Hydrological Summary for the United Kingdom

October 2021

General

October was, for much of the month, typical for mid-autumn: mild (1.4 °C above the 1981 - 2010 average) but largely unsettled, with some dry and warm periods punctuating the showery spells. The final ten days, however, saw persistent and heavy rainfall, especially across northwest Britain in the final week, which resulted in notable monthly totals and attendant river flow responses. The synoptic situation was similar to recent major flood events (principally, November 2009 and December 2015), with an 'atmospheric river' bringing a persistent stream of moisture from the subtropics to the hills of western Britain. While long-duration rainfall totals were comparable, the flow response was less exceptional due to the drier antecedent conditions, although some locally severe flood impacts occurred. The October rainfall wetted soils across much of the country and, in stark contrast to September, river flows for October were significantly above average across western areas and most of southern England. Similarly, groundwater levels increased in many boreholes and were above normal across most aquifers, particularly so in parts of the Chalk. Reservoir stocks increased sharply, from exceptionally low September levels in many cases. Stocks were slightly above average for England & Wales, but below average in a few impoundments in drier areas of central England (e.g. Derwent Valley) and in Northern Ireland and parts of Scotland. Overall, water resources were healthy entering November and the focus was on elevated flood risk, with Outlooks suggesting a continuation of above normal river flows and groundwater levels.

Rainfall

The first week of October was unsettled, with showers (occasionally heavy and thundery) affecting most areas of the UK and high winds and localised surface water flooding in some areas (e.g. London and south Wales). A settled, largely anticyclonic spell prevailed mid-month, with some unseasonably warm temperatures, widespread fog and occasional showery incursions. The second half of the month was very unsettled. Heavy rainfall caused widespread transport disruption across Wales and southern England on the 20th/21st, while the final days of the month were exceptionally wet as a largely stationary frontal system brought persistent and very heavy rainfall to north-west England and southern Scotland from the 26th to the 29th. Exceptional rainfall totals were registered (daily totals of over 100mm were widespread on the 27th) especially in Cumbria (298.8mm in a 24-hour period was registered at Honister) as a result of orographic enhancement over the fells. Across the wettest parts of the Lake District fells, the rainfall in the last six days exceeded the October average rainfall. Substantial rainfall totals were also received across southern Scotland, where surface water flooding and landslides caused transport disruption for many delegates travelling to the COP26 climate negotiations in Glasgow. The late October rainfall contributed to exceptional monthly rainfall totals: the UK October total was 131% of average, but very few areas saw near- or below-average rainfall, and over 170% of average was registered across the Scottish borders, Cumbria and parts of north Wales. It was the second and fourth wettest October on record for the Solway and Tweed regions, respectively (in series from 1910). Large parts of southern England also saw over 150% of average rainfall.

River flows

Early October saw a continuation of the sharp flow recoveries seen in the final days of September. Typically, flows then receded following the onset of settled conditions, before further flow recoveries after mid-month. Rapid increases in flow around the 20th/21st in southern Britain were associated with widespread flood alerts (the Mimram and Lymington registered their second and third highest October flows, in records from 1952 and 1976, respectively). The persistent rainfall across north-western Britain in the last week triggered exceptional responses: the Leven and Derwent (Cumbria) registered the fourth and fifth highest peak flows (for any month) in records from 1954 and 1968, respectively, although peaks were significantly lower than maxima in 2009 and 2015. Impacts, too, were less severe, although there was significant disruption across Cumbria with some property flooding in the Lake District (with at least 40 properties reported) and flood defences were widely deployed, including pumping in Cockermouth. Similarly, flood impacts were reported across southern Scotland, where several bridges were destroyed and residents were evacuated. October mean river flows were significantly above average across western England and Wales (exceptionally so in Cumbria, where the Leven recorded twice the October average) and southern England. Flows were largely in the normal range elsewhere, with less than 70% of average in parts of central England. Flow accumulations for autumn so far (September-October) followed a similar pattern, dominated by the wet October, while longer-term accumulations were mostly in the normal range, except in southern Britain which has seen above-normal accumulations since the spring.

Soil Moisture and Groundwater

As expected for the time of year, soil moisture increased through October across much of the country, as evident from the COSMOS-UK network (page 11), which shows wetter-than-normal soils (exceptionally so in some cases) across southern Britain and in some northern localities at month-end. Correspondingly, by month-end Soil Moisture Deficits (SMDs) were largely eliminated across the south and, as is typical for October, across northern and western Britain. Elsewhere soil moisture was normal or below normal, and SMDs remained in eastern England, as is quite typical in October. Groundwater levels increased significantly in some boreholes in the Chalk in Dorset, Hampshire and Sussex, marking the onset of the recharge season. Levels were within the normal range at about half of the Chalk sites, and above normal or notably high elsewhere, particularly at sites near the south coast. In the Jurassic limestones, levels increased (notable recharge occurred at Ampney Crucis) but remained in the normal range. Levels in the Magnesian Limestone fell at Aycliffe, becoming notably high, while at Brick House Farm they rose and remained exceptionally high. Levels rose in the Carboniferous Limestone and were in the normal range at Alstonfield, but above normal to notably high in south Wales. In the Permo-Triassic Sandstones, levels remained normal to notably high, with recharge commencing at Bussels No. 7a. Record October levels were observed at Lime Kiln Way in the Upper Greensand, while at Royalty Observatory in the Fell Sandstone, levels rose slightly and remained above normal.

Note that due to continuing issues with data access, no data are available for Scotland.

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 1981-2010 average.

