Hydrological Summary *for the United Kingdom*

November 2023

General

The first half of November was unsettled for much of England and Wales before a dry, warm spell which transitioned to colder temperatures with some wintry conditions. November was mild. With rainfall totals near-average for the UK, this varied regionally with eastern Scotland and Northern Ireland receiving below average rainfall. November river flows generally remained above normal to exceptionally high following the wet October, with twice the average for some catchments in east Anglia and southwest England (e.g. Stringside, Stour). Reservoir stocks increased in most impoundments and remains healthy entering the winter (5% above average for England & Wales at month end). November concluded a warm and wet autumn for most parts of the UK. Correspondingly, the recharge season began early, with abundant replenishment since – groundwater levels continued to rise through November and remained above normal across most aquifers. The current Hydrological Outlook for the next three months favours above normal river flows (e.g. southern England and eastern Scotland) and groundwater levels, with elevated flood risk due to a wet start to December.

Rainfall

The persistent wet weather that dominated October continued in the first week of November. From 1st-7th, heavy rainfall associated with storm 'Ciarán' was recorded across southern England, south Wales and eastern Scotland (e.g. 50mm in parts of southern and south-east England from 1st-3rd). 'Ciarán' was a very severe windstorm – yielding a new minimum atmospheric pressure for November for England and Wales – and had parallels with the 1987 "Great Storm", but the storm tracked further southwards, with the Channel Islands suffering the strongest winds. Heavy rains and strong winds led to widespread transport disruption, power cuts for over 100,000 homes and surface water flooding affecting properties in southern England and north Wales. During this seven-day period, southern England received 30-50mm of rain and parts of east Anglia, east Midlands and northeast Scotland received more than the average November rainfall. Between the 12th-14th, storm 'Debi' brought further unsettled conditions. Heavy rains, especially for Northern Ireland and northwest England (e.g. 124mm of rain on the 13th and 209mm between 12th-14th was recorded at Honister Pass, Cumbria), led to localised surface water flooding and localised transport disruptions. Total November rainfall for the UK was 96% of average, with anomalies greatest in parts of south-east England and deficits highest in west Scotland and Northern Ireland. For the autumn (September-November), total UK rainfall was 122% of average. Parts of southern England received over 150% of average autumn rainfall, contrasting with western Scotland and Northern Ireland, which only received three quarters. September to November rainfall total were the highest since 2000 for Northumbria and North East Scotland, and among the 10 wettest for regions of England.

River Flows

River flows began the month climbing following a wet end to October and in response to rainfall from storm 'Ciarán'. The Annacloy and Lagan both recorded their second highest peak flows for any month on the 1st (in series from 1980 and 1977, respectively) and the Lymington its highest for November on the 2nd (in a series from 1976). During the first week of November, the top three highest November peak flows on record were registered at the Stringside, Little Ouse, Mole and Stour (all in series of >50 years) and by the 7th, more than 80 flood warnings had been issued across south-west Wales and southern England. River flows at responsive catchments in south-west Scotland generally receded over the same period but recovered in response to rainfall associated with storm 'Debi' on the 13th before returning to below normal flows at month-end. High river levels caused localised flooding in Cumbria, and several catchments registered maximum daily mean flows on the 13th and 14th across eastern Scotland (e.g. Ythan and Bervie in series from 1983 and 1979 respectively)* and the north of England (e.g. Tees, Ouse and Eden, all in series of >50 years). November mean flows were generally above average across the UK, with the exception for catchments in west Scotland which recorded less than three-quarters of their respective average flows (e.g. Forth, Nevis). Several catchments in southern England recorded exceptionally high flows. The third highest November mean flows was recorded for the Avon (255%) and Stringside (283%), and the second highest for the Stour (292%) (all with records >50 years). November outflows for England were the second highest in a series since 1961. Mean flows for the autumn (September-November) were similarly above normal for most with exceptions in western Scotland where flows were generally normal or below normal (e.g. 85% of average at Cree). Over the 3-month period, the Dorset Stour and the Coquet saw the highest autumn flows on record (in a series from 1973 and 1963 respectively). Autumn outflows for UK were the second highest on record for November (in a record from 1980).

Soil Moisture and Groundwater

At the end of November, soil moisture was close to or above field capacity at most COSMOS-UK sites. With the exception of three sites, groundwater levels in the Chalk continued to rise. For example, levels at Redlands Hall and Chipstead moved from normal to above normal and to notably high levels, and Wetwang, Dalton Holme, Chilgrove House and Houndean moved to exceptionally high at month-end. Levels at Therfield Rectory and at Dial Farm remained normal and below normal respectively, while they fell at Killyglen, moving from exceptionally high to normal. In the Jurassic limestones, levels at New Red Lion and Ampney Crucis rose early in the month and became exceptionally high and above normal by the end of the month respectively. In the Magnesian Limestone, levels at Aycliffe and Brick House Farm were notably high and exceptionally high respectively. In the Carboniferous Limestone, levels remained in the exceptionally high range at Alstonfield and normal elsewhere in the aquifer. Recharge occurred at all four sites in the Permo-Triassic Sandstones. Levels at Weir Farm were exceptionally high and normal to above normal elsewhere. In the Devonian sandstone there was limited recharge at Feddan Junction and Easter Lathrisk with levels remaining in the normal range at both sites. More significant recharge was recorded at Royalty Observatory (Fell Sandstone) and groundwater levels increased to above normal level.

**Highest Instantaneous Flows are no longer available for Scotland, and so daily mean flows are used as an alternative for flood event ranking.*

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.

