Hydrological Summary

for the United Kingdom

December 2022

General

December was a cold month overall – the coldest December since 2010 for the UK as a whole – and drier than average for much of the UK. However, the cold, dry conditions prevailed through a sustained wintry episode in the first half of the month, whereas the latter weeks were mild, unsettled and wet, with rapid river flow recoveries, widespread flood warnings and locally high flows. Despite this runoff response, the December river flows were below average in many catchments and in some areas (northwest Scotland and East Anglia) flow deficiencies continued to grow. Similarly, while stocks increased in a majority of reservoirs, they remained 4% below average for England and 7% below average for Wales, and were particularly low in southwest England (Colliford was 43% below average, the lowest year-end stocks on record; Roadford was 27% below average, the third lowest) as well as some reservoirs in the Pennines, Wales and East Anglia. Groundwater recharge continued in many areas (notably the southern Chalk where levels were above normal) but had yet to start in more slowly responding boreholes where levels remained below normal. Consequently, despite a comparatively wet autumn/early winter, 2022 ended with many regions in England in drought status, a reflection of the longer-term rainfall deficiencies borne out by annual rainfall and flow statistics. The wet weather continued into early January and current Outlooks favour above normal river flows and groundwater levels. The New Year began with elevated flood risk for many areas, but rainfall over the coming weeks will also be important for dictating the water resources outlook for 2023 in those areas where deficits remain.

Rainfall

The first half of December saw predominantly anticyclonic conditions, with easterly and northerly airflows over the UK. This period was mostly settled, cold (very cold at times) and dry, with many areas receiving little rainfall. There were localised showers during the occasional frontal incursions, and these were often wintry during a particularly cold spell from the 6th to the 17th, with significant snowfalls in the north that occasionally encroached further south (e.g. 9cm was reported on the 12th in Cambridge), bringing widespread transport disruption. The 18th saw a sharp transition towards westerly airflows and generally milder and wetter conditions that dominated the rest of the month, with some very heavy rainfall in southern Britain on the 18th/19th (e.g. the 18th saw 151mm at White Barrow, Devon and 87mm at Treherbert, Glamorgan) and across many areas (notably Scotland and Northern Ireland) in the final days of the month. Despite the wetter second half, the December rainfall total was 87% of average for the UK as a whole. The December rainfall was above average along the north-east coast of Britain and across the far south of England (the Southern region received 123% of average), but most areas saw near- or below-average rainfall, with western Scotland being particularly dry (the Highland region received 68% of average). This extends modest rainfall deficiencies in the Highlands but elsewhere rainfall accumulations since the start of autumn are generally near- or above-average (Southern region saw its wettest Oct-Dec since 2013). However, rainfall accumulations for 2022 as a whole were largely below-normal, reflecting the longer-term drought conditions: England saw its driest year since 2011, while in Wales only 2003 and 2011 have been drier since 1976.

River Flows

In a majority of catchments, steep recessions became established during the settled conditions of early December, with some western catchments approaching the lowest December flows on record (e.g. the Camowen and Lagan in Northern Ireland and the Dee in Wales). Responsive rivers then saw rapid increases following heavy rainfall: on the 18th-20th there were widespread flood warnings in southwest England and in Sussex/Kent; on the 30th there were numerous flood alerts nationally and over 20 flood warnings in Scotland. Peak flows ranked among the highest December maxima for some catchments (e.g. the Erch in Wales, the Piddle in Dorset and the Faughan and Bush in Northern Ireland). The Nith registered its fourth highest daily mean flow on record (for any month) in a series from 1957 December average flows were above average in some catchments in the far south of England (e.g. 153% of average on the Sussex Ouse) and far northeast of Scotland (e.g. 143% on the Ythan), but normal or below normal elsewhere. Below normal flows were widespread across Northern Ireland and the western Scottish Highlands and in some catchments in central England and East Anglia (with 34% on the Stringside and 29% on the Waveney). Similar patterns can be seen since early autumn: depressed flows in the Highlands and East Anglia contrast with normal to above normal flows elsewhere, especially for the far south (the November-December flows for the Dart and Sussex Ouse were the second highest in records from 1958 and 1960 respectively). Despite the higher flows in recent months, annual flow accumulations for 2022 were generally below average: outflows for England rank among notable drought years of recent decades (only 2003, 2005 and 2011 were lower post-2000).

Soil Moisture and Groundwater

With a few exceptions in the west, most COSMOS-UK sites showed normal or above-normal soil wetness at the end of the month in response to the late December rainfall. Soil moisture deficits (SMDs) were eliminated across all aquifer areas, meaning recharge occurred at most sites (>80%), and it was only a few slowly responding sites where recharge had yet to start. Groundwater levels rose at all but four Chalk sites (Stonor, Therfield Rectory, Dial Farm and Washpit Farm), and many levels in the Chalk were in the normal range. Levels in the Chalk along the south coast and at Killyglen were above normal to notably high. Some Chalk sites in southern and eastern England were below normal, and levels at Dial Farm remained notably low. Groundwater levels in the Jurassic limestones at Ampney Crucis continued to rise and remained notably high. In the Magnesian Limestone of northeast England, levels also rose but were in the normal range. Levels in the Carboniferous Limestone of South Wales fluctuated, but by the end of the month had risen slightly in response to above average December rainfall and became above normal. In contrast, levels at Alstonfield had fallen and returned to the normal range. Levels rose at Permo-Triassic sandstone sites with the exception of Skirwith where levels continued to fall and were below normal. At Lime Kiln Way in the Upper Greensand, levels rose slightly but remained in the normal range. Levels rose at all three sites in the Devonian and Carboniferous sandstones across Scotland, but these sites remained below normal to notably low (Feddan Junction).

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.