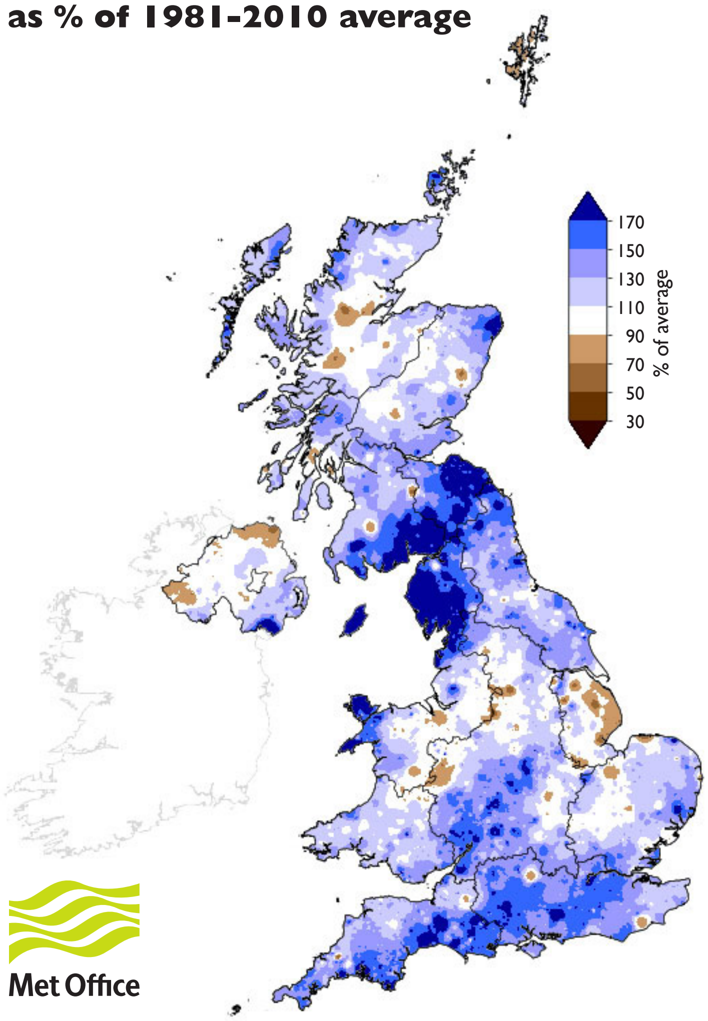
Region	Rainfall	Oct 2021	Sep21 – Oct21	RP	May21– Oct21	RP	Feb21 – Oct21	RP	Nov20 – Oct21	RP
United	mm	**163**	242		542		749		1148	
Kingdom	%	**131**	111	2-5	104	2-5	97	2-5	102	2-5
England	mm	**125**	181		467		601		918	
	%	**138**	114	2-5	115	2-5	102	2-5	109	2-5
Scotland	mm	**219**	324		623		934		1425	
	%	**129**	108	2-5	93	2-5	92	2-5	94	2-5
Wales	mm	**209**	324		723		991		1588	
	%	**126**	117	2-5	113	2-5	105	2-5	112	5-10
Northern	mm	**127**	212		518		724		1091	
Ireland	%	**105**	100	2-5	96	2-5	91	2-5	96	2-5
England &	mm	**136**	201		502		655		1010	
Wales	%	**135**	115	2-5	114	2-5	103	2-5	110	2-5
North West	mm	**218**	306		641		910		1381	
	%	**159**	128	5-10	111	2-5	109	2-5	113	5-10
Northumbria	mm	**122**	165		416		593		916	
	%	**143**	105	2-5	99	2-5	97	2-5	105	2-5
Severn-Trent	mm	**99**	158		423		539		830	
	%	**123**	109	2-5	108	2-5	97	2-5	106	2-5
Yorkshire	mm	**103**	154		449		600		923	
	%	**126**	103	2-5	111	2-5	102	2-5	110	2-5
Anglian	mm	**71**	113		334		418		645	
	%	**112**	96	2-5	101	2-5	91	2-5	103	2-5
Thames	mm	**111**	164		451		540		789	
	%	**142**	120	2-5	128	8-12	108	2-5	110	2-5
Southern	mm	**141**	181		497		590		895	
	%	**144**	113	2-5	135	10-15	110	2-5	112	2-5
Wessex	mm	**149**	205		509		636		940	
	%	**149**	122	2-5	125	5-10	107	2-5	107	2-5
South West	mm	**198**	288		697		876		1382	
	%	**142**	126	5-10	130	10-15	109	2-5	113	5-10
Welsh	mm	**205**	317		708		963		1538	
	%	**128**	118	2-5	115	2-5	106	2-5	113	5-10
Highland	mm	**234**	348		643		1008		1563	
	%	**118**	98	2-5	85	2-5	84	2-5	86	2-5
North East	mm	**146**	226		557		739		1075	
	%	**123**	109	2-5	112	2-5	103	2-5	106	2-5
Tay	mm	**180**	265		637		944		1360	
	%	**119**	100	2-5	106	2-5	104	2-5	101	2-5
Forth	mm	**190**	277		576		829		1224	
	%	**143**	116	5-10	103	2-5	100	2-5	102	2-5
Tweed	mm	**189**	254		528		755		1131	
	%	**170**	131	5-10	108	2-5	106	2-5	110	5-10
Solway	mm	**288**	396		691		1017		1515	
	%	**167**	135	10-15	102	2-5	101	2-5	102	2-5
Clyde	mm	**263**	389		674		1048		1666	
	%	**128**	107	2-5	84	2-5	86	2-5	92	2-5

% = percentage of 1981-2010 average *RP = Return period*

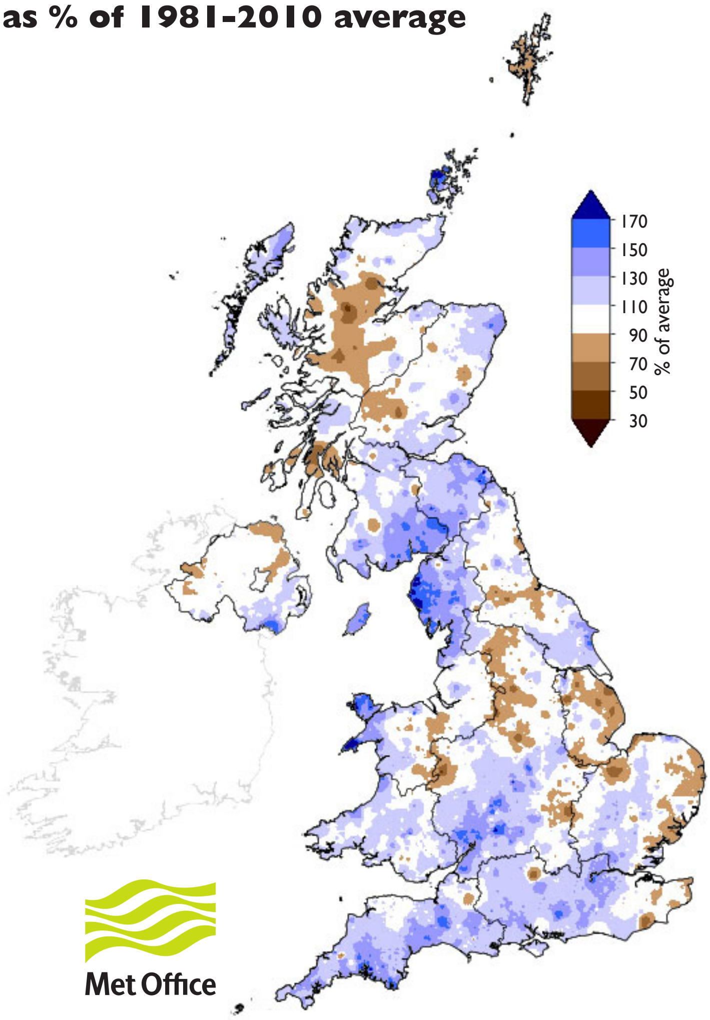
Important note: Figures in the above table may be quoted provided their source is acknowledged (see page 12). Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic variability since 1910; 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 2018 are provisional.

Rainfall . . . Rainfall . . .

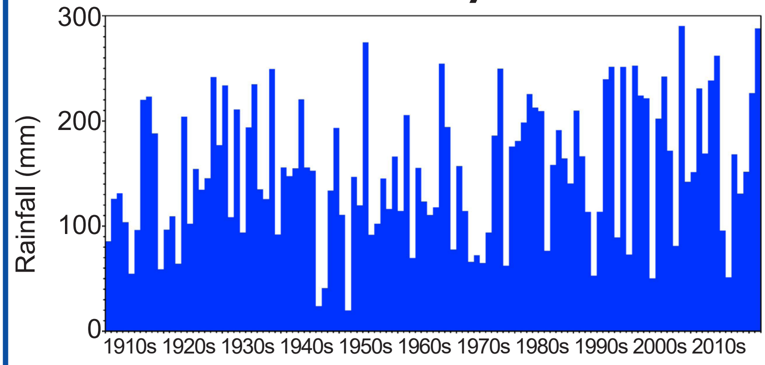
October 2021 rainfall as % of 1981-2010 average