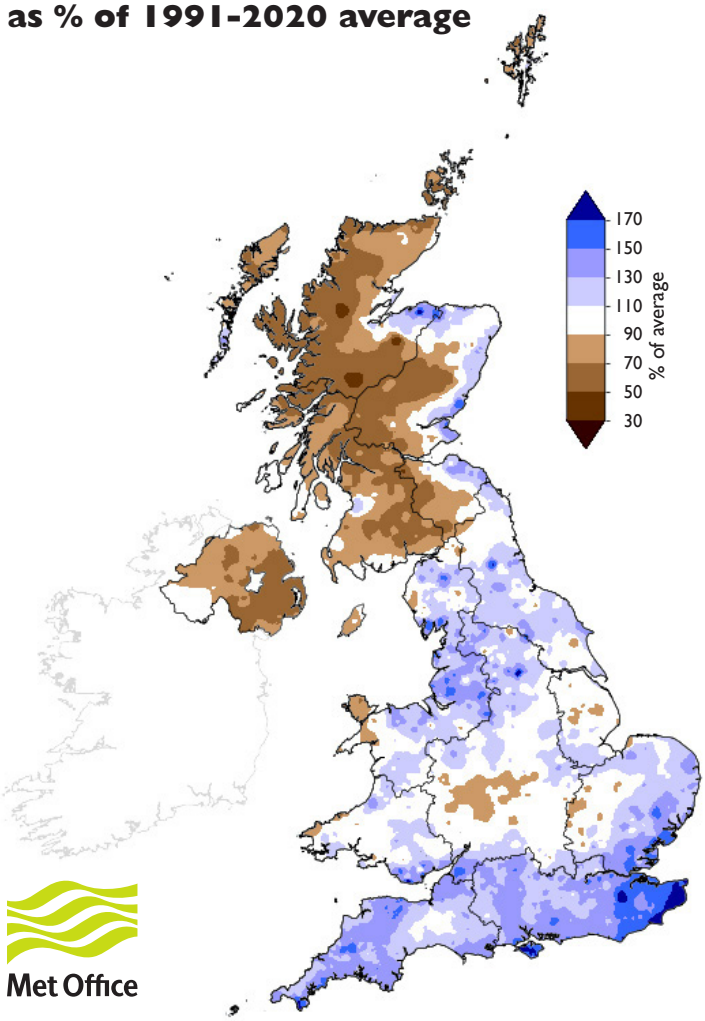
Region	Rainfall	Nov 2023	Oct23 – Nov23	RP	Sep23 – Nov23	RP	Jun23 – Nov23	RP	Dec22 – Nov23	RP
United Kingdom	mm	**119**	290		410		691		1217	
	%	**96**	118	5-10	122	8-12	117	10-20	105	5-10
England	mm	**111**	258		340		573		992	
	%	**120**	141	15-25	135	10-20	125	15-25	114	10-15
Scotland	mm	**122**	321		489		816		1475	
	%	**74**	96	2-5	107	2-5	105	2-5	94	2-5
Wales	mm	**175**	383		539		882		1594	
	%	**108**	119	5-10	125	5-10	120	5-10	109	5-10
Northern Ireland	mm	**92**	284		429		813		1317	
	%	**75**	120	5-10	132	20-30	137	>100	114	20-35
England & Wales	mm	**120**	275		367		615		1074	
	%	**118**	137	10-20	133	10-20	124	10-20	113	10-15
North West	mm	**160**	311		468		863		1440	
	%	**120**	116	2-5	125	5-10	129	15-25	112	10-15
Northumbria	mm	**105**	276		359		620		984	
	%	**110**	151	30-50	140	15-25	128	15-25	108	5-10
Severn-Trent	mm	**81**	236		310		528		885	
	%	**104**	148	15-25	139	10-20	124	10-15	110	5-10
Yorkshire	mm	**105**	253		337		601		977	
	%	**117**	146	15-25	138	10-20	130	15-25	112	5-10
Anglian	mm	**70**	198		255		418		709	
	%	**113**	157	25-40	143	15-25	119	5-10	112	5-10
Thames	mm	**96**	220		289		476		865	
	%	**121**	139	10-15	135	8-12	125	8-12	119	8-12
Southern	mm	**144**	322		376		558		1023	
	%	**147**	168	20-30	148	15-25	132	10-20	125	15-25
Wessex	mm	**133**	291		373		607		1137	
	%	**127**	142	10-20	138	10-15	131	15-25	125	25-40
South West	mm	**195**	344		452		735		1415	
	%	**133**	122	5-10	122	5-10	118	5-10	113	8-12
Welsh	mm	**167**	370		518		850		1534	
	%	**107**	120	5-10	124	5-10	120	5-10	109	5-10
Highland	mm	**126**	339		524		889		1649	
	%	**66**	88	2-5	98	2-5	102	2-5	89	2-5
North East	mm	**103**	338		441		682		1127	
	%	**92**	145	20-35	139	20-30	120	10-20	106	2-5
Tay	mm	**109**	395		555		855		1420	
	%	**74**	132	10-20	138	20-30	124	15-25	102	2-5
Forth	mm	**95**	290		424		701		1232	
	%	**77**	114	5-10	122	5-10	111	5-10	99	2-5
Tweed	mm	**94**	251		357		634		1094	
	%	**84**	111	2-5	116	5-10	112	5-10	101	2-5
Solway	mm	**131**	226		419		772		1471	
	%	**77**	66	2-5	91	2-5	97	2-5	93	2-5
Clyde	mm	**152**	337		547		930		1712	
	%	**76**	84	2-5	99	2-5	100	2-5	90	2-5

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

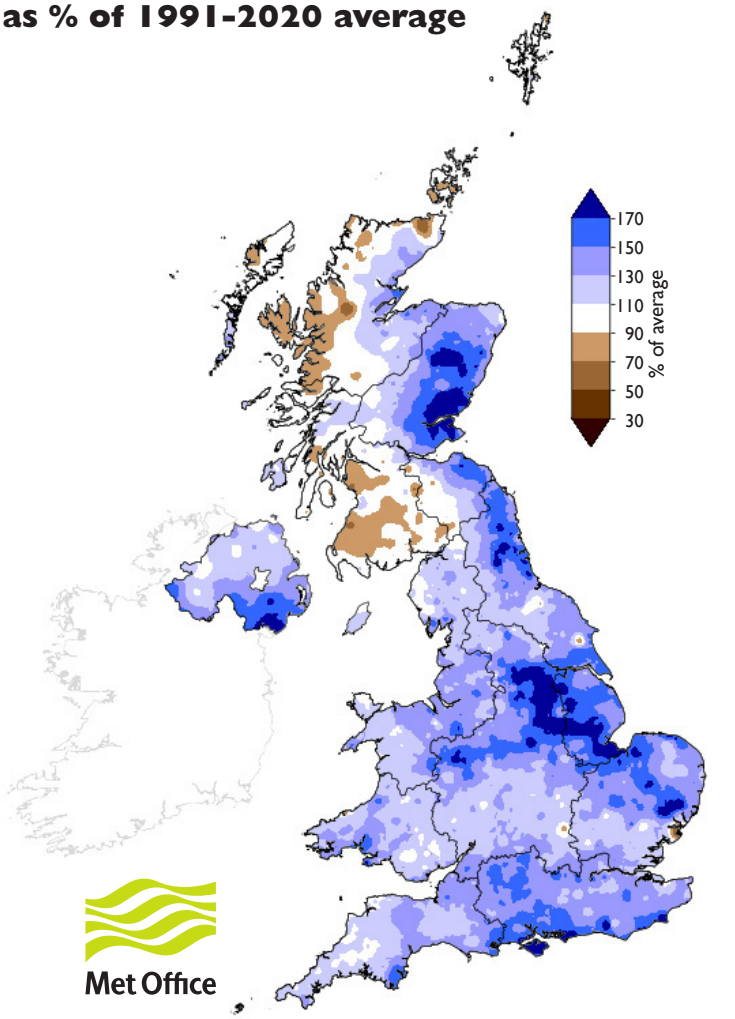
Important note: Figures in the above table may be quoted provided their source is acknowledged. Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic variability 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 . . .

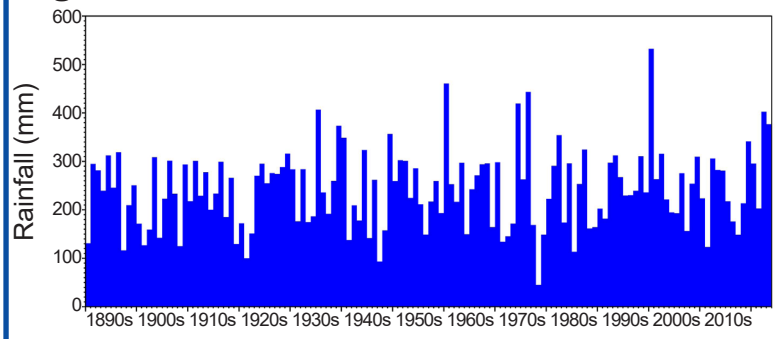
November 2023 rainfall as % of 1991-2020 average