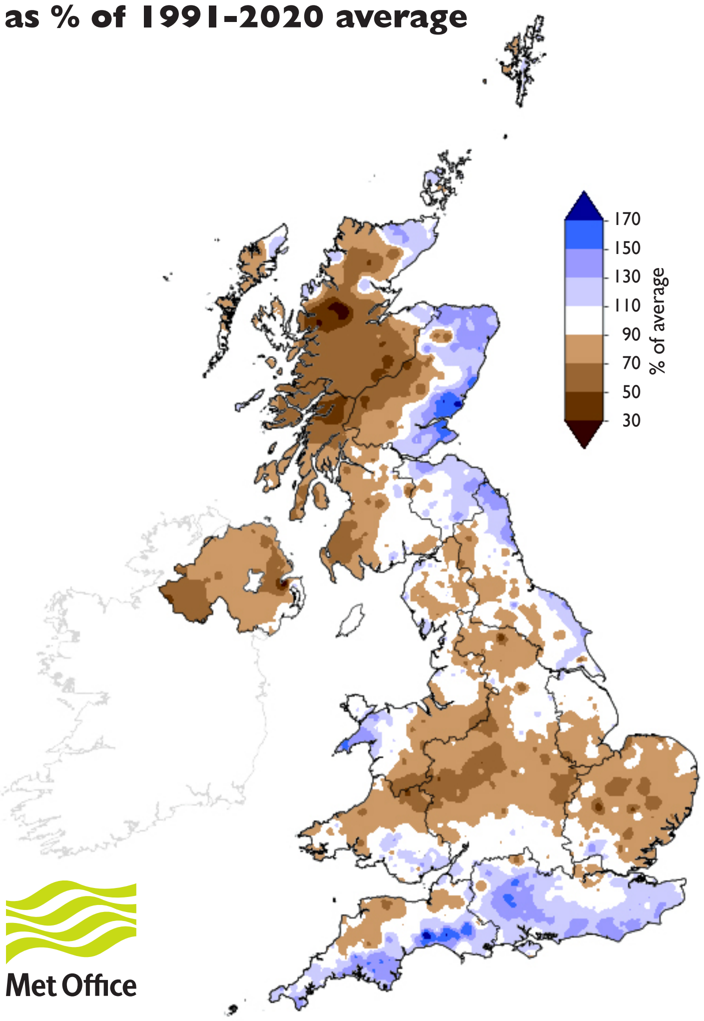
Region	Rainfall	Dec 2022	Oct22 – Dec22	RP	Sep22 – Dec22	RP	Jul22 – Dec22	RP	Jan22 – Dec22	RP
United Kingdom	mm	**111**	412		514		611		1051	
	%	**87**	110	5-10	111	5-10	95	2-5	90	2-5
England	mm	**89**	323		398		456		747	
	%	**97**	118	5-10	116	5-10	94	2-5	86	5-10
Scotland	mm	**137**	532		667		831		1498	
	%	**79**	105	2-5	106	2-5	97	2-5	95	2-5
Wales	mm	**165**	540		654		746		1246	
	%	**94**	109	2-5	108	2-5	91	2-5	85	5-10
Northern Ireland	mm	**89**	384		522		613		1105	
	%	**74**	107	2-5	117	8-12	97	2-5	96	2-5
England & Wales	mm	**100**	353		433		496		815	
	%	**96**	116	5-10	114	5-10	94	2-5	86	5-10
North West	mm	**131**	449		559		689		1176	
	%	**90**	109	2-5	107	2-5	94	2-5	92	2-5
Northumbria	mm	**90**	286		386		463		766	
	%	**98**	104	2-5	111	5-10	92	2-5	84	5-10
Severn-Trent	mm	**65**	275		335		387		677	
	%	**79**	114	5-10	110	2-5	88	2-5	84	5-10
Yorkshire	mm	**83**	284		357		426		753	
	%	**93**	108	2-5	107	2-5	89	2-5	86	2-5
Anglian	mm	**48**	209		251		293		488	
	%	**83**	113	2-5	106	2-5	83	2-5	77	10-20
Thames	mm	**77**	289		354		393		620	
	%	**104**	125	5-10	123	5-10	98	2-5	85	5-10
Southern	mm	**116**	397		496		533		758	
	%	**123**	139	10-20	142	15-25	115	5-10	92	2-5
Wessex	mm	**114**	400		469		500		788	
	%	**113**	131	10-15	126	8-12	99	2-5	86	2-5
South West	mm	**166**	527		645		702		1098	
	%	**109**	121	5-10	123	8-12	100	2-5	87	2-5
Welsh	mm	**159**	526		638		726		1204	
	%	**95**	110	2-5	109	2-5	92	2-5	86	5-10
Highland	mm	**143**	562		687		891		1732	
	%	**68**	94	2-5	92	2-5	90	2-5	94	2-5
North East	mm	**97**	354		485		607		1002	
	%	**95**	105	2-5	116	5-10	102	2-5	94	2-5
Tay	mm	**122**	547		684		827		1389	
	%	**82**	122	10-15	125	15-25	110	5-10	99	2-5
Forth	mm	**132**	446		567		698		1174	
	%	**100**	116	8-12	118	10-15	103	2-5	94	2-5
Tweed	mm	**125**	392		511		602		996	
	%	**107**	115	8-12	121	20-30	100	2-5	92	2-5
Solway	mm	**155**	610		762		914		1536	
	%	**87**	118	8-12	119	10-20	104	2-5	97	2-5
Clyde	mm	**154**	627		790		976		1795	
	%	**72**	102	2-5	103	2-5	94	2-5	95	2-5

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

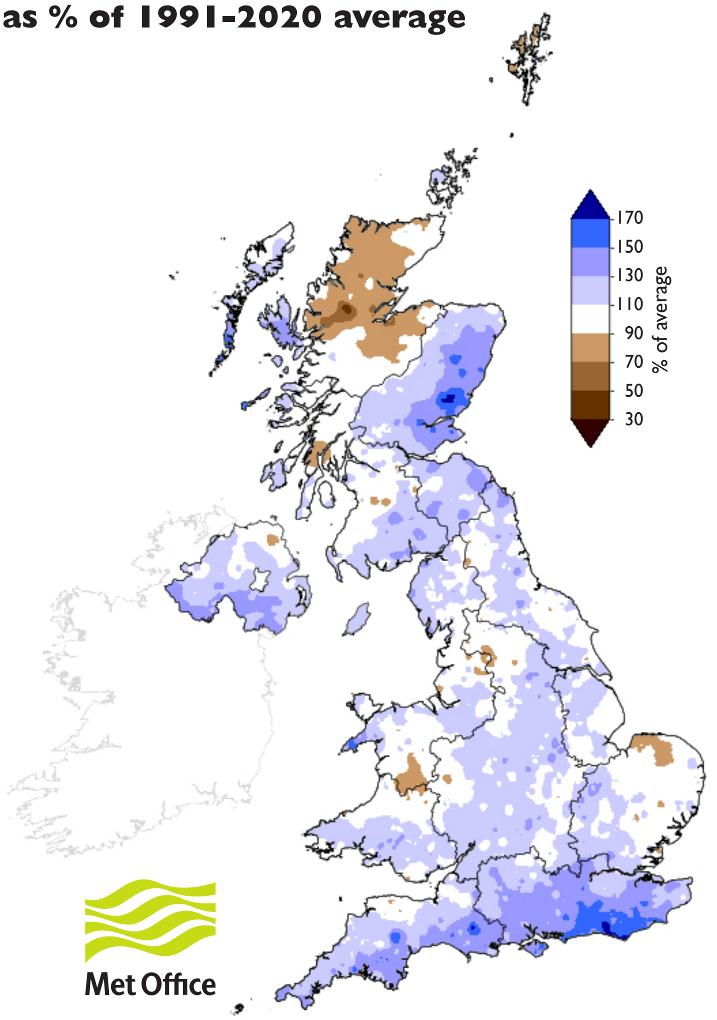
Important note: Figures in the above table may be quoted provided their source is acknowledged. Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic variability 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 2022 are provisional. Source: Data from HadUK-Grid dataset at 1km resolution v1.1.0.0.

Rainfall . . . Rainfall . . .