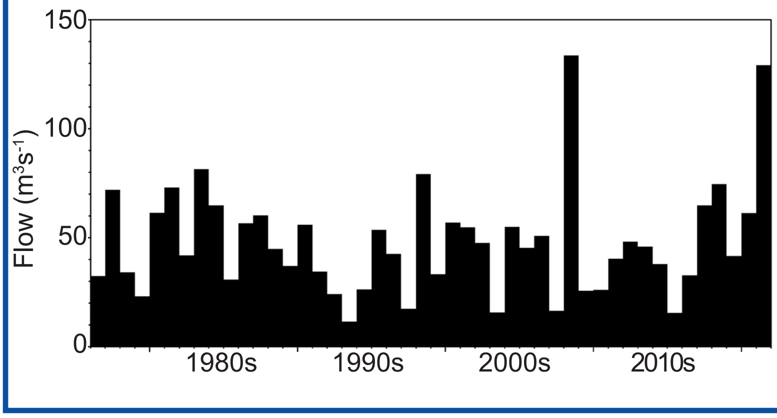
September 2021 - October 2021 rainfall as % of 1981-2010 average



October rainfall for Solway



October maximum daily flows for the River Leven



Hydrological Outlook UK

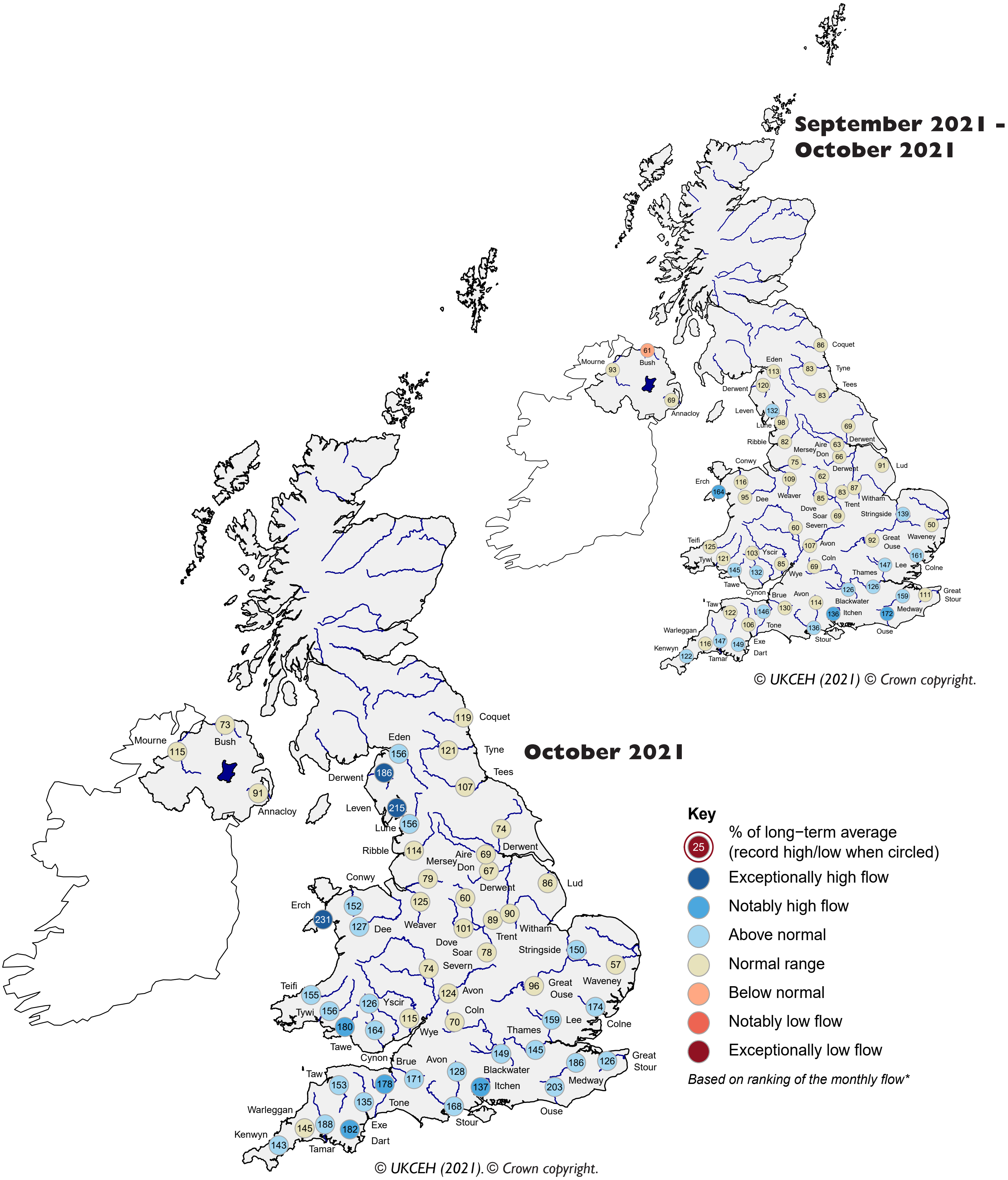
The Hydrological Outlook provides an insight into future hydrological conditions across the UK. Specifically it describes likely trajectories for river flows and groundwater levels on a monthly basis, with particular focus on the next three months.

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

Period: **from November 2021**
Issued: **08.11.2021**
using data to the end of October 2021

In most regions of the UK river flows are likely to be normal to above normal during November, while in south Wales and southern areas of England river flows are likely to be above normal. Groundwater levels are likely to be above normal except in parts of eastern England where normal levels are most likely. Over the three month period to January 2022, river flows expected to be normal to above normal everywhere, while groundwater levels are likely to be normal.

River flow . . . River flow . . .

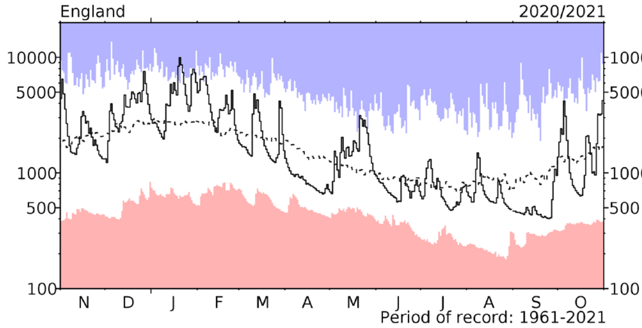


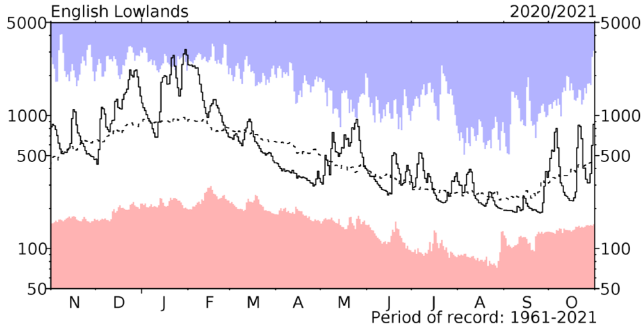
River flows

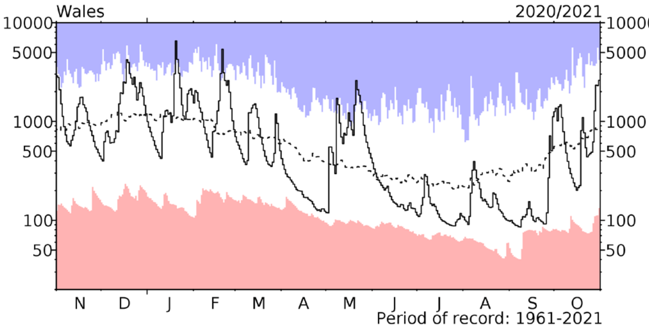
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much greater. Note: the averaging period on which these percentages are based is 1981-2010. Percentages may be omitted where flows are under review.