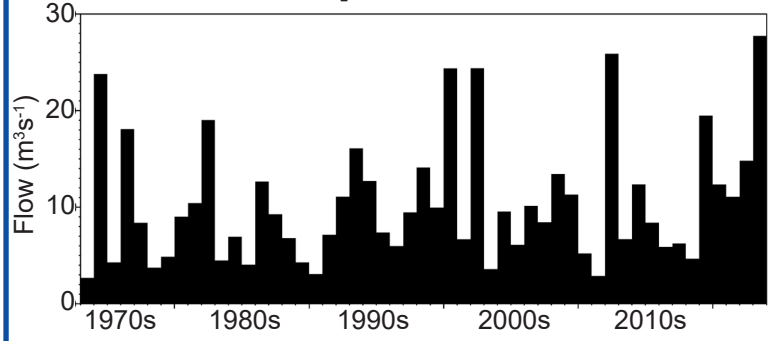
September 2023 - November 2023 rainfall as % of 1991-2020 average



September - November rainfall for Southern region



September - November average river flows for Stour at Throop



UK Hydrological Outlook

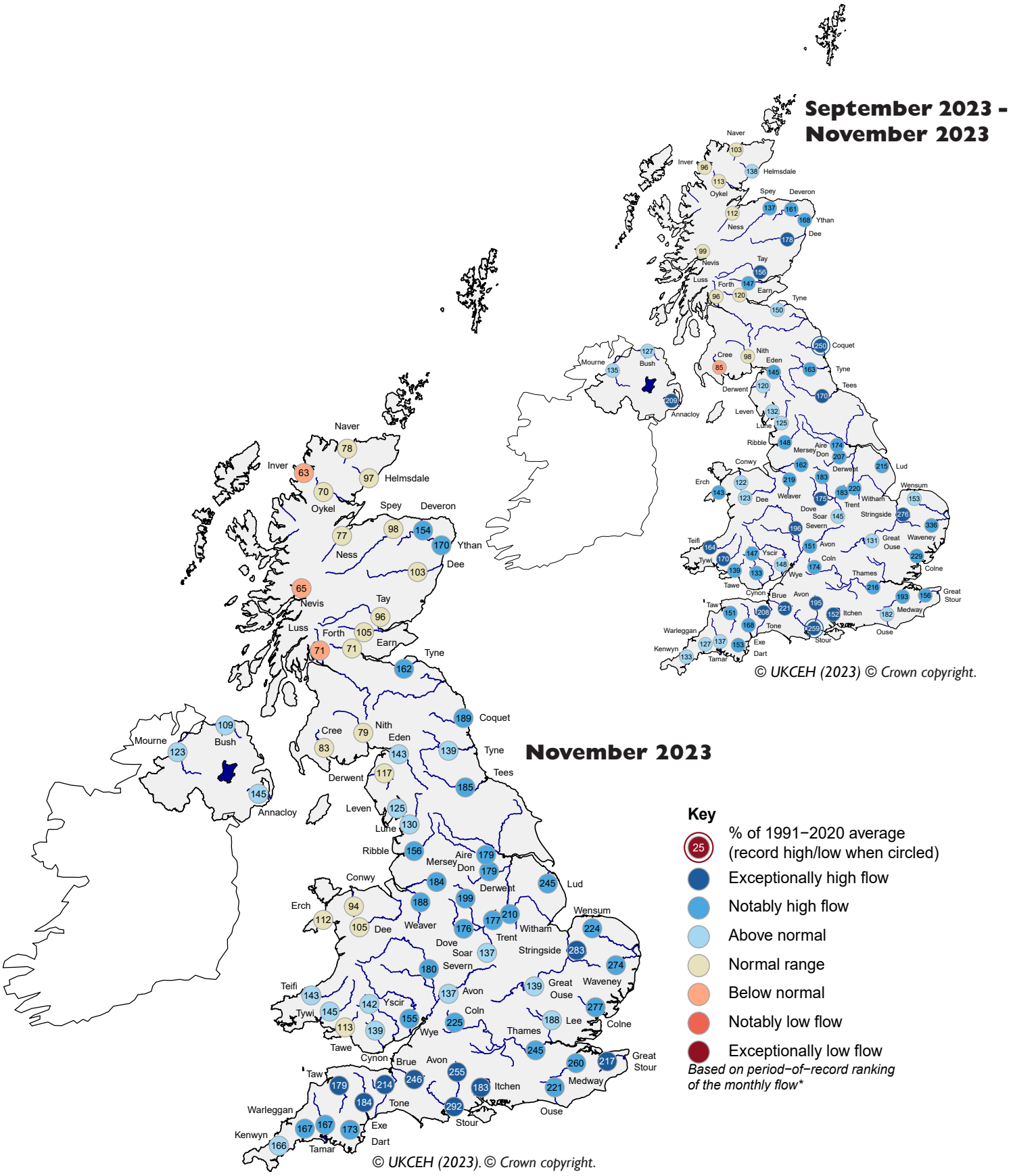
The Hydrological Outlook provides an insight into future hydrological conditions across the UK. Specifically it describes likely trajectories for river flows and groundwater levels on a monthly basis, with particular focus on the next three months.

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

Period: **from December 2023**
Issued: **08.12.2023**
using data to the end of November 2023

The outlook for December is for normal to above normal river flows, except for in parts of the west where normal flows are favoured, and for above normal groundwater levels across most of the country. The three month outlook is for a very similar picture, with a similar east/west contrast in river flows and above normal groundwater levels.

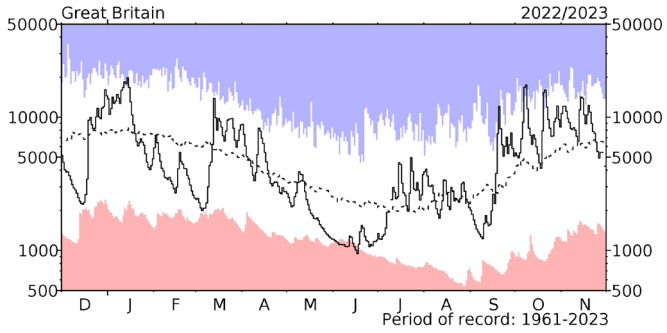
River flow . . . River flow . . .

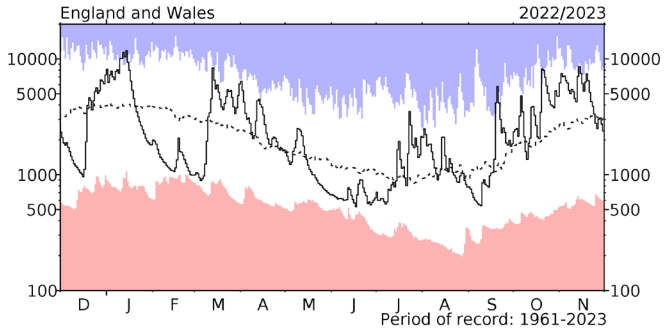


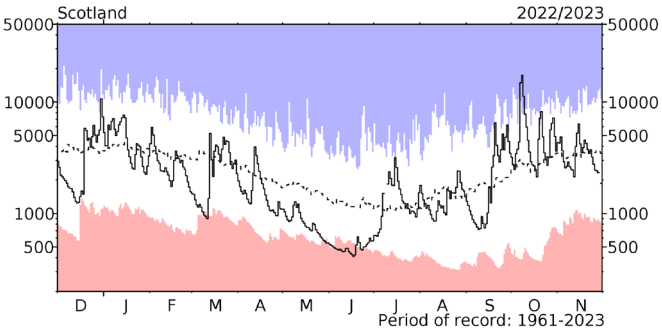
River flows

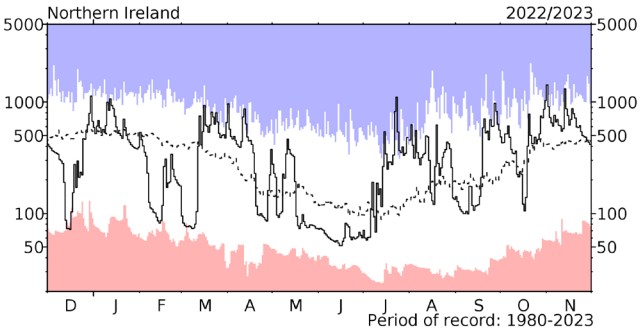
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much 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.

