Hydrological Summary

for the United Kingdom

December 2015

General

December was an extraordinary month in both meteorological and hydrological terms, with some of the most widespread and severe flooding witnessed in the UK. It was remarkably mild throughout the UK, and the warmest December in the Central England Temperature series (from 1659) by a wide margin, ~5°C above the 1971-2000 average. Exceptionally stormy and wet conditions across the north contributed to the wettest calendar month on record for the UK (in a series from 1910). Slow-moving low pressure systems (including the named storms 'Desmond', 'Eva' and 'Frank'), driven by a sustained moist south-westerly airflow, brought prolonged heavy rainfall to northern and western areas. Several major flood episodes caused widespread and severe impacts: early estimates indicate 16,000 homes were flooded in England alone, while Scotland also suffered major impacts. 'Desmond' established new UK rainfall records over 24-hour (341.4mm at Honister Pass, Cumbria) and 48-hour (405.0mm at Thirlmere, Cumbria) timeframes. Saturated soils resulting from substantial November rainfall exacerbated the fluvial flooding which followed in December. The spatial scale of sustained very high flows was remarkable; many large catchments in northern Britain recorded their highest ever peak flows and/or monthly mean flows. The three largest flows ever registered in river flow records for England occurred on the Eden, Lune and Tyne. The wettest parts of the UK were away from the main aquifers, although groundwater levels increased sharply in some boreholes in the north. Reservoir stocks in the Northern Command Zone (north-west England) doubled since the end of October, and end of December stocks for England & Wales were appreciably above average. With the exceptional wetness and flooding continuing into January in parts of northern Britain, the risk of further flooding in early 2016 remains high.

Rainfall

A relentless sequence of cyclonic systems in December caused unsettled conditions throughout the month. On the 5th/6th 'Desmond' traversed northern Britain slowly, and substantial orographic enhancement of moist air over the uplands of northern England and southern Scotland delivered prolonged heavy rainfall. Further storms on the 9th and 22nd generated surface water flooding in Cumbria, and on the 23rd/24th 'Eva' brought gales to the far north-west of the UK. On the 25th/26th, intense stormy conditions associated with another low pressure system delivered further substantial rainfall to a wide swathe of northern England and Wales (e.g. 211mm at Capel Curig, Snowdonia). 'Frank' brought heavy rainfall across northern and western areas of the UK on the 29th/30th, causing further landslides and transport disruption. For December overall, Crib Goch (Snowdonia) received 1,396mm, amongst the largest monthly totals ever recorded in the UK. Most northern and western parts of the UK registered more than double the average rainfall, and three times the average across some upland areas. For many Scottish regions, December 2015 was the wettest calendar month on record by wide margins (in series from 1910), and North West England exceeded its previous maximum December rainfall by an amount almost equivalent to its average monthly rainfall. Further south and east, rainfall for December was near or slightly below average. Across November and December 2015, many regions of northern Britain registered their wettest two-month periods on record by considerable margins. The calendar year 2015 was the sixth wettest on record for the UK. This is notable because rainfall over the first ten months was only marginally above average, and annual rainfall for much of the English Lowlands was marginally below average.

River flows

Following a wet November, soils in many northern and western catchments were saturated and river flows were rising entering December. On the 5th/6th following record rainfall associated with 'Desmond', new peak flow maxima were registered in several large catchments with record lengths of more than 45 years; flows on the Eden, Lune and Tyne were approximately 1,700 cumecs (provisionally corresponding to approximate return periods of 1 in 300-, 150- and 100-years, respectively). A new maximum daily outflow from the UK was established (in a series from 1980), a third larger than the previous maximum. Thousands of properties flooded across northern England, including more than 6,000 in Cumbria with Carlisle particularly severely inundated. Some communities in the Lake District (e.g. Glenridding) were flooded twice more before Christmas; an aggravating factor was the reduced conveyance in many rivers caused by heavy sedimentation, landslides and the collapse of structures. On the 25th/26th, new peak flow maxima were established for many large rivers draining the Pennines with records longer than 50 years (e.g. the Nidd, Wharfe, Aire and Irwell). Thousands of homes flooded across northern England, including in York, Leeds and Greater Manchester. On the 29th/30th 'Frank' caused widespread flooding (e.g. on the Nith, Cree and Dee) and the evacuation of thousands of homes in Scotland. Flooding in December disrupted transport networks and collapsed bridges across northern and western areas (notably in Pooley Bridge and Tadcaster, both 18th century structures), closed schools and hospitals, and substantially impacted agriculture. Power outages affected more than 55,000 properties for several days following 'Desmond', and at least 20,000 homes on Boxing Day. Monthly mean flows for December were outstanding in the north and west, and generally within the normal range elsewhere. Most exceptional December mean flows were new period of record maxima, many by considerable margins (twice the previous maximum for the Tyne), and approached or substantially exceeded the previous maximum for any month in a number of catchments. Mean flows for 2015 were substantially above average across most of the north and west of the UK and generally below normal across the English Lowlands and for small catchments in eastern Britain.