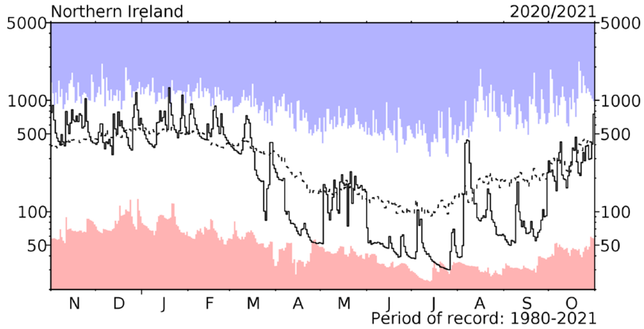
Note that due to continuing issues with data access, no data are available for Scotland.

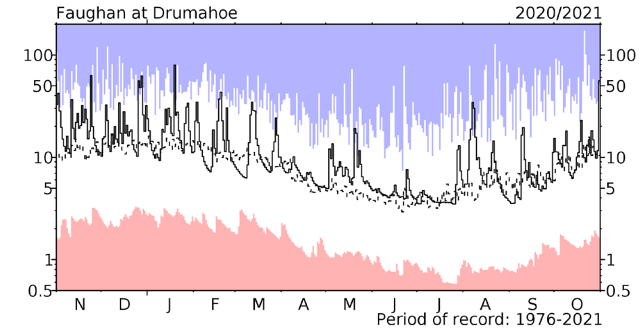
River flow . . . River flow . . .