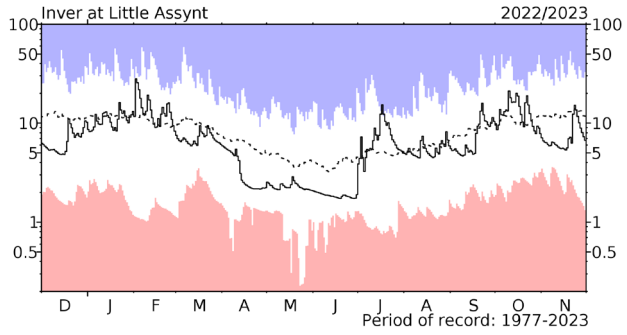
River flow . . . River flow . . .

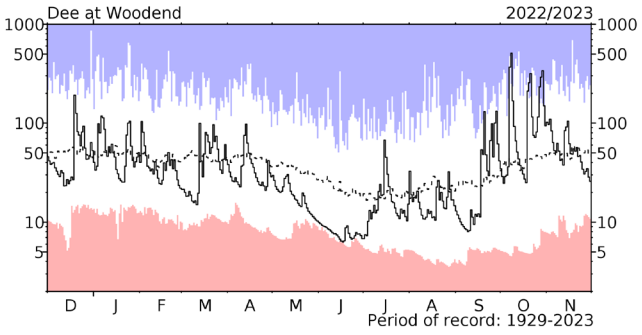


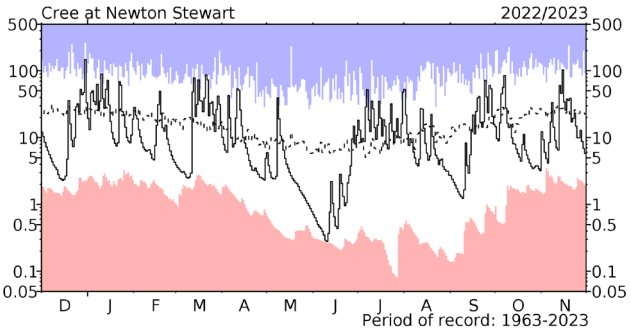


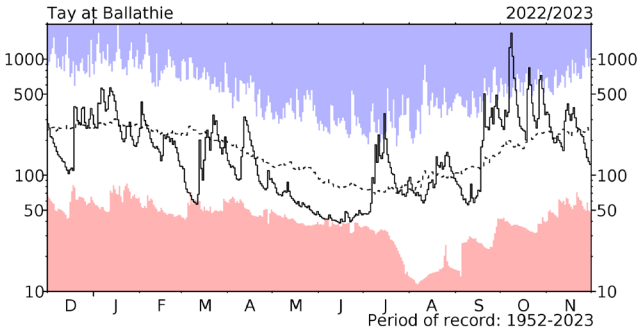


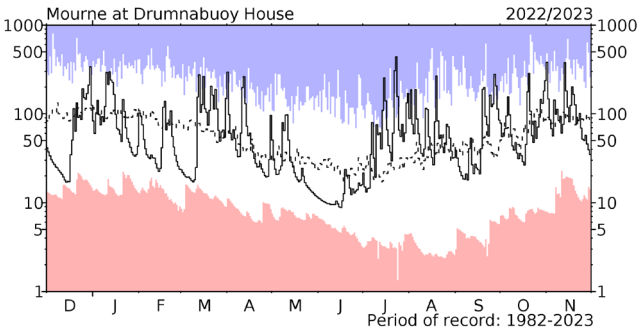


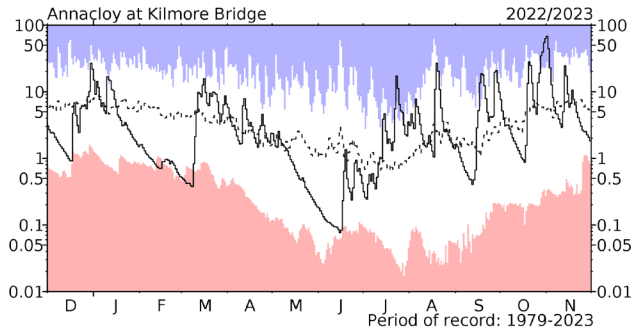








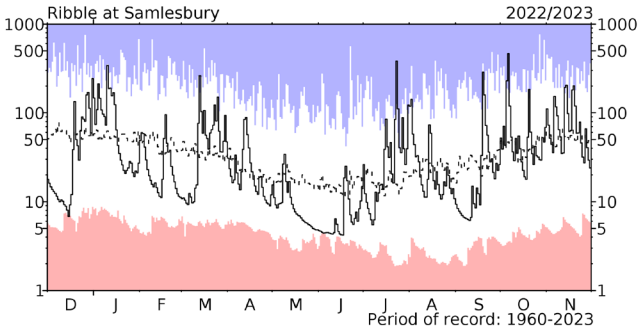


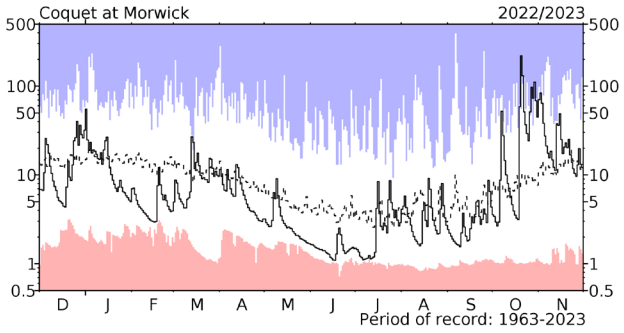


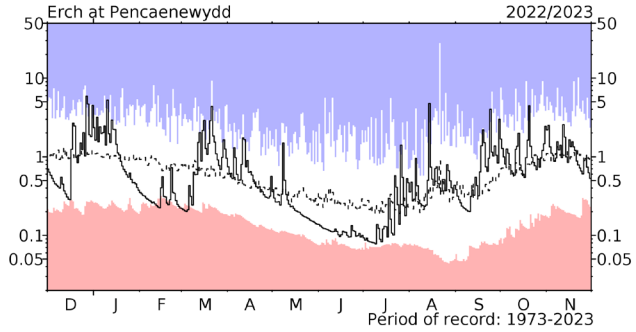
River flow hydrographs

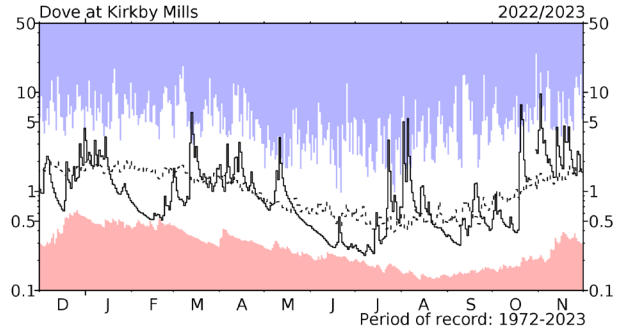
*The river flow hydrographs show the daily mean flows (measured in m^3s^{-1}) together with the maximum and minimum daily flows prior to November 2022 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed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

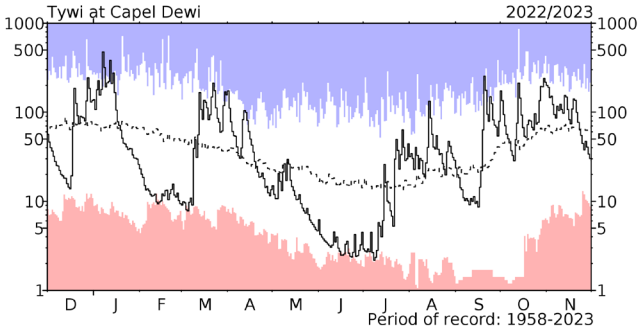
River flow . . . River flow . . .