Groundwater

Levels in the index boreholes were generally in the normal range or above for December. Levels recovered in response to winter recharge, except at some sites in parts of the eastern Chalk with thick unsaturated zones or where recharge was limited by superficial deposits (Aylesby, Therfield Rectory, Stonor Park, Well House Inn and Westdean No. 3) and at Nuttalls Farm (in the Permo-Triassic sandstone). The exceptional rainfall in the northern half of the UK resulted in high groundwater levels with record monthly values recorded at Killyglen (Chalk) and Newbridge (Permo-Triassic sandstone). Other levels in the north were notably high, except for Dalton Holme, which normally responds slowly to recharge from rainfall. Groundwater from the Corallian aquifers at Old Malton in North Yorkshire contributed to high river levels, and high groundwater levels in permeable superficial deposits contributed to flooding in river valleys across northern Britain.

Centre for Ecology & Hydrology
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British Geological Survey
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Rainfall . . . Rainfall . . .

Met Office

Rainfall accumulations and return period estimates

Percentages are from the 1971-2000 average.

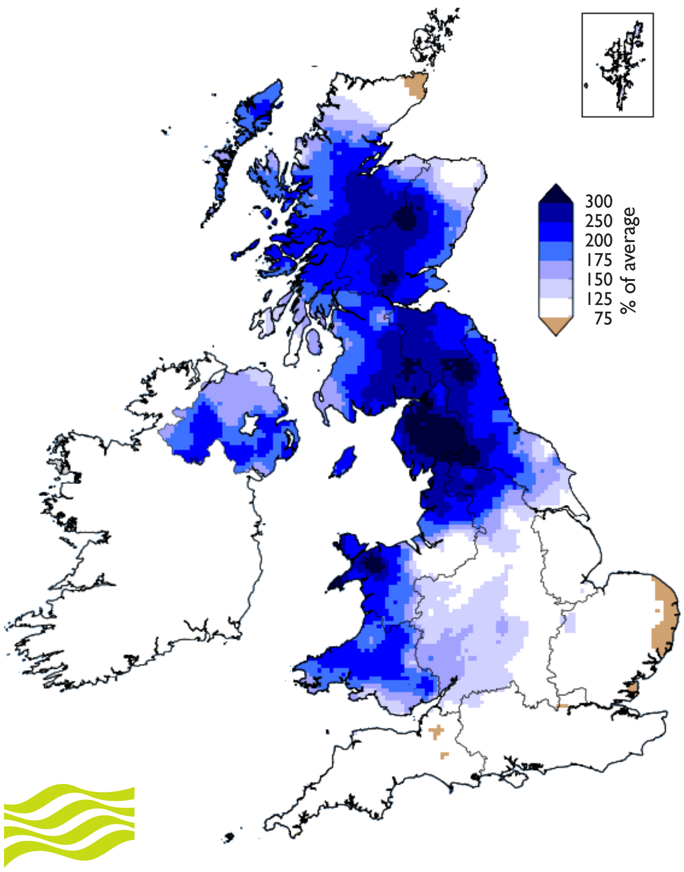
Area	Rainfall	Dec 2015	Nov15 – Dec15	RP	Jul15 – Dec15	RP	Apr15 – Dec15	RP	Jan15 – Dec15	RP
United	mm	**230**	406		749		960		1289	
Kingdom	%	**191**	173	>100	127	15-25	122	15-25	119	30-50
England	mm	**137**	256		550		690		883	
	%	**154**	150	10-20	125	5-10	113	2-5	108	2-5
Scotland	mm	**351**	597		1003		1323		1869	
	%	**218**	186	>>100	127	20-30	129	60-90	130	>100
Wales	mm	**359**	627		1027		1254		1627	
	%	**218**	197	>100	136	20-30	126	10-20	119	10-15
Northern	mm	**221**	405		756		991		1308	
Ireland	%	**187**	177	>>100	126	10-20	122	15-25	118	25-40
England &	mm	**168**	307		616		768		986	
Wales	%	**169**	161	25-40	127	5-10	115	2-5	110	2-5
North West	mm	**352**	613		964		1195		1542	
	%	**268**	239	>>100	146	40-60	137	50-80	131	60-90
Northumbrian	mm	**225**	390		696		860		1060	
	%	**261**	230	>>100	157	>100	138	30-50	128	30-50
Severn-Trent	mm	**115**	217		453		591		758	
	%	**143**	143	8-12	113	2-5	103	2-5	100	2-5
Yorkshire	mm	**180**	339		652		810		984	
	%	**202**	202	>100	151	25-40	133	15-25	121	8-12
Anglian	mm	**57**	124		364		464		576	
	%	**101**	110	2-5	113	2-5	99	2-5	96	2-5
Thames	mm	**76**	151		409		515		666	
	%	**105**	109	2-5	110	2-5	97	2-5	95	2-5
Southern	mm	**86**	168		488		598		796	
	%	**97**	98	2-5	114	2-5	102	2-5	102	2-5
Wessex	mm	**98**	192		519		647		846	
	%	**97**	102	2-5	112	2-5	102	2-5	98	2-5
South West	mm	**149**	288		732		899		1228	
	%	**99**	102	2-5	112	2-5	104	2-5	102	2-5
Welsh	mm	**340**	589		981		1199		1553	
	%	**216**	194	>100	135	15-25	125	10-15	117	8-12
Highland	mm	**393**	647		1058		1439		2156	
	%	**199**	162	>100	112	2-5	120	10-15	126	40-60
North East	mm	**215**	318		682		893		1128	
	%	**236**	167	20-35	132	5-10	126	5-10	119	5-10
Tay	mm	**372**	574		978		1251		1676	
	%	**264**	211	>100	145	50-80	141	40-60	132	80-120
Forth	mm	**300**	554		890		1141		1533	
	%	**243**	233	>>100	145	>100	141	>100	135	>100
Tweed	mm	**295**	505		804		1008		1311	
	%	**283**	255	>>100	157	>100	143	50-80	137	>100
Solway	mm	**409**	729		1147		1436		1957	
	%	**254**	235	>>100	147	80-120	141	>100	139	>100
Clyde	mm	**409**	767		1257		1653		2341	
	%	**208**	200	>>100	130	20-30	135	70-100	135	>100