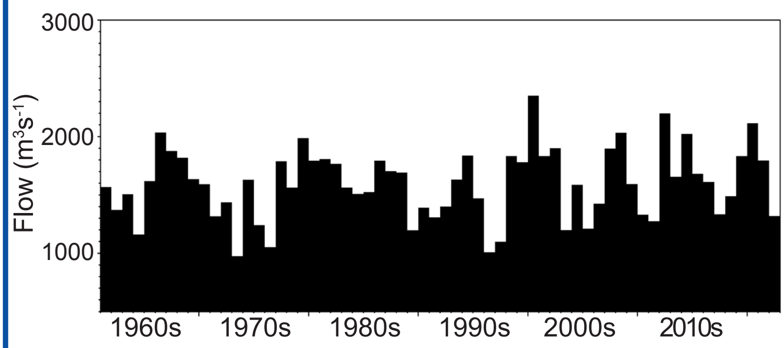
December 2022 rainfall as % of 1991-2020 average



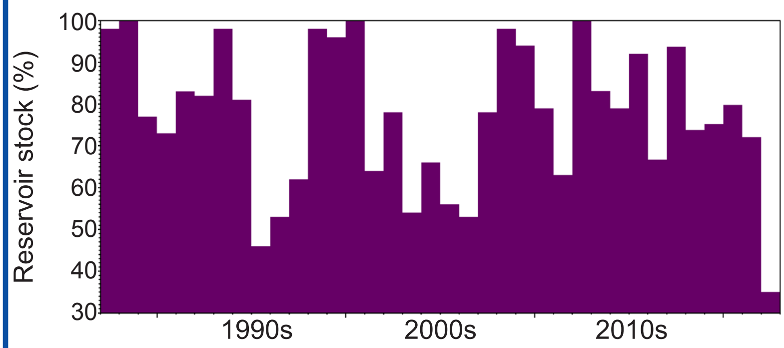
September 2022 - December 2022 rainfall as % of 1991-2020 average



January - December outflows for England



End of December reservoir stocks for Colliford



UK Hydrological Outlook

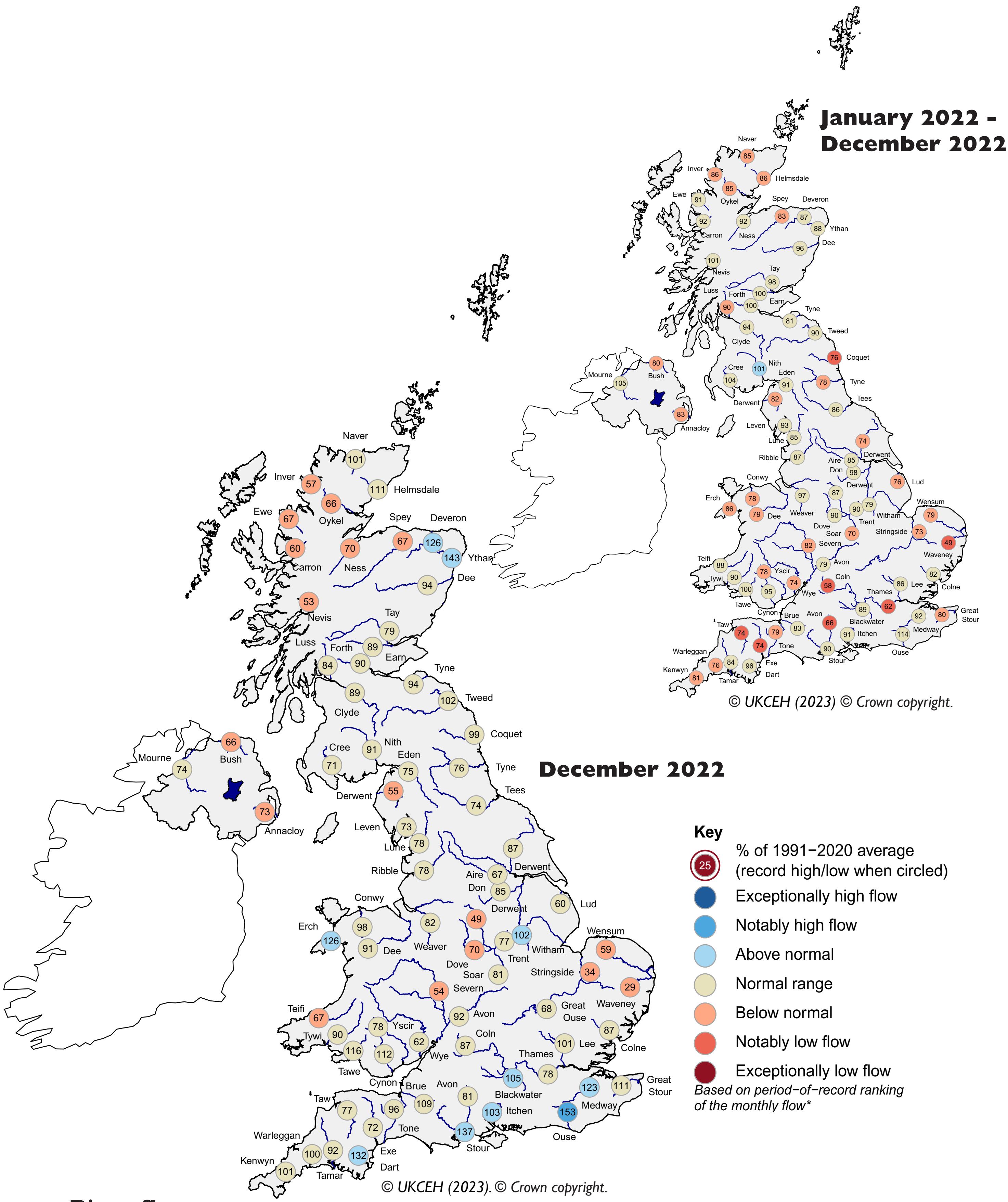
The Hydrological Outlook provides an insight into future hydrological conditions across the UK. Specifically it describes likely trajectories for river flows and groundwater levels on a monthly basis, with particular focus on the next three months.

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

Period: **from January 2023**
Issued: **09.01.2023**
using data to the end of December 2022