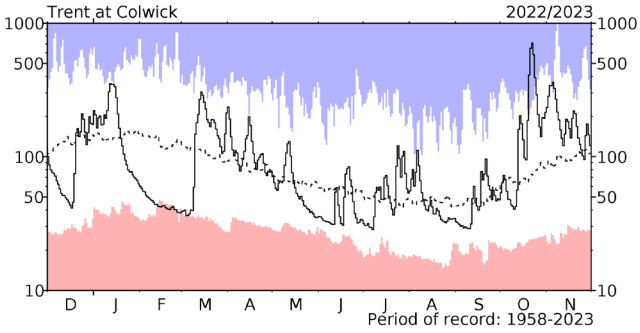


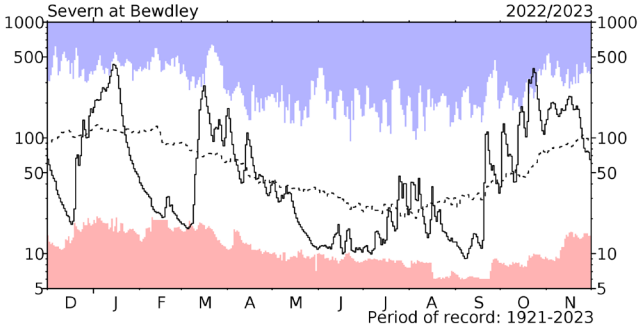


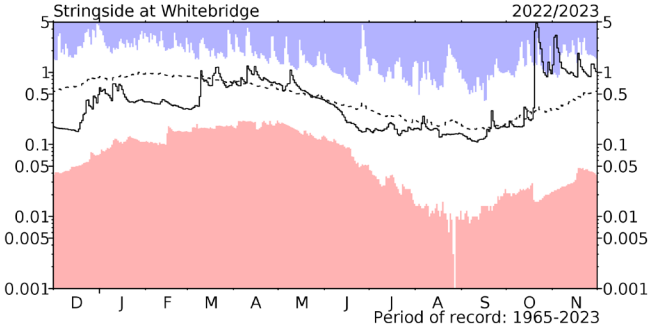


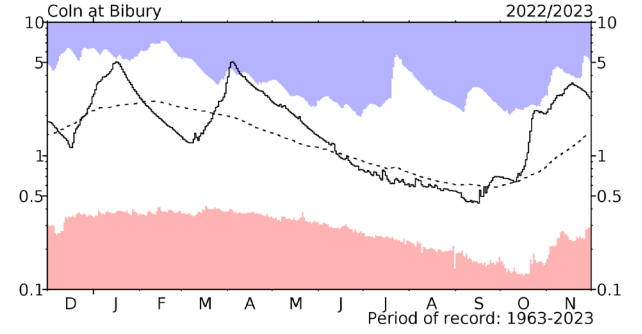


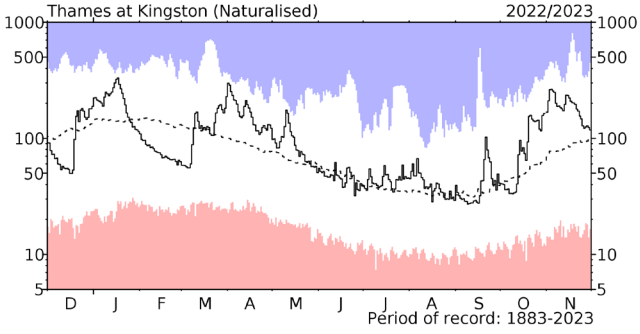


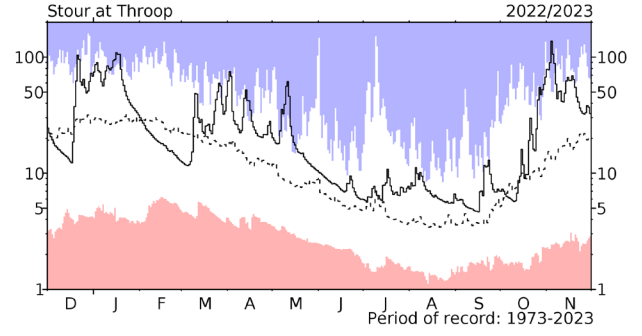


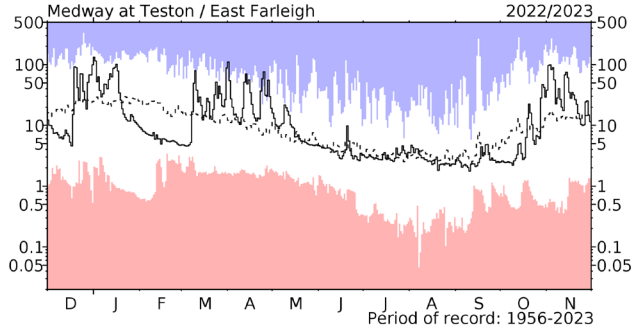




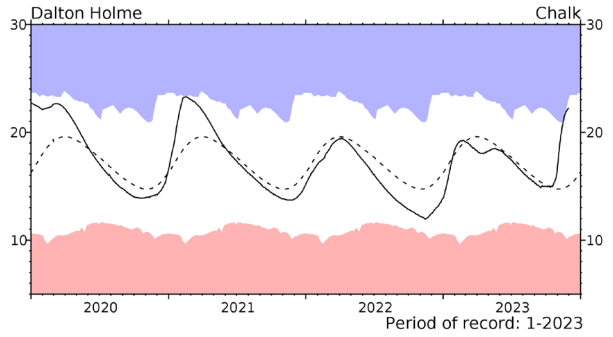


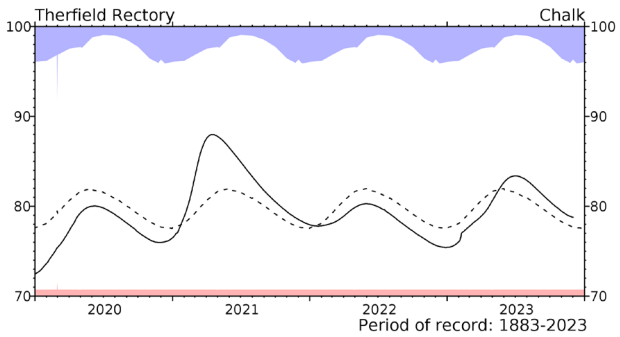


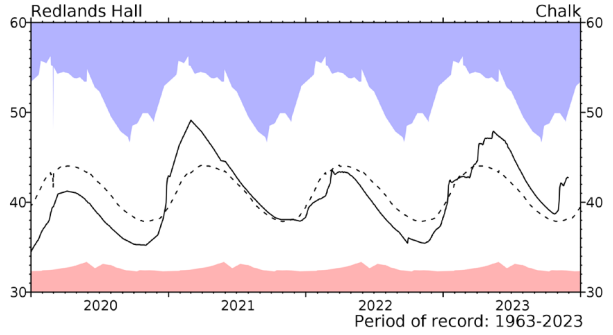


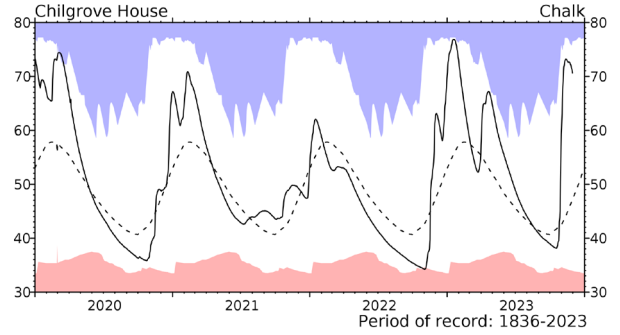


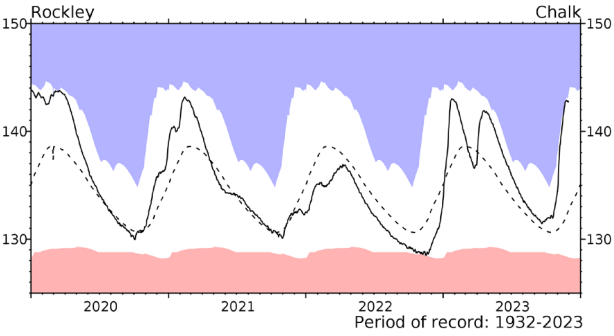