% = percentage of 1971-2000 average *RP = Return period*

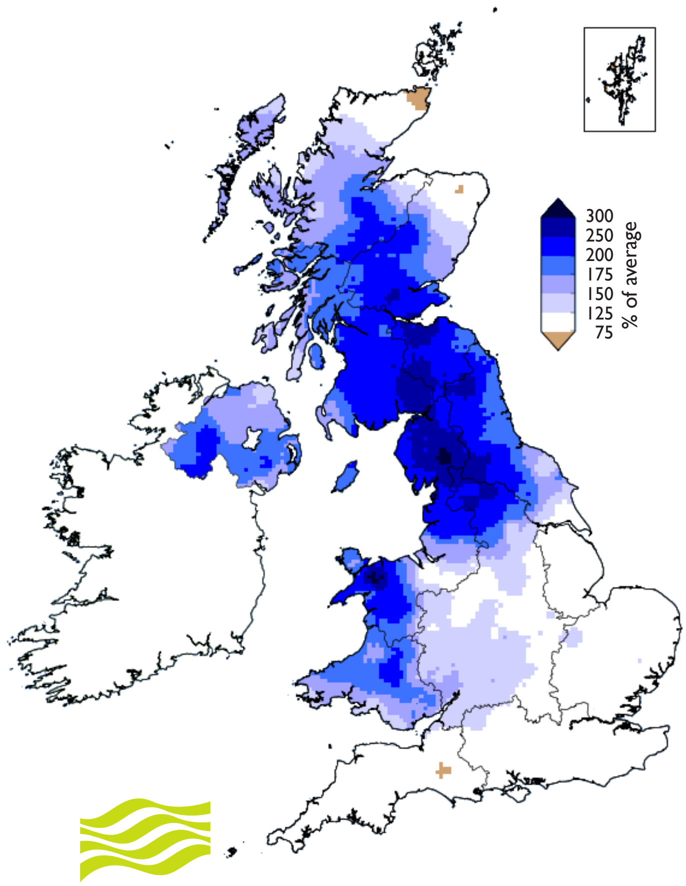
Important note: Figures in the above table may be quoted provided their source is acknowledged (see page 12). Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic 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 from January 2015 (inclusive) are provisional.

Rainfall . . . Rainfall . . .

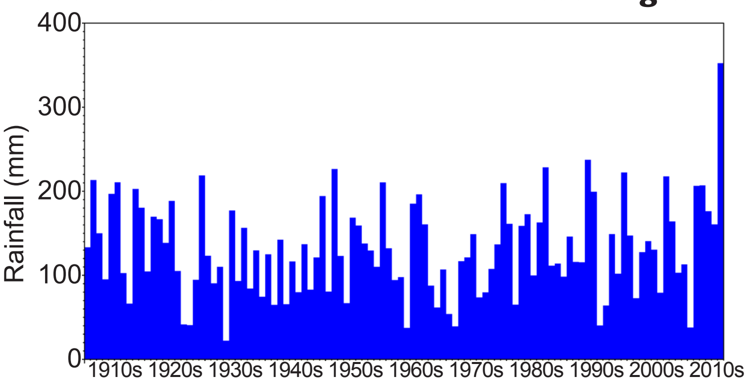
December 2015 rainfall as % of 1971-2000 average



