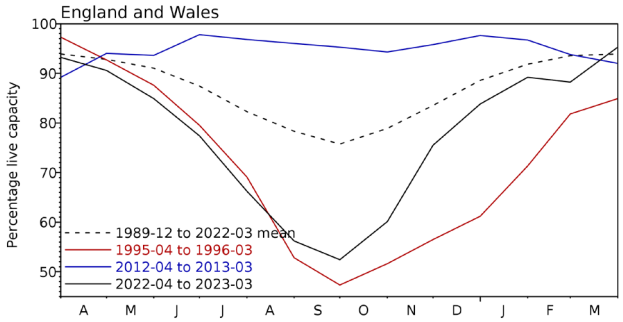
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. The rankings are designed as a qualitative indicator, and ranks at extreme levels, and when levels are changing rapidly, need to be interpreted with caution.

Reservoirs . . . Reservoirs . . .

Guide to the variation in overall reservoir stocks for England and Wales



Comparison between overall reservoir stocks for England and Wales in recent years



Percentage live capacity of selected reservoirs at end of month

Area	Reservoir		Capacity (Ml)	2023 Jan	2023 Feb	2023 Mar	Mar Anom.	Min Mar	Year* of min	2022 Mar	Diff 23-22
North West	N Command Zone	•	124929	95	88	99	7	77	1993	92	7
	Vyrnwy		55146	100	86	100	5	64	1996	96	4
Northumbrian	Teesdale	•	87936	92	87	100	7	77	2003	95	5
	Kielder		(199175)	90	90	96	4	81	1993	89	7
Severn-Trent	Clywedog		49936	87	89	98	2	86	1996	97	1
	Derwent Valley	•	46692	93	89	101	5	54	1996	92	9
Yorkshire	Washburn	•	23373	97	95	99	5	70	1996	91	8
	Bradford Supply	•	40942	87	83	92	-2	59	1996	89	3
Anglian	Grafham		(55490)	75	80	80	-11	77	1997	94	-14
	Rutland		(116580)	96	96	97	5	73	2012	96	1
Thames	London	•	202828	87	93	98	3	88	1990	97	1
	Farmoor	•	13822	96	99	89	-6	80	2013	94	-5
Southern	Bewl		31000	96	96	100	9	49	2012	90	10
	Ardingly		4685	100	100	100	2	51	2012	100	0
Wessex	Clatworthy		5662	100	92	100	2	82	1992	100	0
	Bristol	•	(38666)	99	96	100	6	71	1992	93	7
South West	Colliford		28540	47	49	60	-28	58	1997	79	-19
	Roadford		34500	61	58	68	-18	37	1996	98	-30
	Wimbleball		21320	100	97	100	3	78	1996	100	0
	Stithians		4967	91	92	99	4	52	1992	100	-1
Welsh	Celyn & Brenig	•	131155	78	79	89	-9	72	1996	89	0
	Brianne		62140	92	89	100	2	90	1993	94	6
	Big Five	•	69762	94	93	100	4	78	1993	96	4
	Elan Valley	•	99106	96	93	100	3	89	1993	93	7
Scotland(E)	Edinburgh/Mid-Lothian	•	97223	98	98	98	3	71	1998	98	0
	East Lothian	•	9317	100	100	100	1	95	2012	100	0
Scotland(W)	Loch Katrine	•	110326	96	98	100	7	74	2010	97	3
	Daer		22494	90	88	90	-6	77	2013	84	6
	Loch Thom		10721	100	99	99	3	83	2020	95	4
Northern Ireland	Total+	•	56800	96	92	98	7	83	2002	93	5
	Silent Valley	•	20634	99	89	100	12	57	2000	96	4