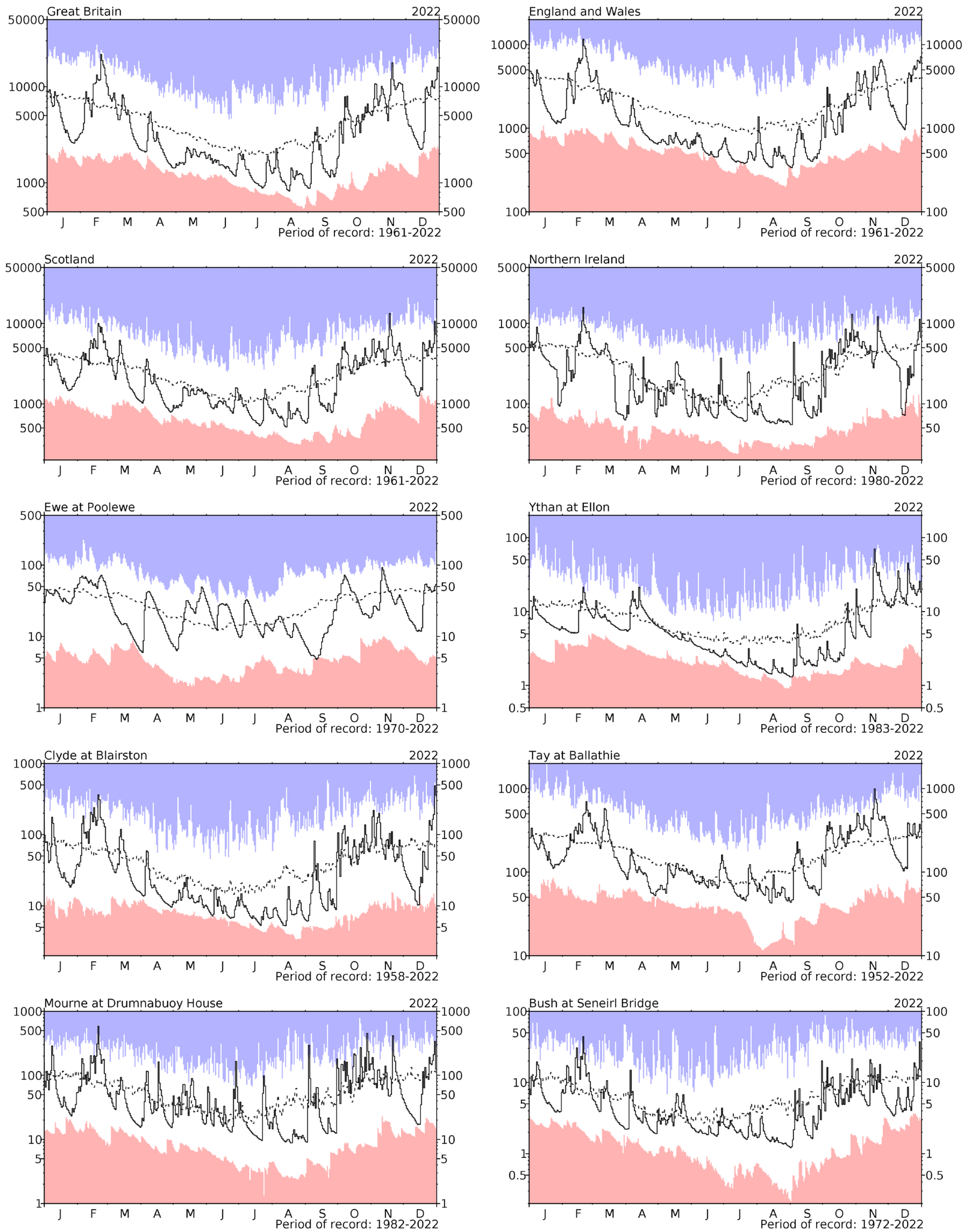
The outlook for January is for above normal flows for much of the UK, with the exception of East Anglia, where below normal flows are likely to persist. For the January-March period, normal to above normal river flows are expected for much of the UK. Groundwater levels for the January and the January-March period are likely to be normal to above normal in most of the UK, with above normal levels particularly in the far south of England. However, in the Lincolnshire Chalk aquifer and East Anglia normal to below normal levels are more likely.

River flow . . . River flow . . .



River flows

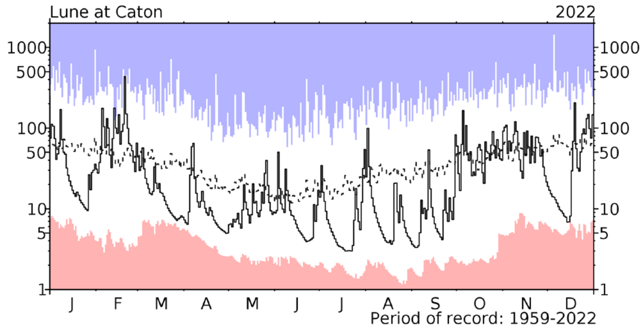
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much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

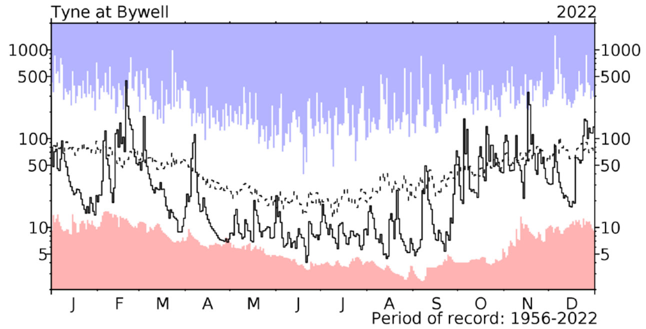


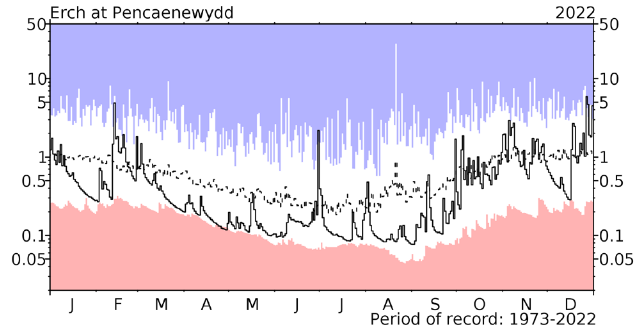
River flow hydrographs

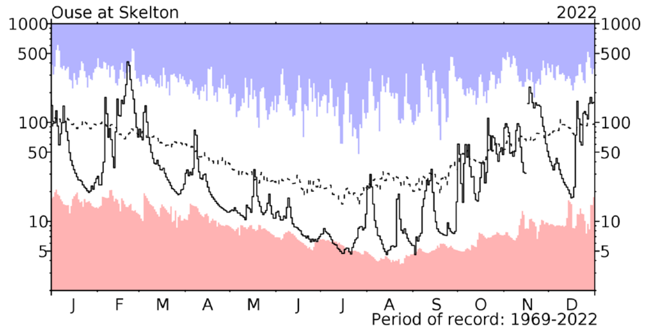
*The river flow hydrographs show the daily mean flows (measured in m^3s^{-1}) together with the maximum and minimum daily flows prior to January 2022 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed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

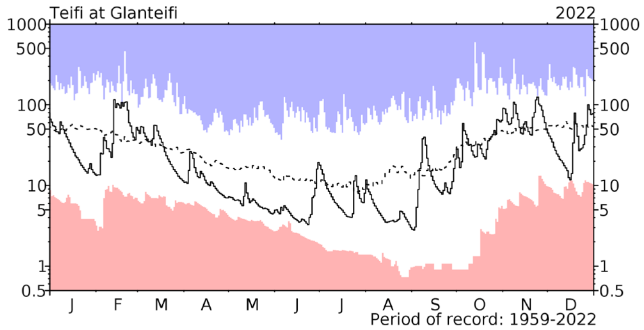
River flow . . . River flow . . .