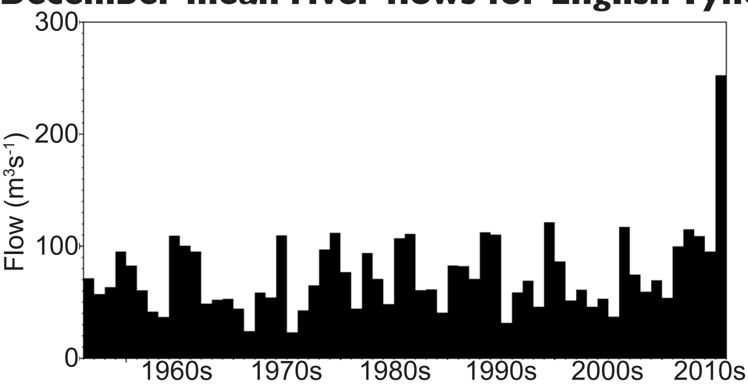
November - December 2015 rainfall as % of 1971-2000 average



December rainfall for North West England



December mean river flows for English Tyne



Met Office 3-month outlook Updated: December 2015

For January-February-March both above- and below-average precipitation are equally probable.

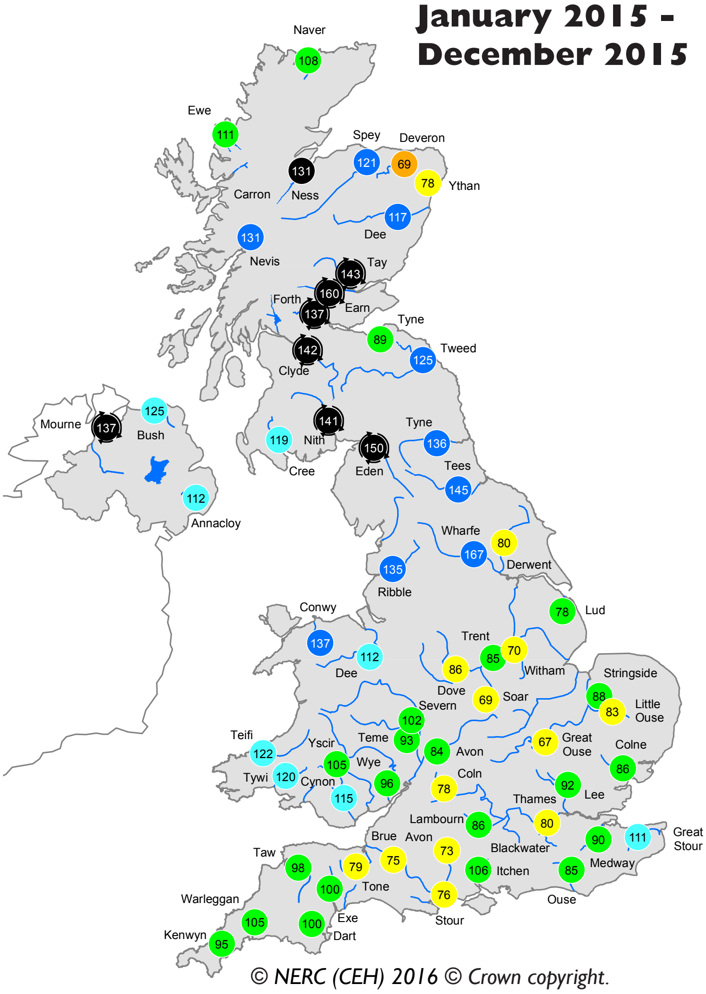
The probability that UK-average precipitation for January-February-March will fall into the driest of our five categories is around 20% and the probability that it will fall into the wettest of our five categories is also around 20% (the 1981-2010 probability for each of these categories is 20%).