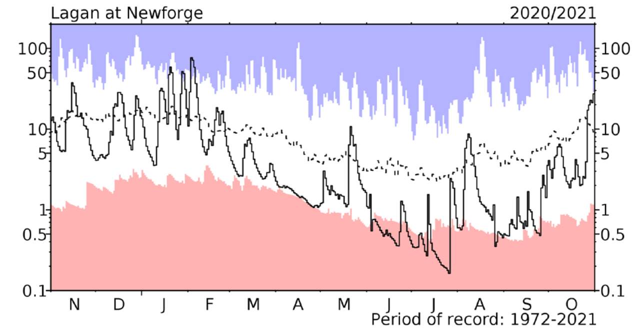


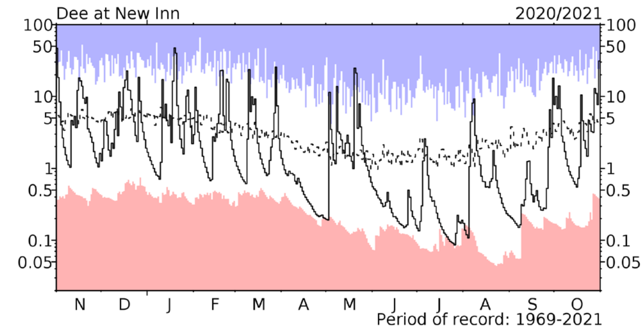


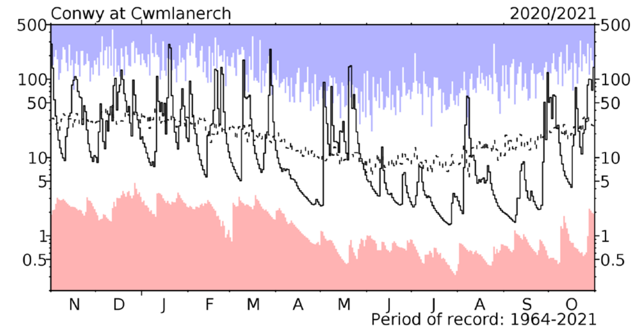


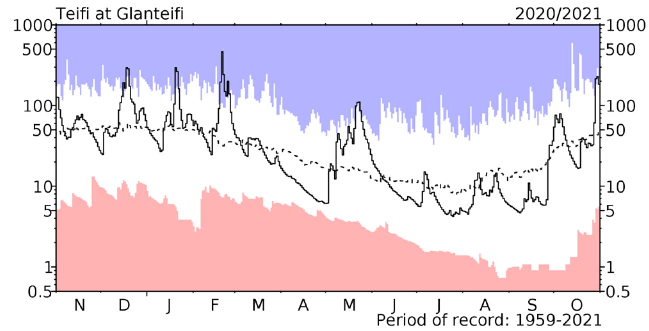


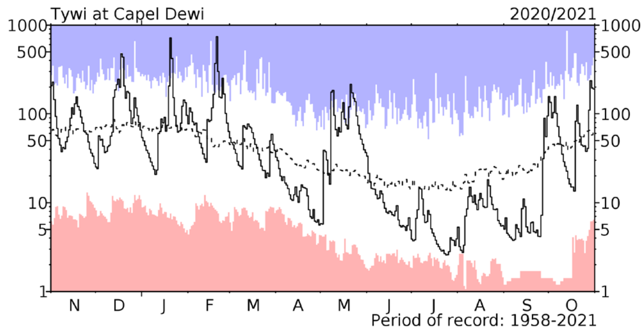






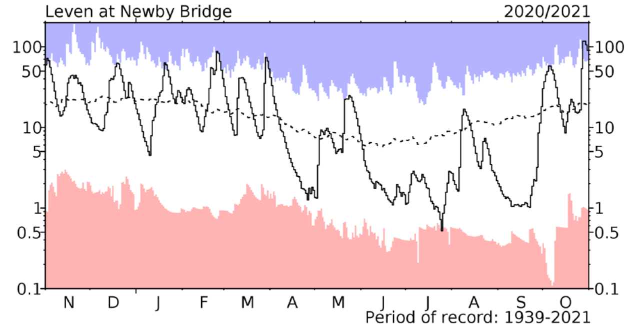


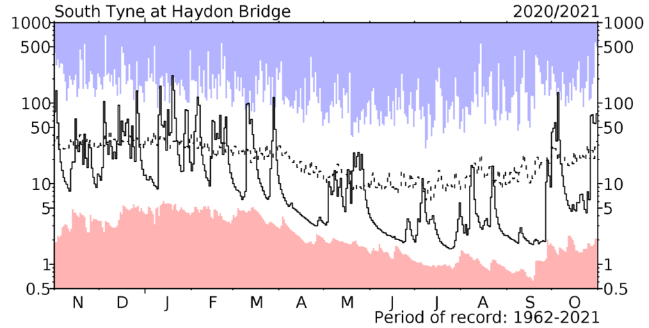


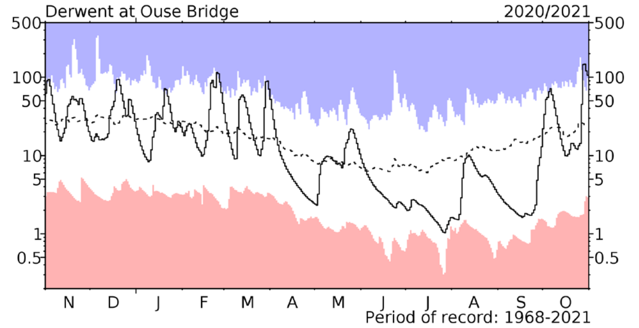


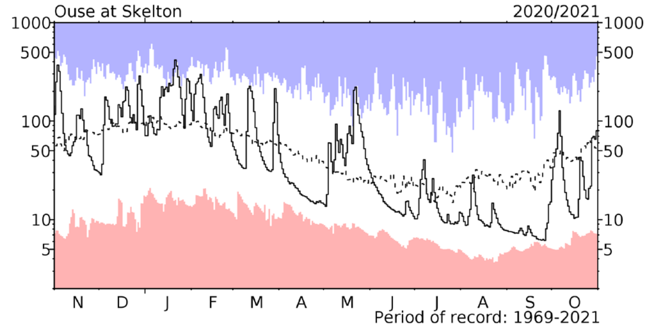
River flow hydrographs

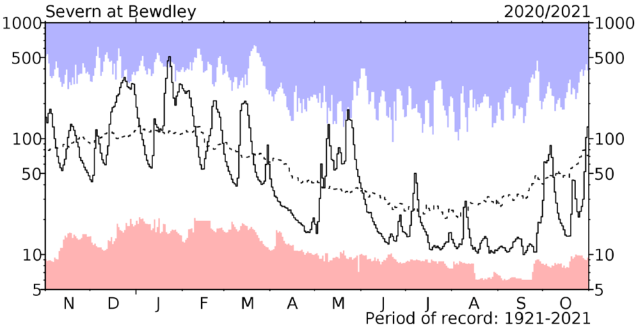
*The river flow hydrographs show the daily mean flows (measured in m^3s^{-1}) together with the maximum and minimum daily flows prior to November 2020 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed line represents the period-of-record average daily flow.