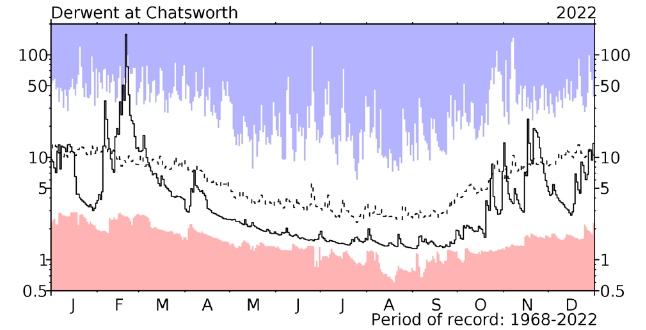


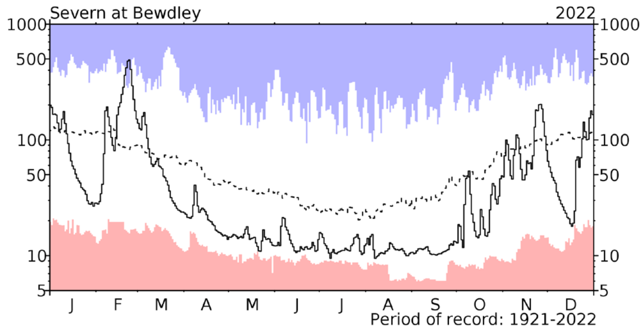


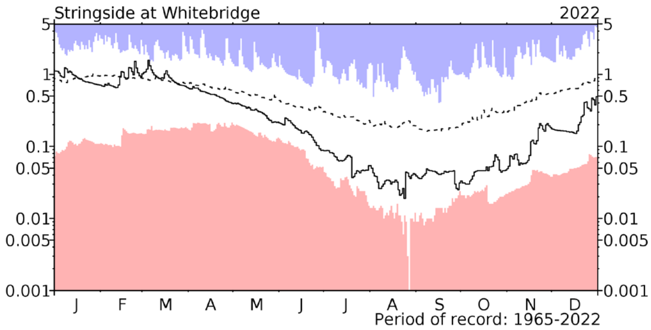


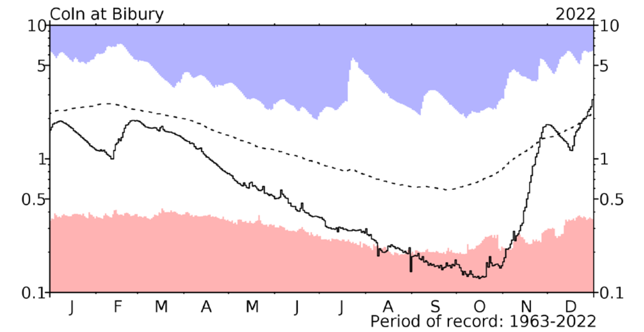


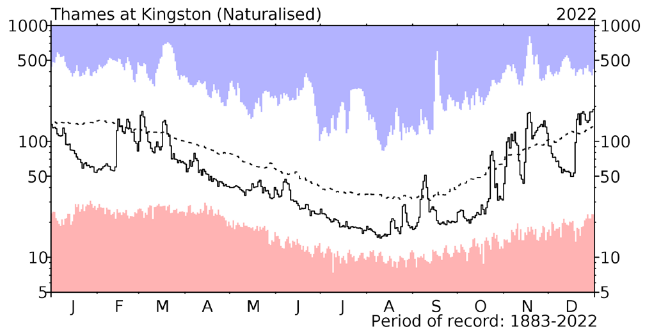


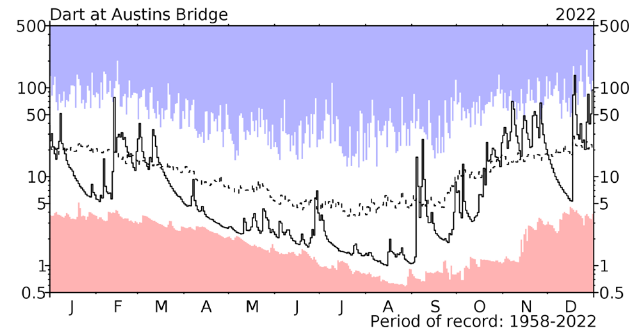


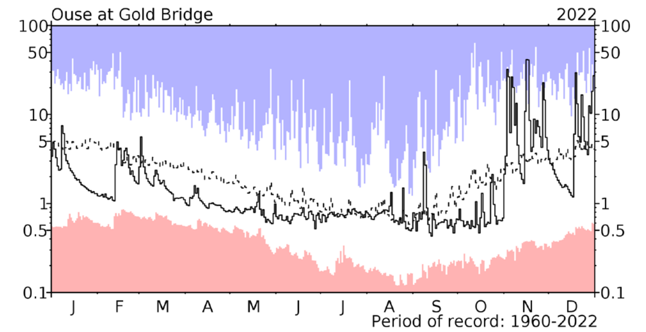




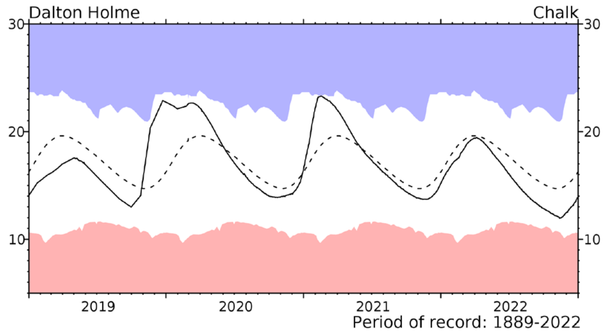


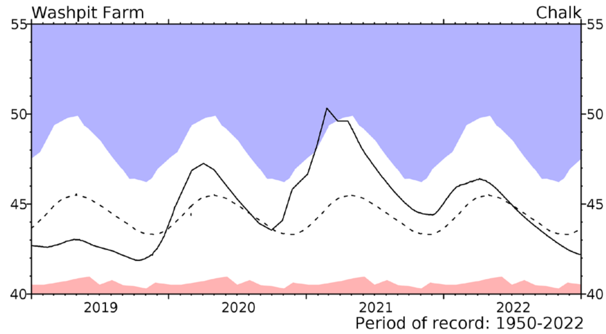


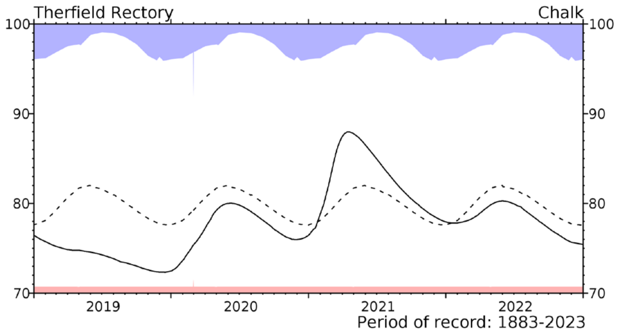


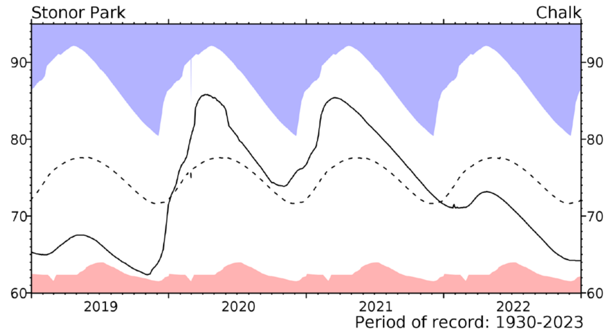


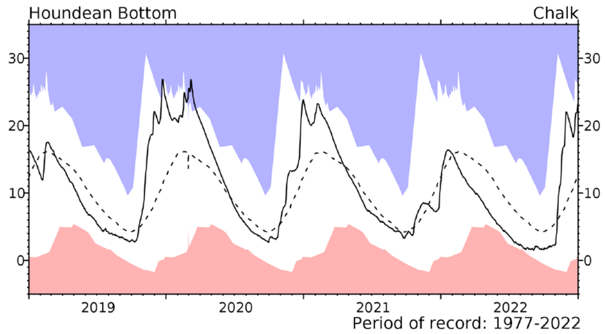
Groundwater . . . Groundwater