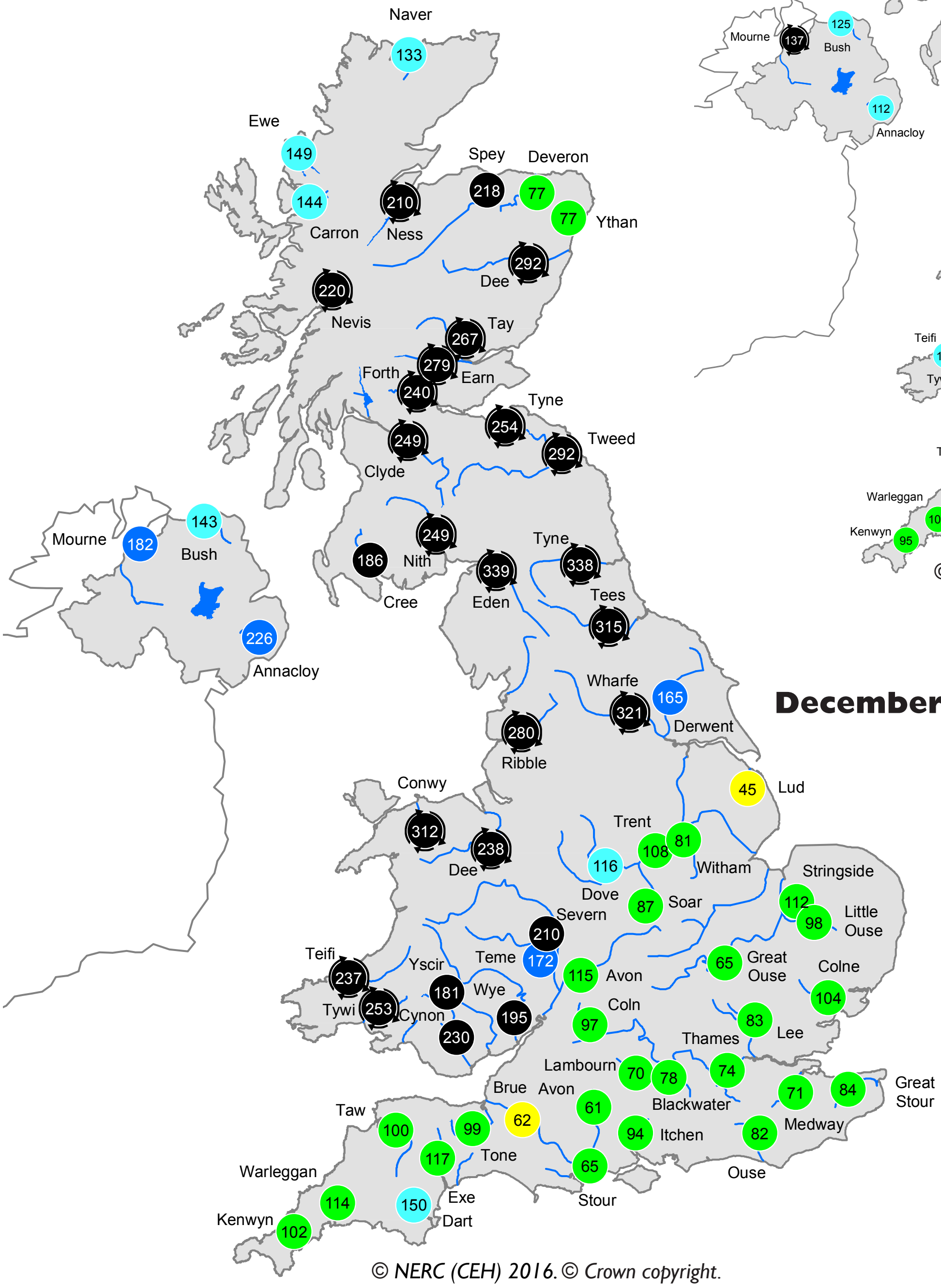
The complete version of the 3-month outlook may be found at:
http://www.metoffice.gov.uk/publicsector/contingency-planners
This outlook is updated towards the end of each calendar month.

The latest shorter-range forecasts, covering the upcoming 30 days, can be accessed via:
http://www.metoffice.gov.uk/weather/uk/uk_forecast_weather.html
These forecasts are updated very frequently.

River flow . . . River flow . . .

January 2015 - December 2015





December 2015

Key

25 — % of long-term average (record figure when circled)

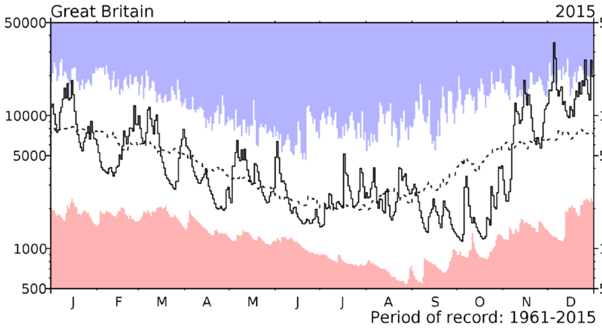
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