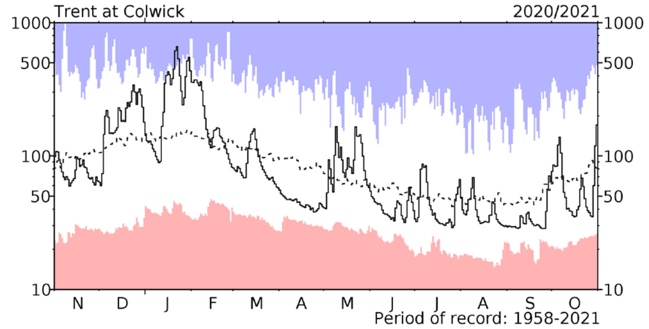

Leven at Newby Bridge
2020/2021
Period of record: 1939-2021

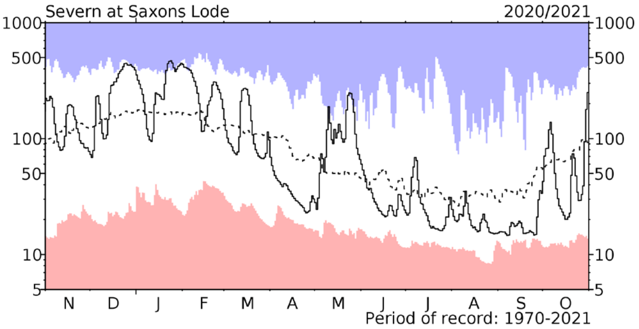

South Tyne at Haydon Bridge
2020/2021
Period of record: 1962-2021

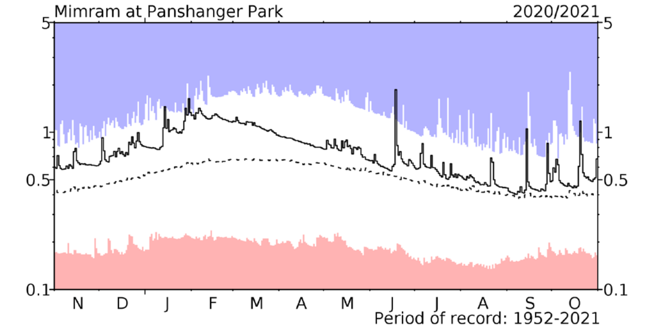

Derwent at Ouse Bridge
2020/2021
Period of record: 1968-2021

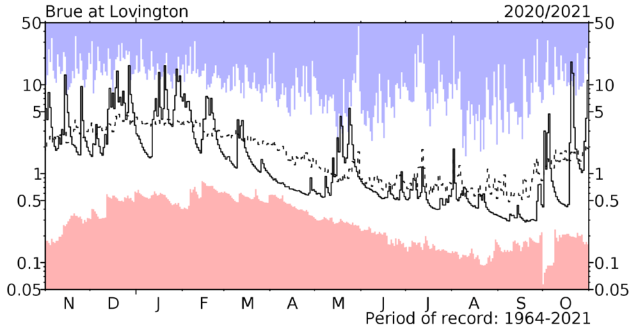

Ouse at Skelton
2020/2021
Period of record: 1969-2021

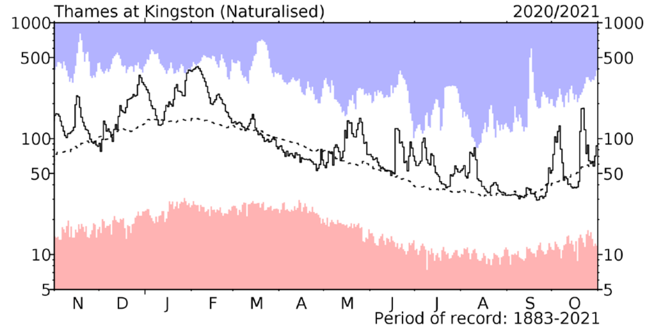

Severn at Bewdley
2020/2021
Period of record: 1921-2021

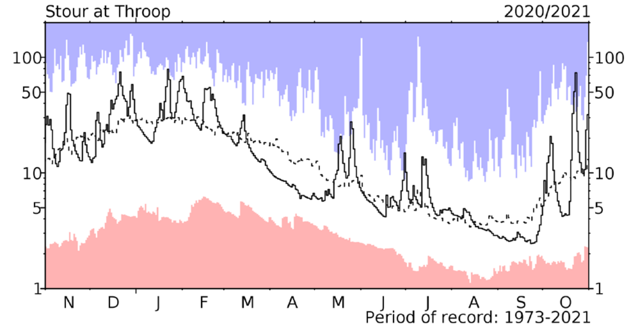

Trent at Colwick
2020/2021
Period of record: 1958-2021

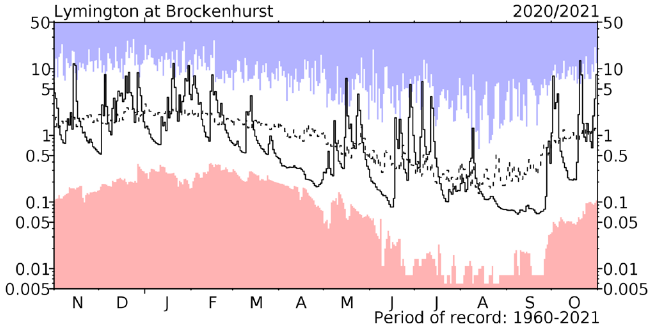

Severn at Saxons Lode
2020/2021
Period of record: 1970-2021


Mimram at Panshanger Park
2020/2021
Period of record: 1952-2021

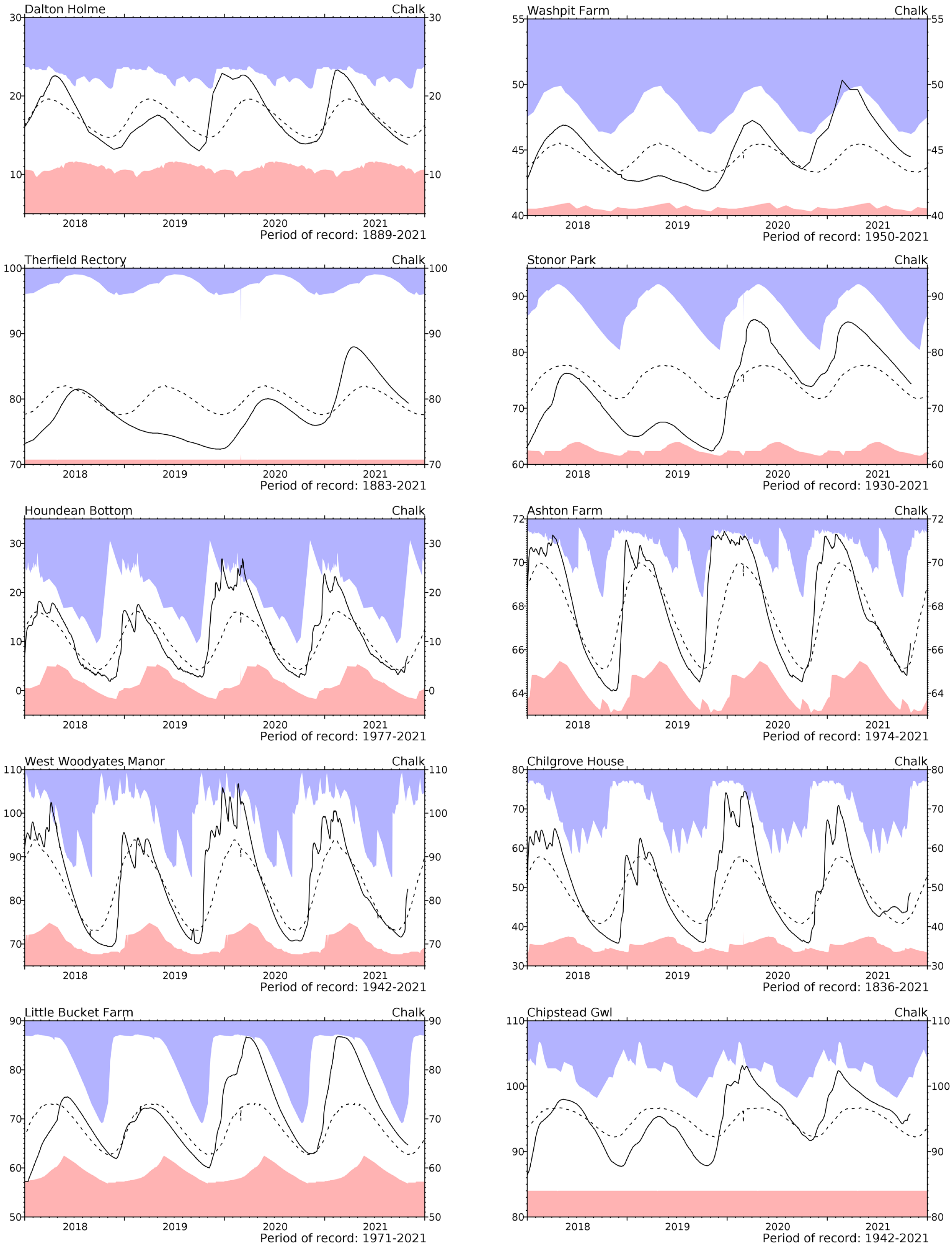

Brue at Lovington
2020/2021
Period of record: 1964-2021


Thames at Kingston (Naturalised)
2020/2021
Period of record: 1883-2021


Stour at Throop
2020/2021
Period of record: 1973-2021

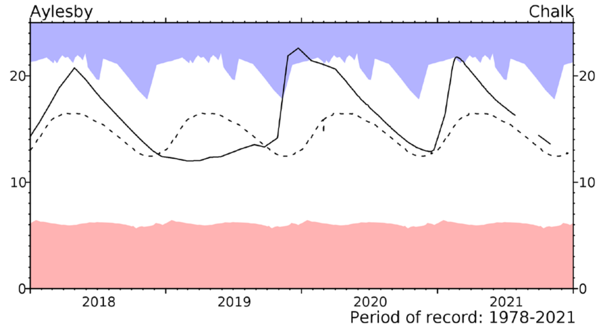

Lymington at Brockenhurst
2020/2021
Period of record: 1960-2021

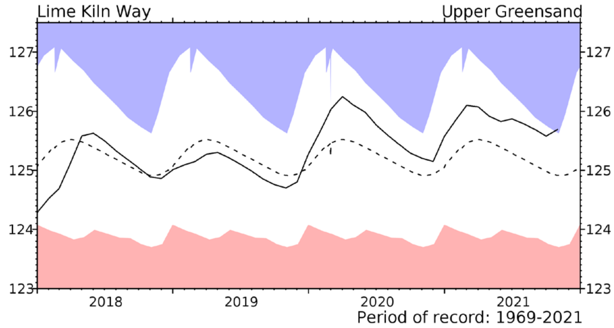
Groundwater...Groundwater

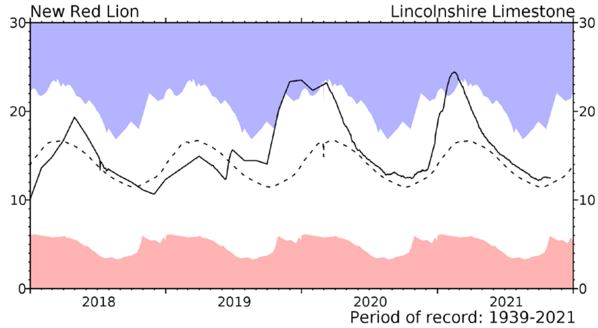


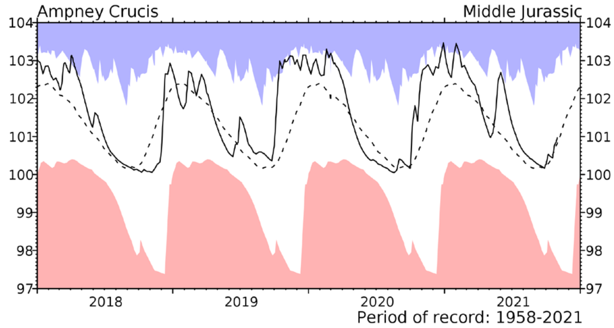
Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is 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 2017. 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.