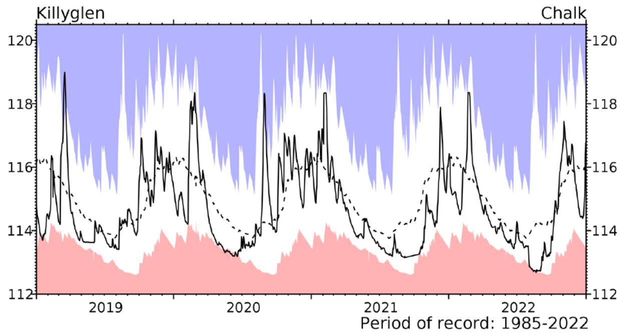


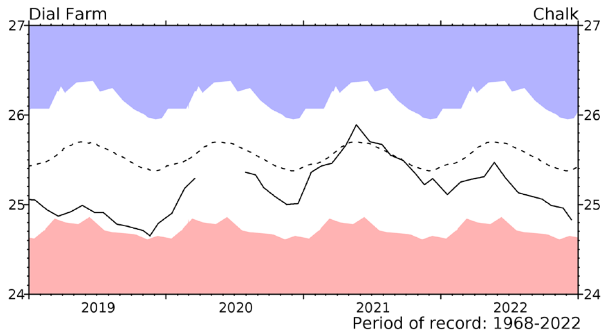


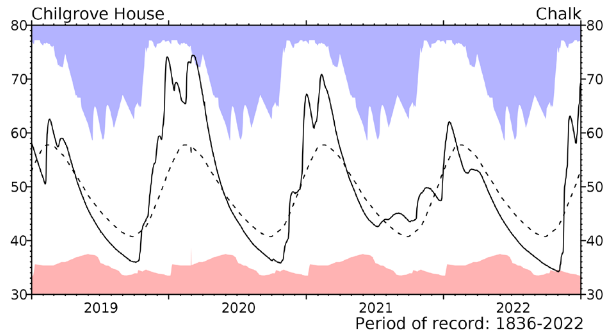


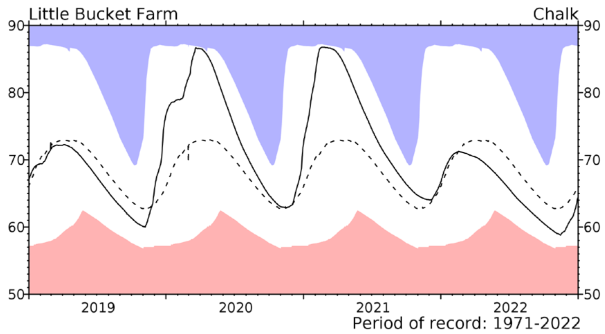


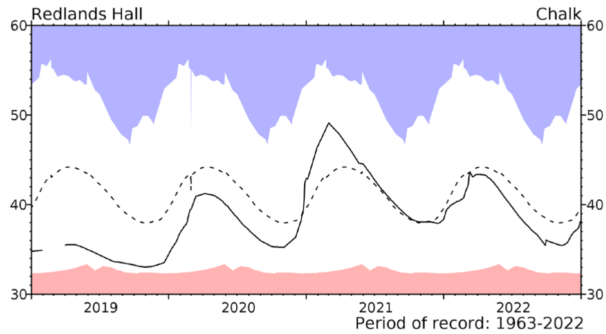






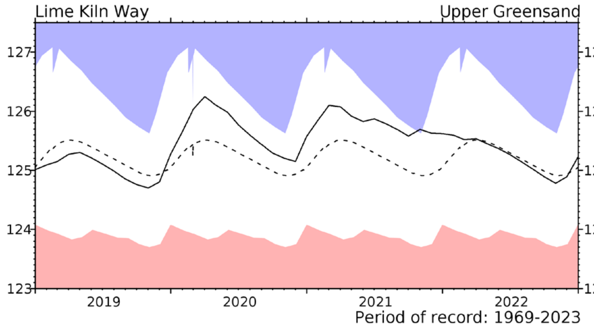


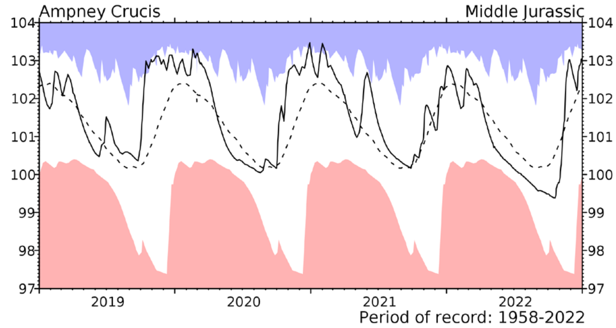


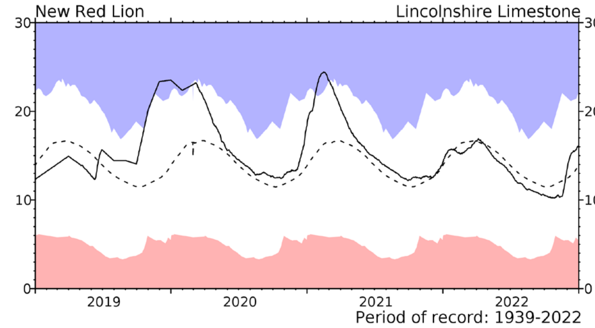


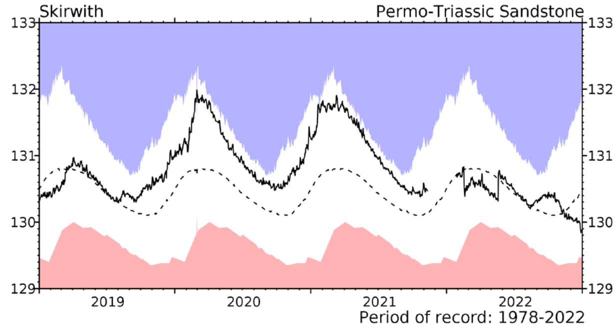
Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is 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 2018. 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.