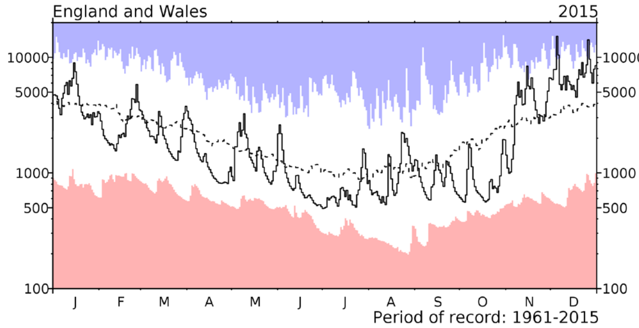
*Based on ranking of the monthly flow**

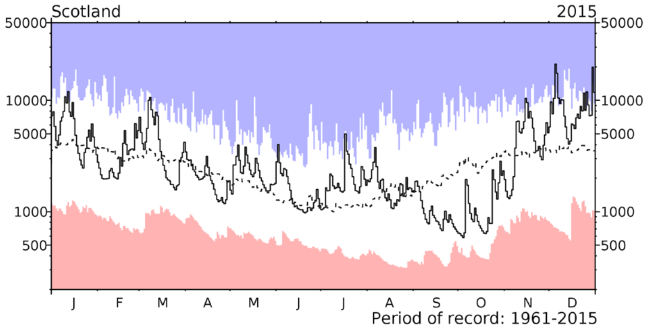
River flows

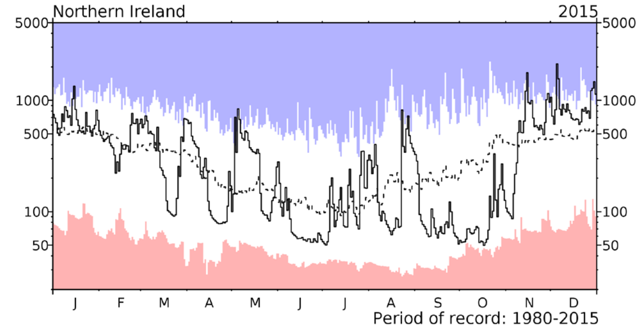
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much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

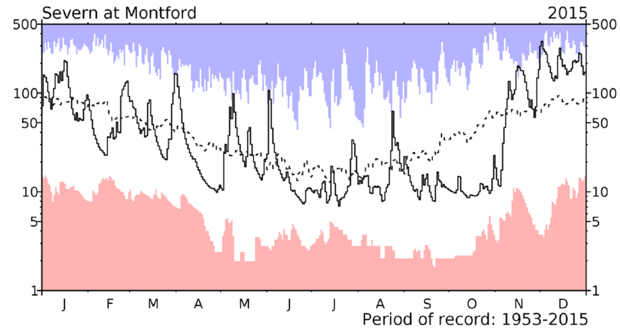
River flow . . . River flow . . .