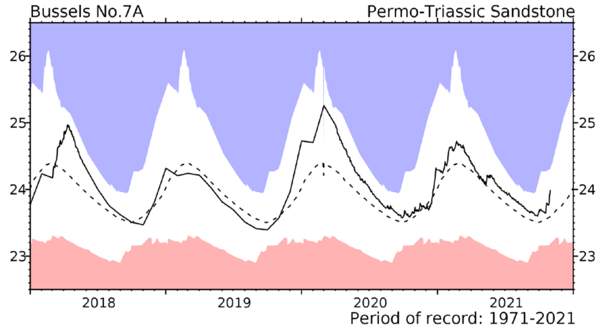
Groundwater ... Groundwater

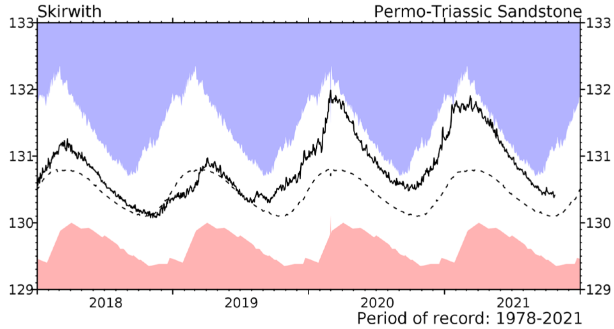


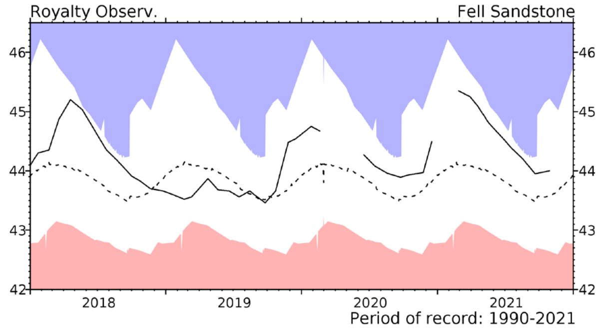


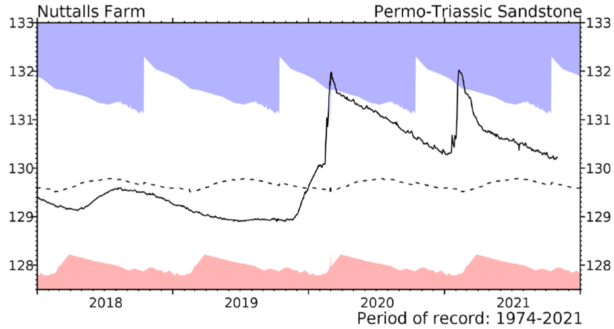


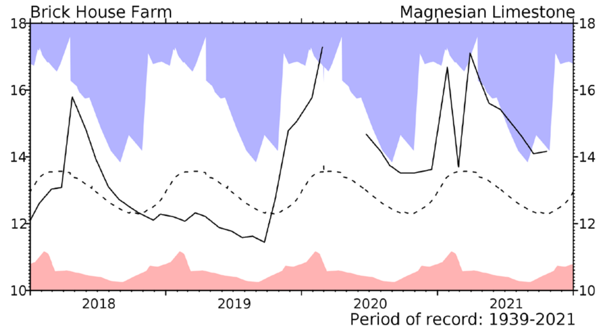


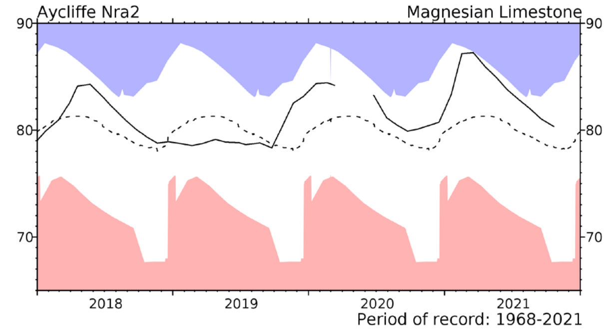


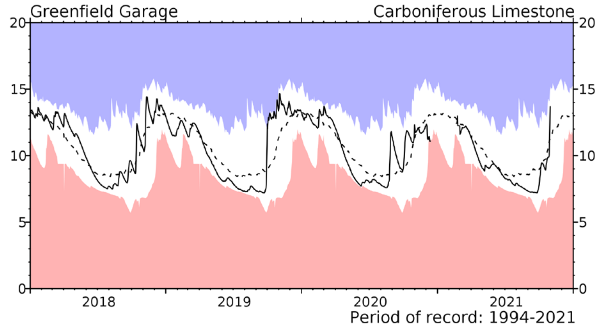


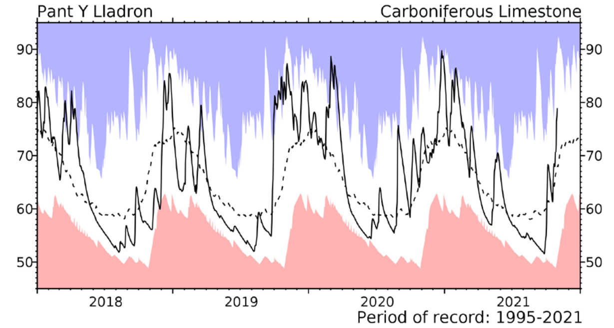












Groundwater...Groundwater

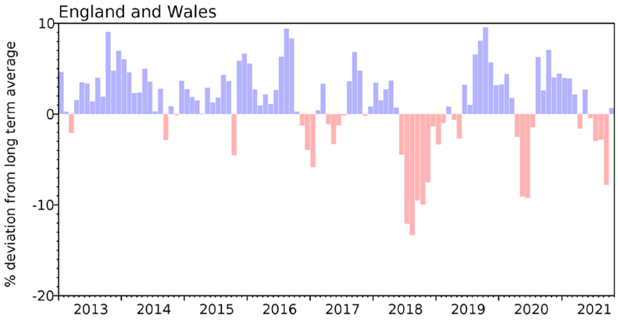
Groundwater levels - October 2021

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.

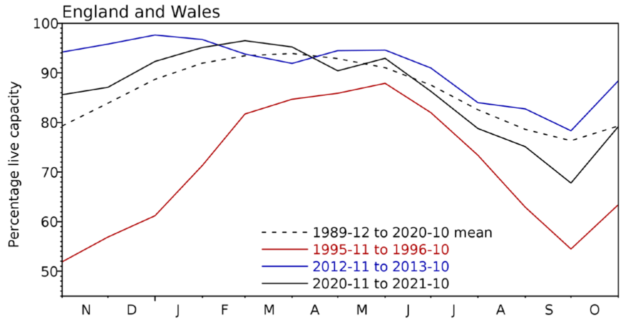
Note that due to continuing issues with data access, no data are available for Scotland.

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



*Note: Due to data access issues, the England and Wales stocks do not include Bristol for October.