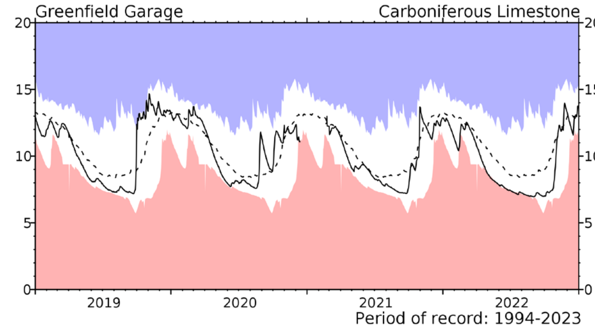
Groundwater ... Groundwater

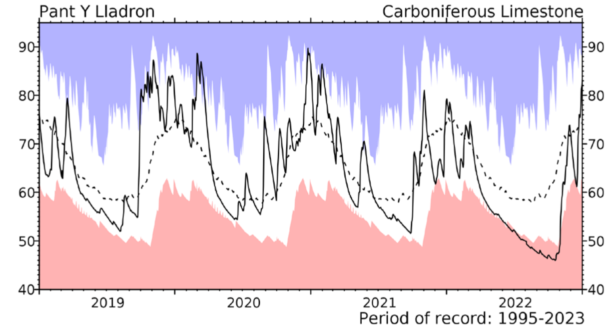


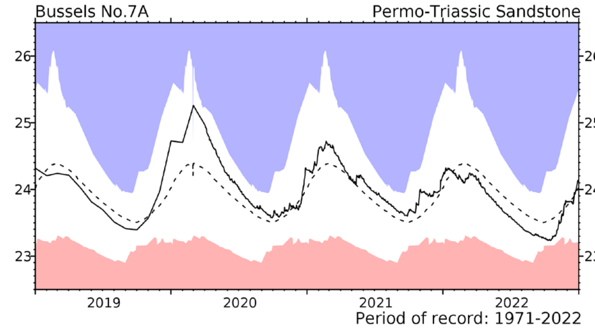


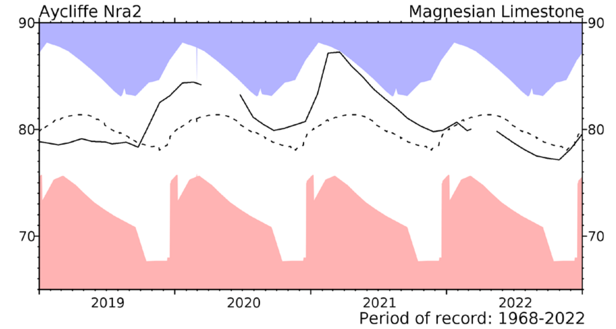


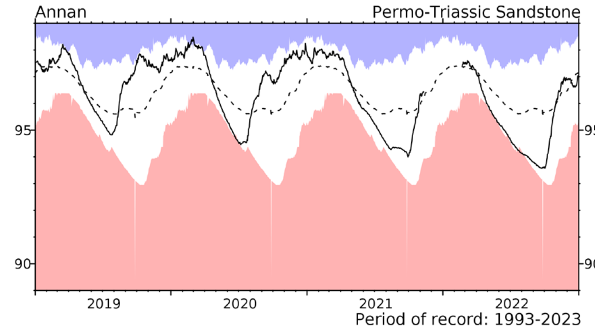


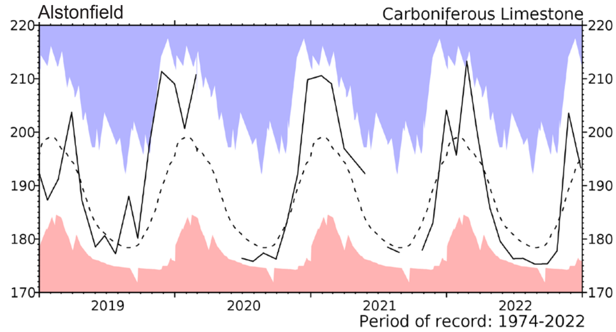


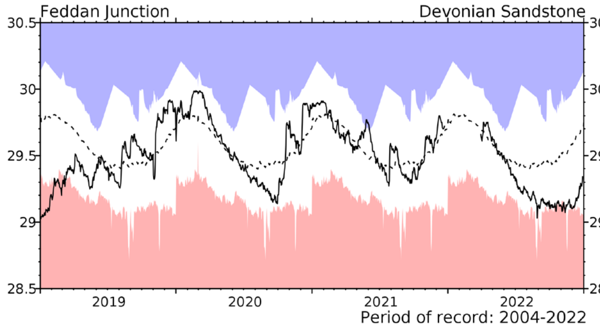


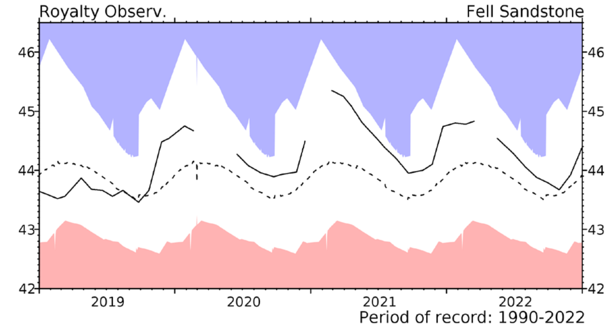










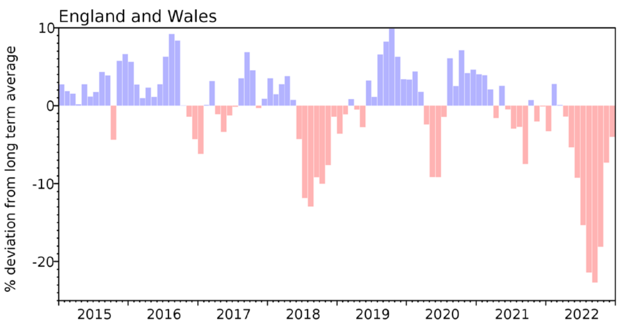


Groundwater levels - December 2022

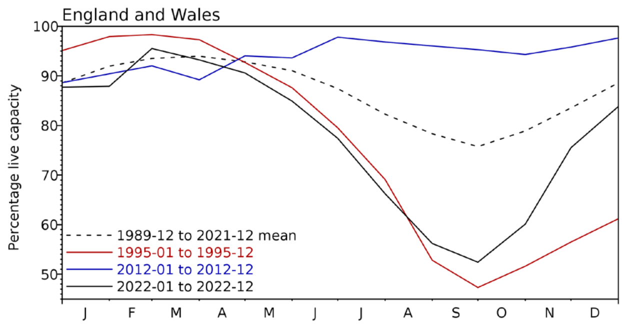
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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