Groundwater…Groundwater

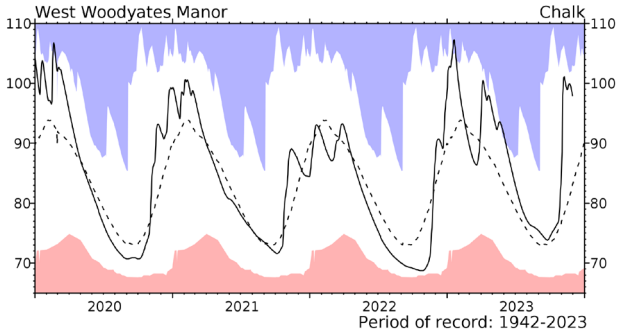


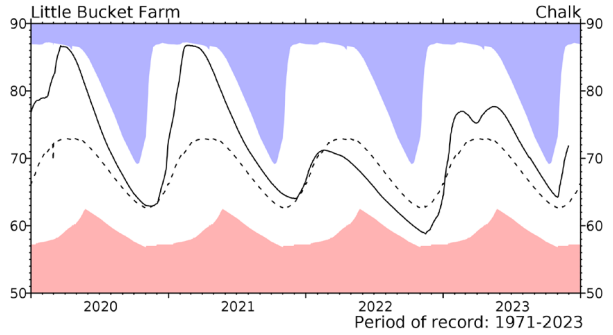


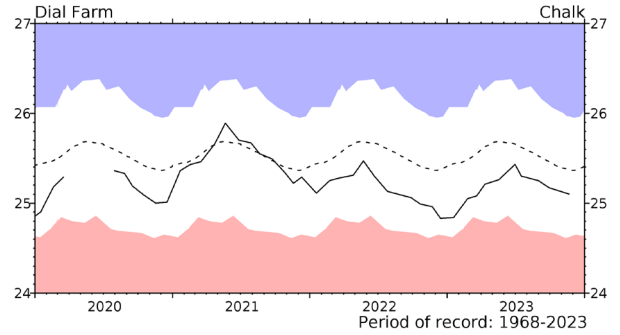


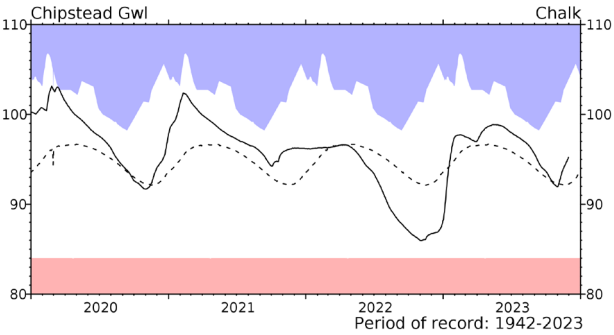


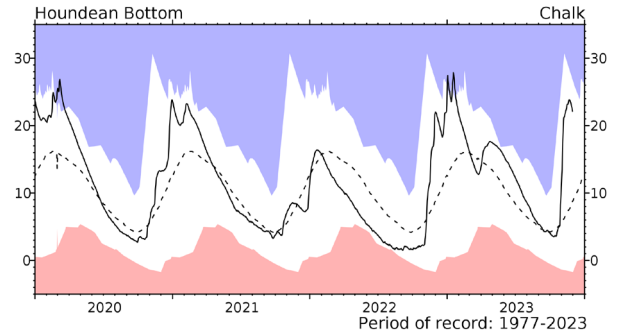






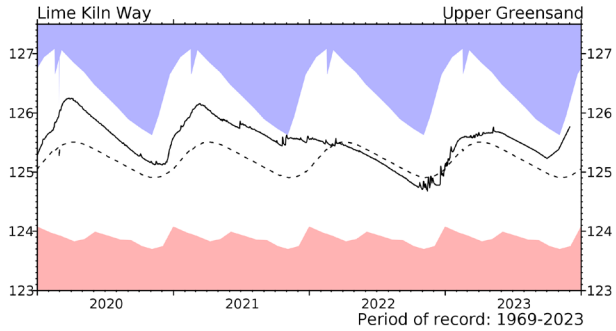


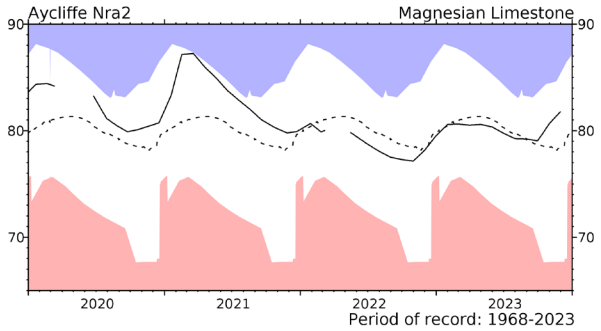


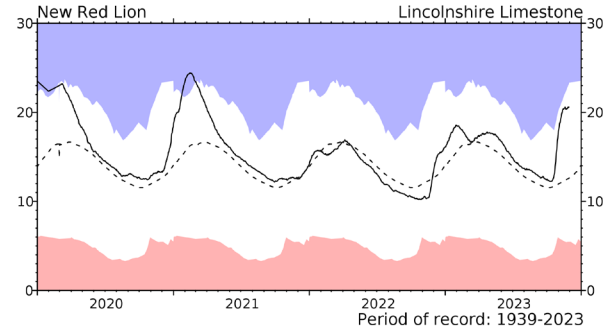


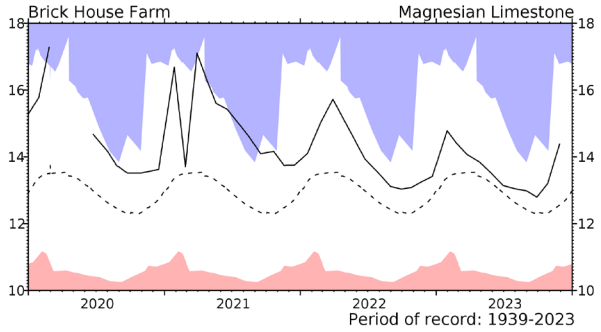
Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is 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.