( ) figures in parentheses relate to gross storage

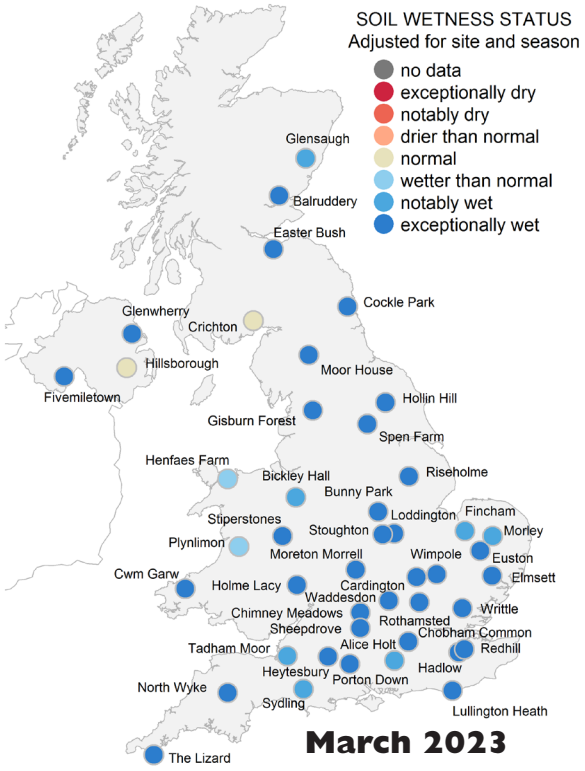
• denotes reservoir groups

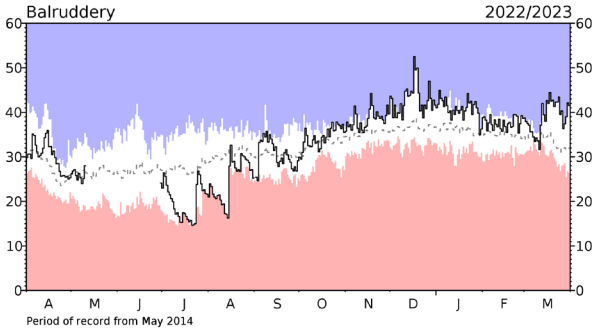
*last occurrence

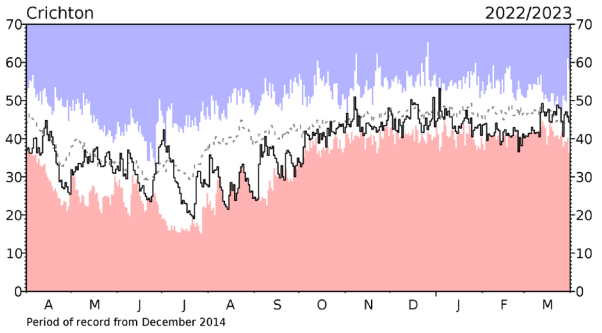
+ excludes Lough Neagh

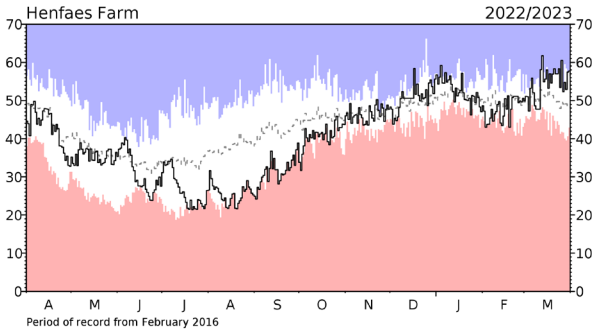
Details of the individual reservoirs in each of the groupings listed above are available on request. The percentages given in the Average and Minimum storage columns relate to the 1988-2012 period except for West of Scotland and Northern Ireland where data commence in the mid-1990s. In some gravity-fed reservoirs (e.g. Clywedog) stocks are kept below capacity during the winter to provide scope for flood attenuation purposes. Monthly figures may be artificially low due to routine maintenance or turbidity effects in feeder rivers.

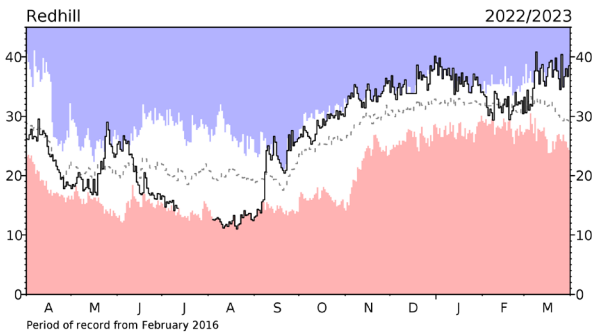
Soil Moisture . . . Soil Moisture

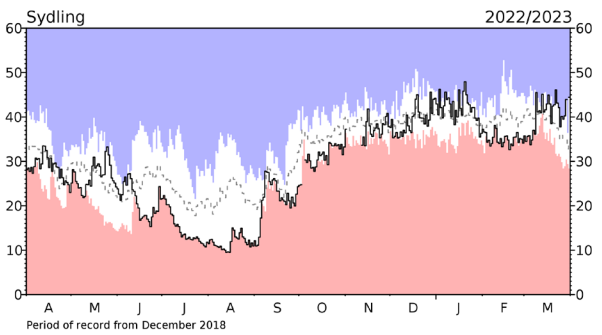












Widespread rain in March saw soil moisture increase across most of the COSMOS-UK network, recovering from dry soil moisture levels from the previous month.