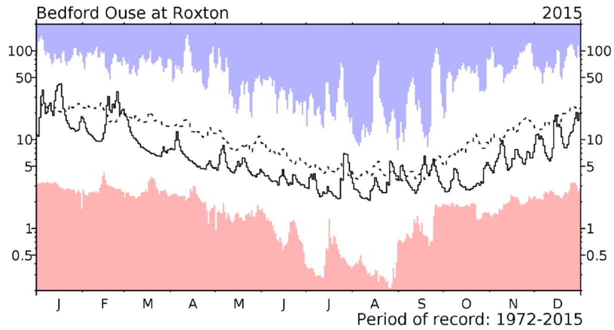


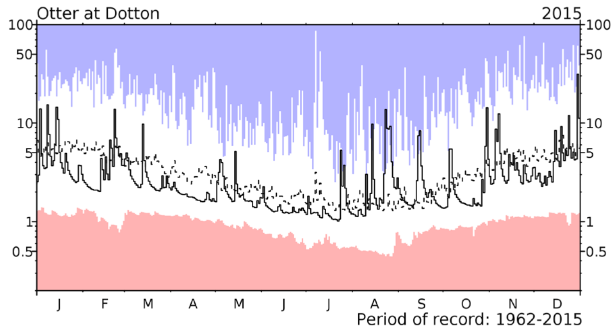


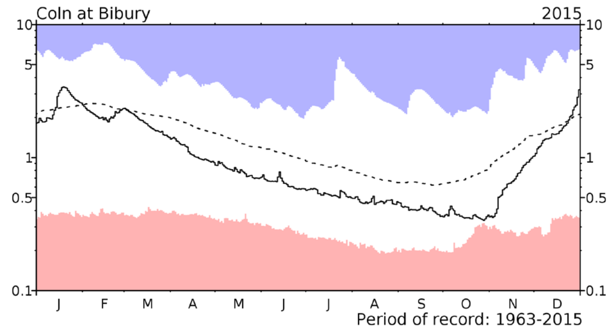


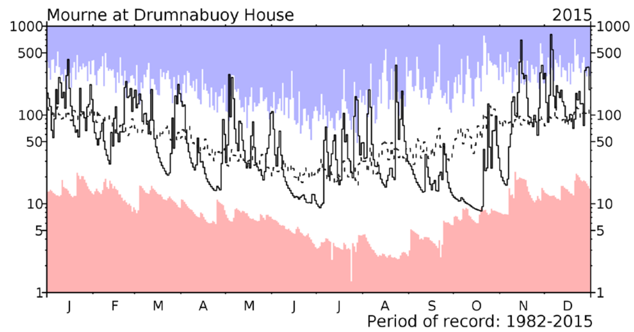


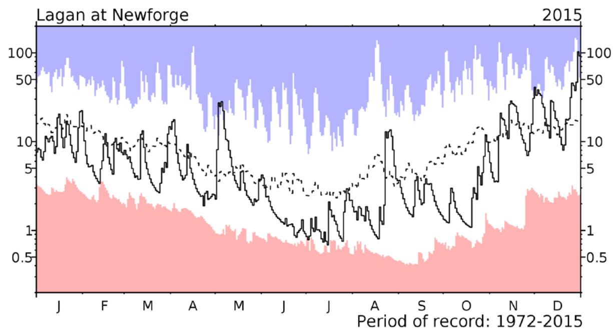








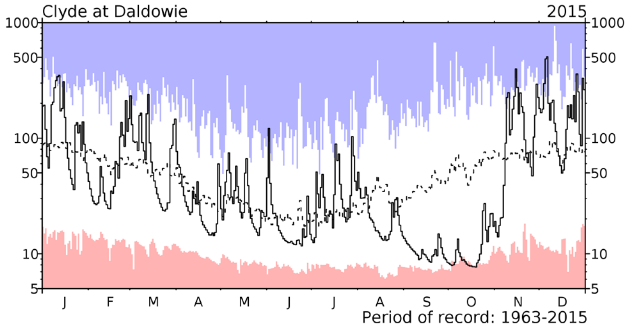


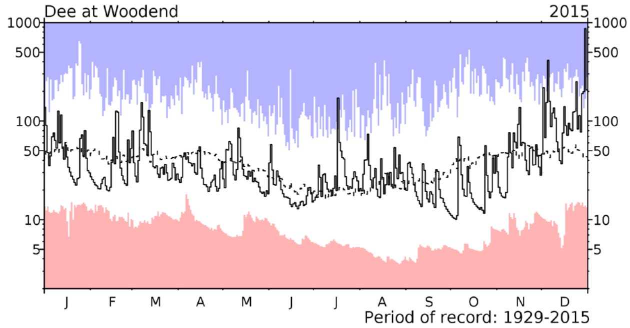


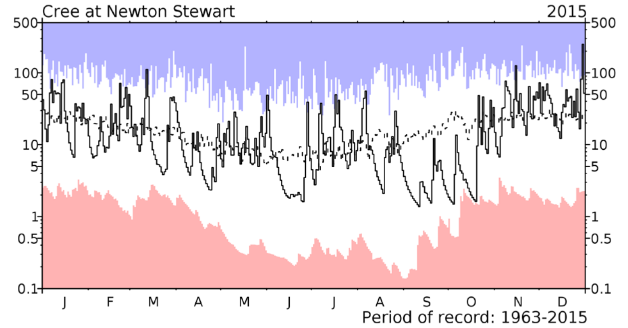
River flow hydrographs

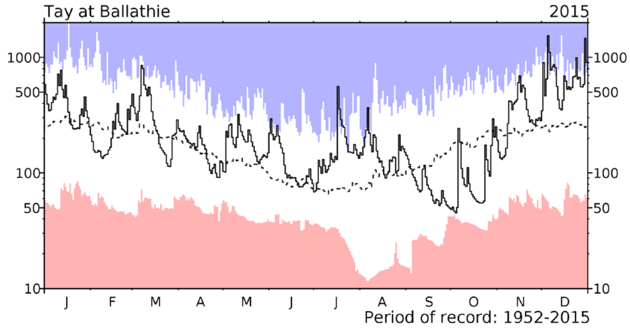
The river flow hydrographs show the daily mean flows together with the maximum and minimum daily flows prior to January 2015 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. Mean daily flows are shown as the dashed line.

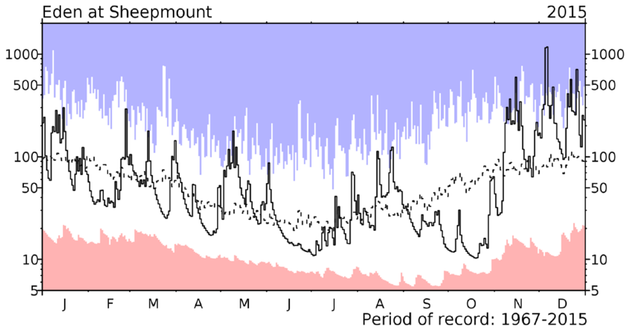
River flow . . . River flow . . .