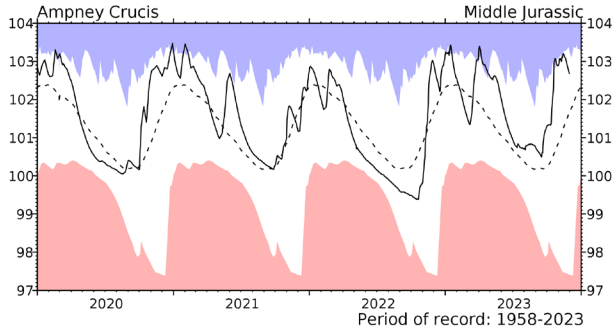
Groundwater … Groundwater

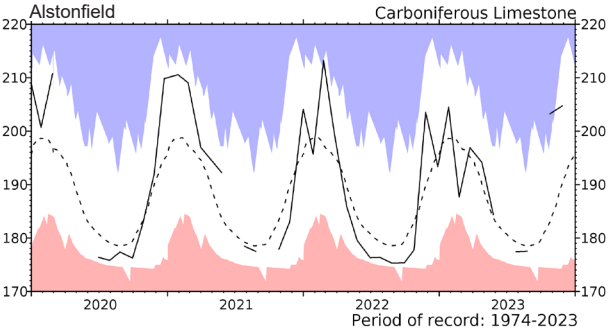


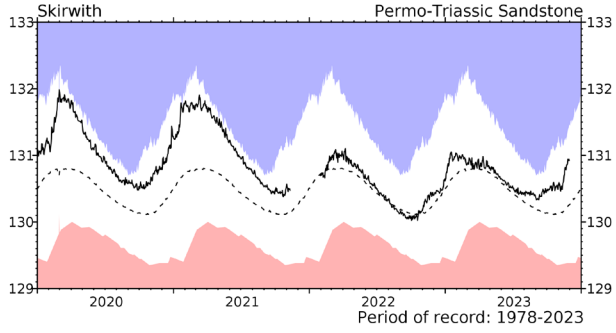


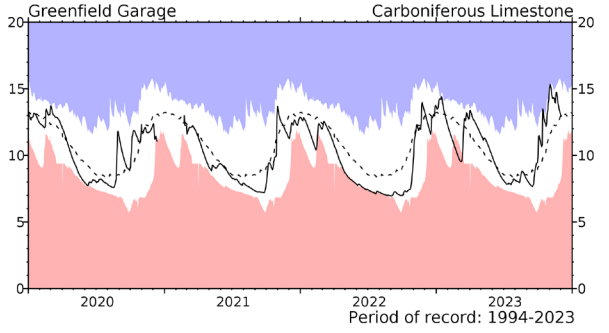


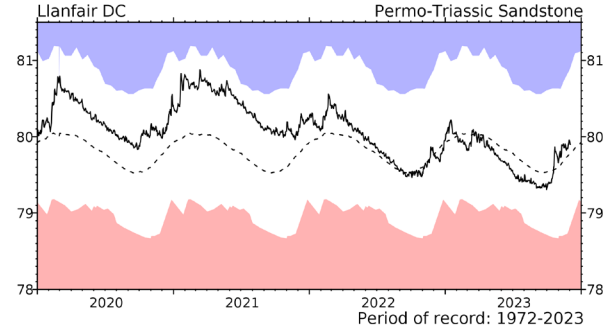


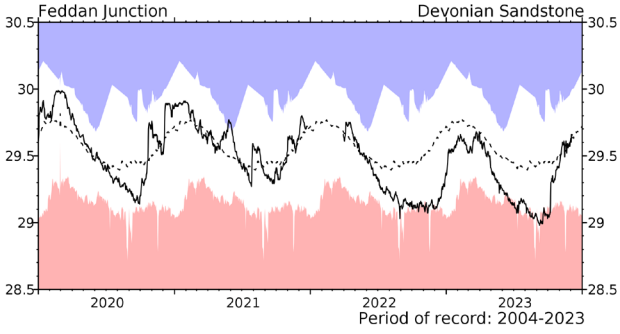


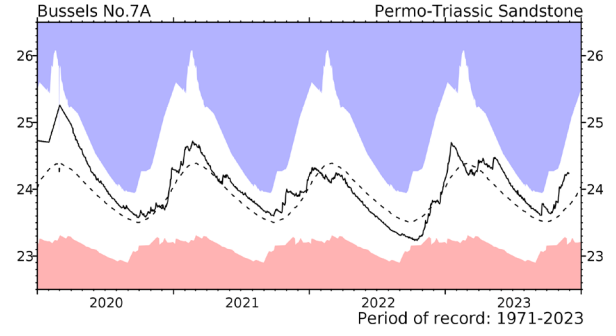


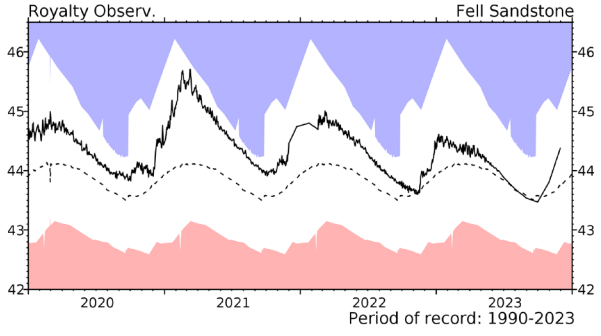










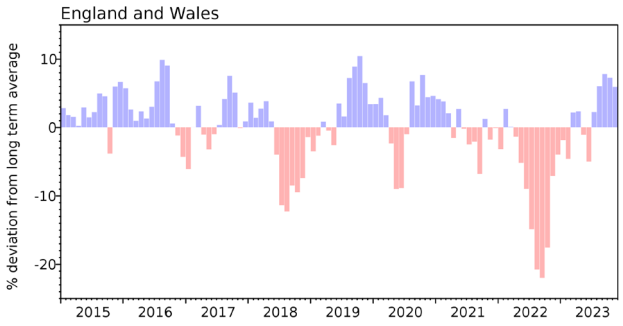


Groundwater levels - November 2023

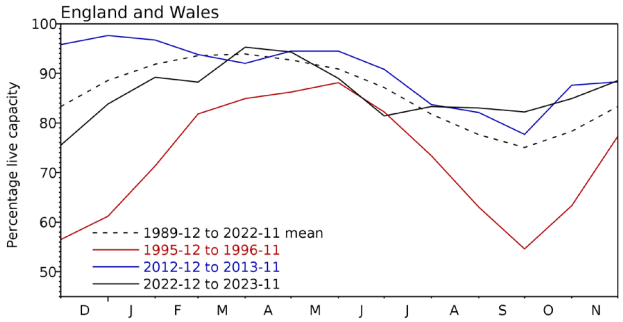
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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 Sep	2023 Oct	2023 Nov	Nov Anom.	Min Nov	Year* of min	2022 Nov	Diff 23-22
North West	N Command Zone	•	124929	76	80	89	9	44	1993	85	4
	Vyrnwy		55146	95	100	100	17	33	1995	83	17
Northumbrian	Teesdale	•	87936	98	100	99	16	39	1995	81	18
	Kielder		(199175)	85	85	90	4	55	2007	91	-1
Severn-Trent	Clywedog		49936	89	85	86	4	43	1995	74	12
	Derwent Valley	•	46692	71	93	96	18	9	1995	68	28
Yorkshire	Washburn	•	23373	81	93	91	14	16	1995	82	9
	Bradford Supply	•	40942	74	99	100	17	20	1995	68	31
Anglian	Grafham		(55490)	90	85	82	-1	47	1997	64	18
	Rutland		(116580)	85	85	90	10	57	1995	77	13
Thames	London	•	202828	94	91	87	5	52	1990	76	11
	Farmoor	•	13822	96	91	97	8	52	1990	84	13
Southern	Bewl		31000	71	67	67	3	33	2017	64	3
	Ardingly		4685	46	44	80	6	14	2011	82	-1
Wessex	Clatworthy		5662	75	81	100	21	16	2003	71	29
	Bristol	•	(38666)	71	78	97	27	27	1990	70	27
South West	Colliford		28540	52	52	67	-4	25	2022	25	42
	Roadford		34500	54	55	62	-11	19	1995	46	17
	Wimbleball		21320	74	83	100	28	34	1995	45	55
	Stithians		4967	56	57	89	22	29	2001	33	55
Welsh	Celyn & Brenig	•	131155	67	67	72	-16	50	1995	65	7
	Brianne		62140	100	100	100	4	72	1995	98	2
	Big Five	•	69762	71	78	86	3	49	1990	73	13