Sites in Northern Ireland (e.g. Glenwherry and Fivemiletown), Eastern Scotland (e.g. Balruddery), and most of England (e.g. Redhill and Moorhouse) recorded very high soil moisture. At some sites in southern England such as Sydling, the high levels of precipitation returned soil moisture to within the normal range. Similarly, in northern Wales and Western Scotland, Henfaes and Crichton returned close to their normal soil moisture levels in March.

Overall, soil moisture increased from the low levels of the previous month, reflecting the higher amount of precipitation. This resulted in wetter than normal soils at some sites, whereas at other sites soil moisture recovered to within its normal range following a dry February.

Soil moisture data

These data are from UKCEH's COSMOS-UK network. The time series graphs show volumetric water content as a percentage in black together with the maximum and minimum daily values for the period-of-record of the sites. The dashed line represents the period-of-record mean VWC. For more information visit cosmos.ceh.ac.uk.

NHMP

The National Hydrological Monitoring Programme (NHMP) was started in 1988 and is undertaken jointly by the UK Centre for Ecology & Hydrology (UKCEH) and the British Geological Survey (BGS). The NHMP aims to provide an authoritative voice on hydrological conditions throughout the UK, to place them in a historical context and, over time, identify and interpret any emerging hydrological trends. Hydrological analysis and interpretation within the Programme is based on the data holdings of the National River Flow Archive (NRFA; maintained by UKCEH) and National Groundwater Level Archive (NGLA; maintained by BGS), including rainfall, river flows, borehole levels, and reservoir stocks.

The Hydrological Summary is supported by the Natural Environment Research Council award number NE/R016429/1 as part of the UK-SCAPE programme delivering National Capability.

Data Sources

The NHMP depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged. A location map of all sites used in the Hydrological Summary can be found on the NHMP website. River flow and groundwater level data are provided by the Environment Agency (EA), Natural Resources Wales - Cyfoeth Naturiol Cymru (NRW), the Scottish Environment Protection Agency (SEPA) and, for Northern Ireland, the Department for Infrastructure - Rivers and the Northern Ireland Environment Agency. In all cases the data are subject to revision following validation (high flow and low flow data in particular may be subject to significant revision).

Details of reservoir stocks are provided by the Water Service Companies, the EA, Scottish Water and Northern Ireland Water.

The Hydrological Summary and other NHMP outputs may also refer to and/or map soil moisture data for the UK. These data are provided by the Meteorological Office Rainfall and Evaporation Calculation System (MORECS). MORECS provides estimates of monthly soil moisture deficit in the form of averages over 40 x 40 km grid squares over Great Britain and Northern Ireland. The monthly time series of data extends back to 1961.

Rainfall data are provided by the Met Office. To allow better spatial differentiation the rainfall data for Britain are presented for the regional divisions of the precursor organisations of the EA, NRW and SEPA. The areal rainfall figures have been produced by the Met Office National Climate Information Centre (NCIC), and are based on the HadUK-Grid 1km resolution gridded data from rain gauges. The majority of the full rain gauge network across the UK is operated by the EA, NRW, SEPA and Northern Ireland Water; supplementary rain gauges are operated by the Met Office. The Met Office NCIC monthly rainfall series extend back to 1836 and form the official source of UK areal rainfall statistics which have been adopted by the NHMP. The gridding technique used is described in Hollis, 2019 available at https://doi.org/10.1002/gdj3.78

Long-term averages are based on the period 1991-2020 and are derived from the monthly areal series.

The regional figures for the current month in the hydrological summaries are based on a limited rain gauge network so these (and the associated return periods) should be regarded as a guide only.

The monthly rainfall figures are provided by the Met Office NCIC and are Crown Copyright and may not be passed on to, or published by, any unauthorised person or organisation.

For further details on rainfall or MORECS data, please contact the Met Office:

Tel: 0370 900 0100
Email: enquiries@metoffice.gov.uk

Enquiries

Enquiries should be directed to the NHMP:

Tel: 01491 692599
Email: nhmp@ceh.ac.uk

A full catalogue of past Hydrological Summaries can be accessed and downloaded at:

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

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