Percentage live capacity of selected reservoirs at end of month

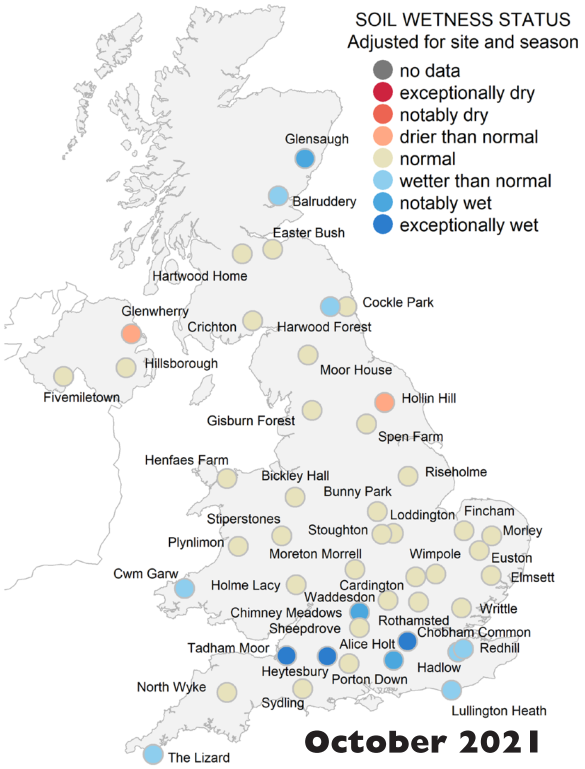
Area	Reservoir		Capacity (Ml)	2021 Aug	2021 Sep	2021 Oct	Oct Anom.	Min Oct	Year* of min	2020 Oct	Diff 21-20
North West	Northern Command Zone	•	124929	46	30	72	3	33	2003	85	-14
	Vyrnwy		55146	75	62	91	14	25	1995	98	-7
Northumbrian	Teesdale	•	87936	53	41	69	-9	33	1995	83	-14
	Kielder		(199175)	81	76	81	-5	63	1989	86	-5
Severn-Trent	Clywedog		49936	81	73	88	10	38	1995	89	-1
	Derwent Valley	•	46692	58	47	51	-20	15	1995	92	-41
Yorkshire	Washburn	•	23373	79	66	73	3	15	1995	97	-24
	Bradford Supply	•	40942	65	51	66	-8	16	1995	100	-34
Anglian	Grafham		(55490)	96	92	94	11	44	1997	91	3
	Rutland		(116580)	91	86	80	1	59	1995	88	-8
Thames	London	•	202828	89	81	82	5	46	1996	79	3
	Farmoor	•	13822	95	84	90	1	43	2003	98	-7
Southern	Bewl		31000	78	74	74	14	33	1990	60	14
	Ardingly		4685	89	73	96	31	15	2003	27	69
Wessex	Clatworthy		5662	67	60	78	15	14	2003	93	-15
South West	Colliford		28540	69	59	64	-6	38	2006	62	2
	Roadford		34500	84	79	87	17	18	1995	68	19
	Wimbleball		21320	81	69	74	8	26	1995	65	9
	Stithians		4967	66	52	56	-3	18	1990	61	-5
Welsh	Celyn & Brenig	•	131155	77	71	80	-4	48	1989	100	-20
	Brianne		62140	77	80	100	7	57	1995	100	0
	Big Five	•	69762	62	61	78	1	38	2003	71	7
	Elan Valley	•	99106	68	66	80	-5	37	1995	86	-6
Scotland(E)	Edinburgh/Mid-Lothian	•	97223	68	64	85	4	48	2003	89	-4
	East Lothian	•	9317	96	91	100	15	38	2003	100	0
Scotland(W)	Loch Katrine	•	110326	50	41	71	-17	40	2003	95	-24
	Daer		22494	45	37	100	9	42	2003	100	0
	Loch Thom		10721	50	40	75	-14	63	2020	63	12
Northern Ireland	Total+	•	56800	69	63	75	-7	39	1995	98	-23
	Silent Valley	•	20634	58	51	68	-10	34	1995	100	-33

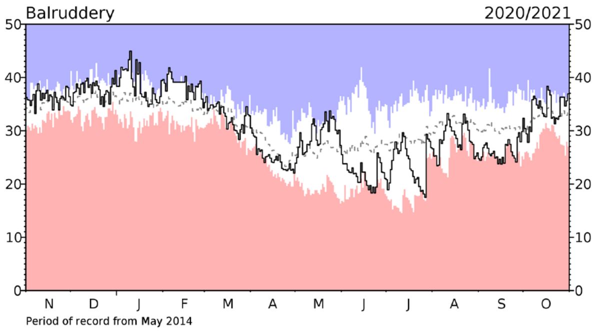
( ) figures in parentheses relate to gross storage • denotes reservoir groups *last occurrence

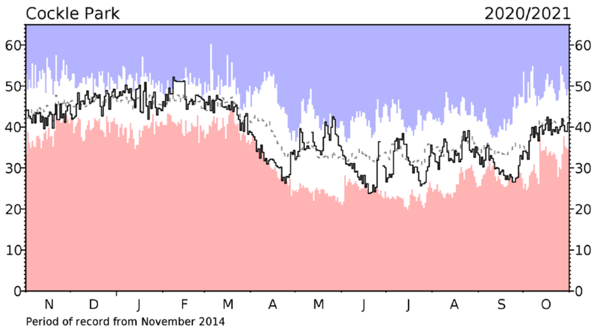
+ excludes Lough Neagh

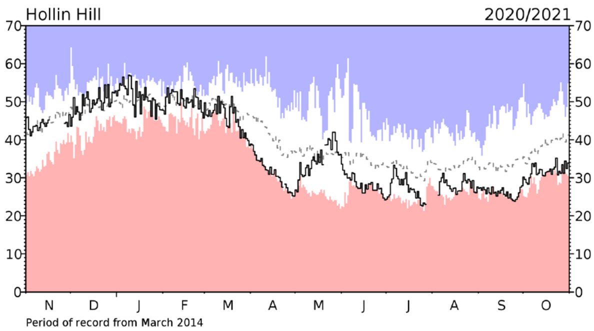
Details of the individual reservoirs in each of the groupings listed above are available on request. The percentages given in the Average and Minimum storage columns relate to the 1988-2012 period except for West of Scotland and Northern Ireland where data commence in the mid-1990s. In some gravity-fed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

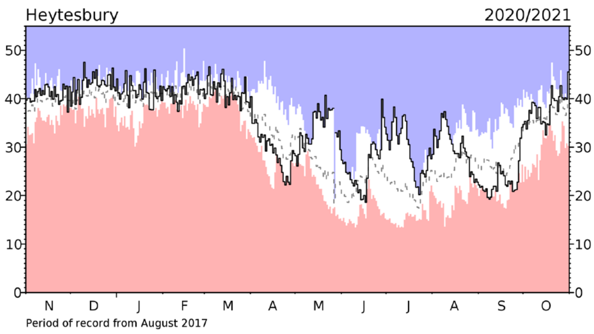
Soil Moisture . . . Soil Moisture

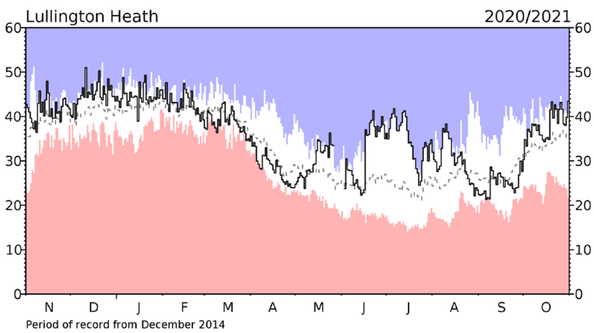












At the end of October soil moisture is mostly normal or above normal with some locations being very wet especially in the south of England.

The autumn is usually a transitional time with soil moisture recovering from summer minima towards wetter winter conditions. This is seen clearly at some sites in southern England that show a significant change from mid-September, leaving soils wetter than normal for the end of October (e.g. Heytesbury, Lullington Heath).

In parts of Scotland and northern England there has been a steadier increase in soil moisture resulting in soil moisture being normal to slightly above normal at the end of the month (e.g. Balruddery, Cockle Park).

Between these areas, where rainfall has been closer to normal and rainfall was interspersed with periods during which soils dried, soil moisture is normal or slightly below normal for the time of year (e.g. Hollin Hill).

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. 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 5km 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 1910 and form the official source of UK areal rainfall statistics which have been adopted by the NHMP. The gridding technique used is described in Perry MC and Hollis DM (2005) available at https://doi.org/10.1002/joc.1161

Long-term averages are based on the period 1981-2010 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: 0870 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