	Elan Valley	•	99106	85	96	99	6	47	1995	71	28
Scotland(E)	Edinburgh/Mid-Lothian	•	97223	92	95	98	11	45	2003	93	5
	East Lothian	•	9317	91	100	100	10	38	2003	100	0
Scotland(W)	Loch Katrine	•	110326	93	88	95	3	65	2007	98	-3
	Daer		22494	89	85	85	-12	73	2003	90	-5
	Loch Thom		10721	73	91	99	6	72	2003	81	18
Northern Ireland	Total+	•	56800	99	99	99	12	59	2003	94	5
	Silent Valley	•	20634	100	100	99	16	43	2001	100	-1

( ) figures in parentheses relate to gross storage

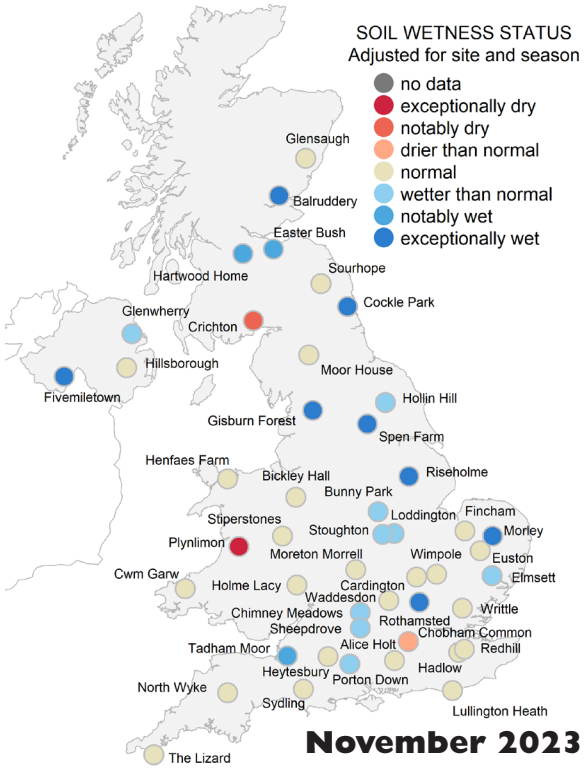
• denotes reservoir groups

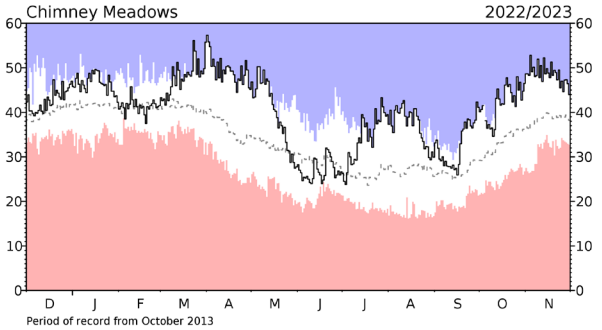
*last occurrence

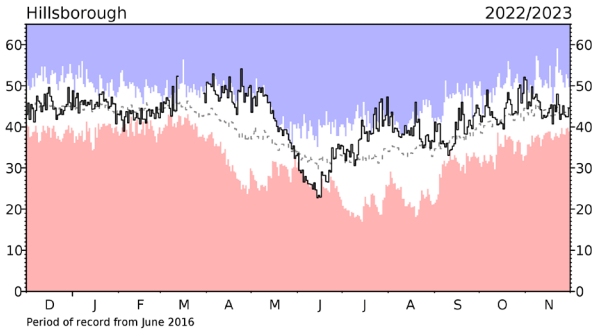
+ excludes Lough Neagh

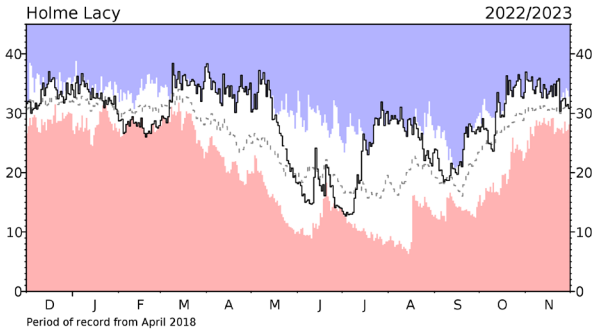
Details of the individual reservoirs in each of the groupings listed above are available on request. The percentages given in the Average and Minimum storage columns relate to the 1988-2012 period except for West of Scotland and Northern Ireland where data commence in the mid-1990s. In some gravity-fed 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.

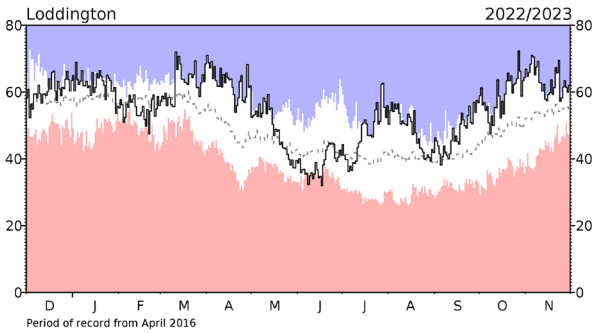
Soil Moisture . . . Soil Moisture

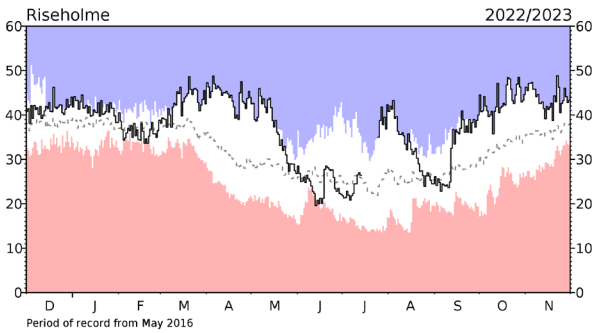












At the end of the month, soil moisture is close to or above field capacity most COSMOS-UK sites, which is expected for this time of year when there is more consistent rainfall and lower temperatures. There has been a slight reduction in soil moisture at most COSMOS-UK sites compared to the very wet month of October. Some sites remain wet (for example Chimney Meadows, Riseholme) whereas others have returned to more normal levels (for example Hillsborough, Holme Lacy, Loddington).

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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