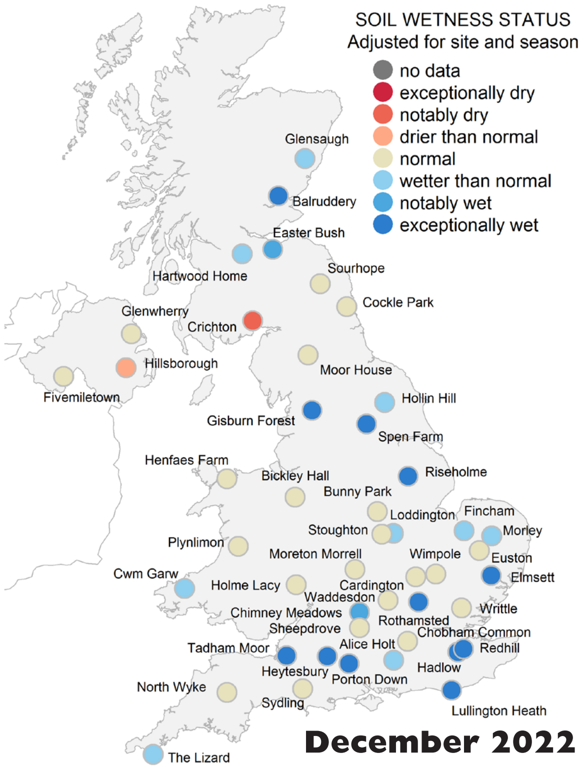
Area	Reservoir		Capacity (Ml)	2022 Oct	2022 Nov	2022 Dec	Dec Anom.	Min Dec	Year* of min	2021 Dec	Diff 22-21
North West	N Command Zone	•	124929	62	85	82	-4	51	1995	78	5
	Vyrnwy		55146	55	83	88	-4	35	1995	96	-8
Northumbrian	Teesdale	•	87936	71	81	89	-2	41	1995	83	6
	Kielder		(199175)	86	91	92	1	70	1989	87	5
Severn-Trent	Clywedog		49936	54	74	86	1	54	1995	89	-3
	Derwent Valley	•	46692	52	68	85	-6	10	1995	99	-14
Yorkshire	Washburn	•	23373	42	82	94	7	23	1995	88	6
	Bradford Supply	•	40942	41	68	75	-15	22	1995	87	-11
Anglian	Grafham		(55490)	57	64	67	-17	57	1997	90	-23
	Rutland		(116580)	69	77	87	4	60	1990	77	10
Thames	London	•	202828	60	76	82	-5	60	1990	85	-3
	Farmoor	•	13822	70	84	97	7	71	1990	91	6
Southern	Bewl		31000	43	64	78	6	34	2005	76	2
	Ardingly		4685	26	82	100	15	30	2011	100	0
Wessex	Clatworthy		5662	24	71	100	9	54	2003	91	9
	Bristol	•	(38666)	44	70	86	6	40	1990	75	11
South West	Colliford		28540	15	25	35	-43	35	2022	72	-37
	Roadford		34500	34	46	51	-27	20	1989	96	-45
	Wimbleball		21320	18	45	69	-14	46	1995	86	-17
	Stithians		4967	14	33	61	-19	33	2001	71	-10
Welsh	Celyn & Brenig	•	131155	58	65	76	-17	54	1995	98	-22
	Brianne		62140	83	98	100	2	76	1995	99	1
	Big Five	•	69762	52	73	88	-2	67	1995	90	-2
	Elan Valley	•	99106	51	71	95	-2	56	1995	100	-5
Scotland(E)	Edinburgh/Mid-Lothian	•	97223	86	93	99	8	60	1998	89	10
	East Lothian	•	9317	72	100	100	3	48	1989	100	0
Scotland(W)	Loch Katrine	•	110326	96	98	100	8	75	2007	96	4
	Daer		22494	94	90	94	-4	83	1995	100	-6
	Loch Thom		10721	97	81	97	0	80	2007	100	-3
Northern	Total+	•	56800	84	94	95	6	61	2001	89	7
Ireland	Silent Valley	•	20634	83	100	100	13	39	2001	89	11

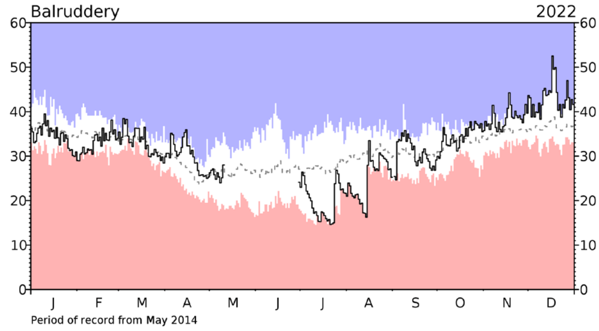
( ) figures in parentheses relate to gross storage • denotes reservoir groups *last occurrence

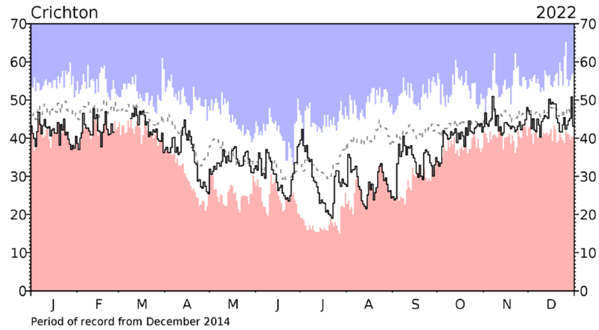
+ excludes Lough Neagh

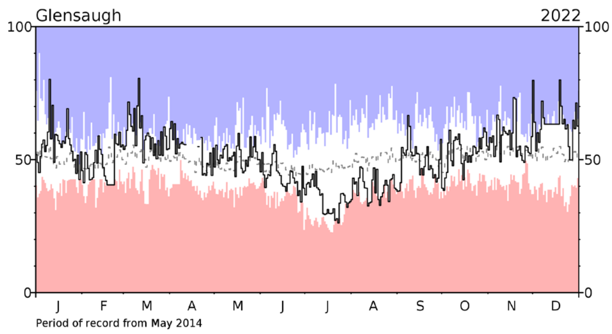
Details of the individual reservoirs in each of the groupings listed above are available on request. The percentages given in the Average and Minimum storage columns relate to the 1988-2012 period except for West of Scotland and Northern Ireland where data commence in the mid-1990s. In some gravity-fed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

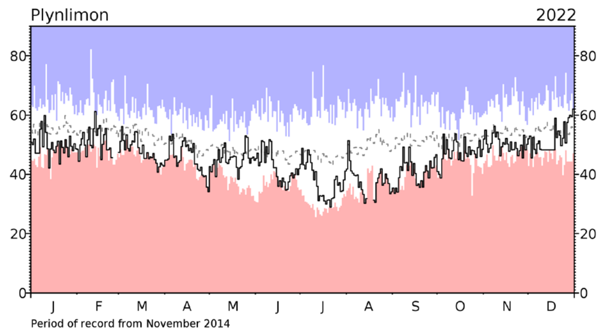
Soil Moisture . . . Soil Moisture

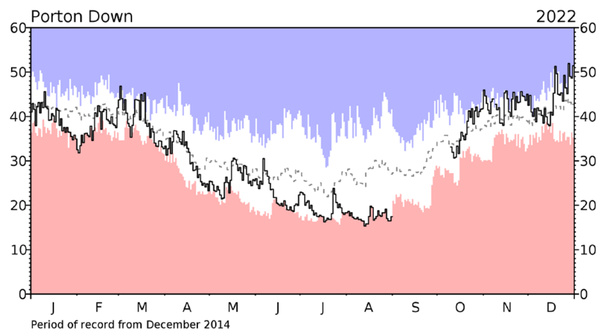












At the end of December, soil moisture at most COSMOS-UK sites remained wet.

Most COSMOS-UK sites exhibited soil moisture within the normal range over December, with easterly sites such as Glensaugh and Balruddery becoming very wet. In contrast, sites in western regions were slightly drier than usual for much of the month. Crichton was one of the driest sites, whereas other western sites, such as Plynlimon and The Lizard, fluctuated between dry and normal/wet conditions. Porton Down was dry at the start of the month and wetted up by the end of the month.

Generally, high soil moisture has been retained after a wet November and a cool December.

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.

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

01/2023

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UKRI Natural Environment Research Council