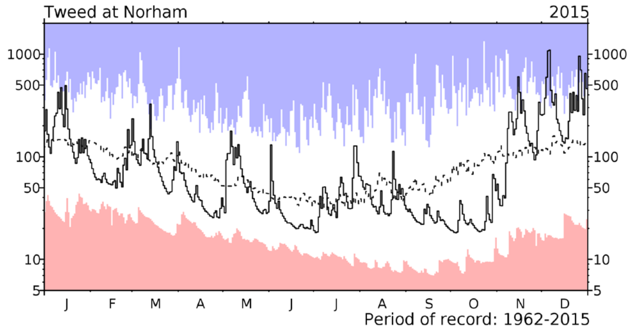


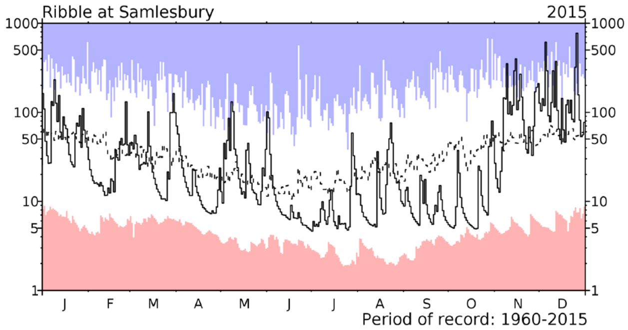


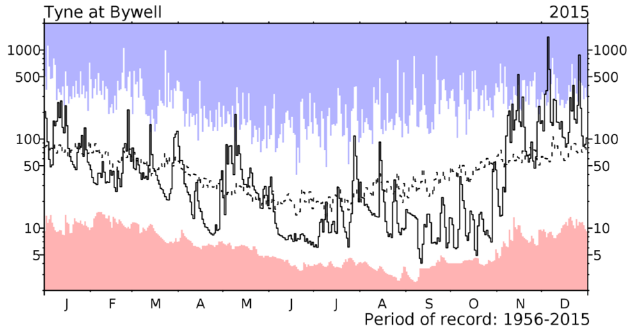


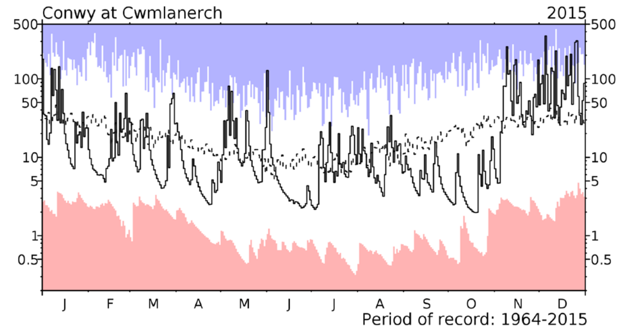


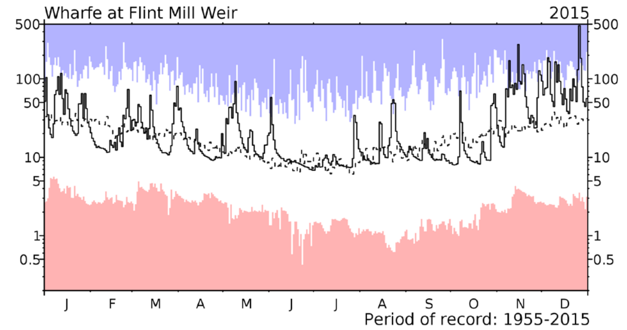


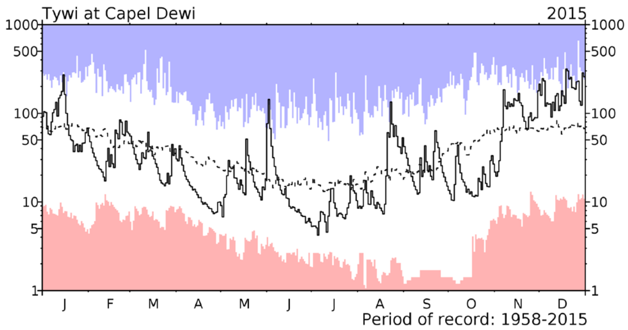


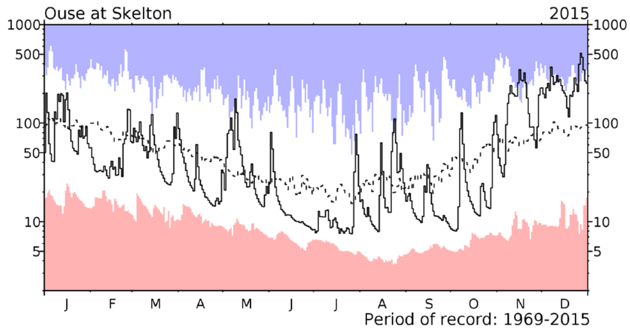




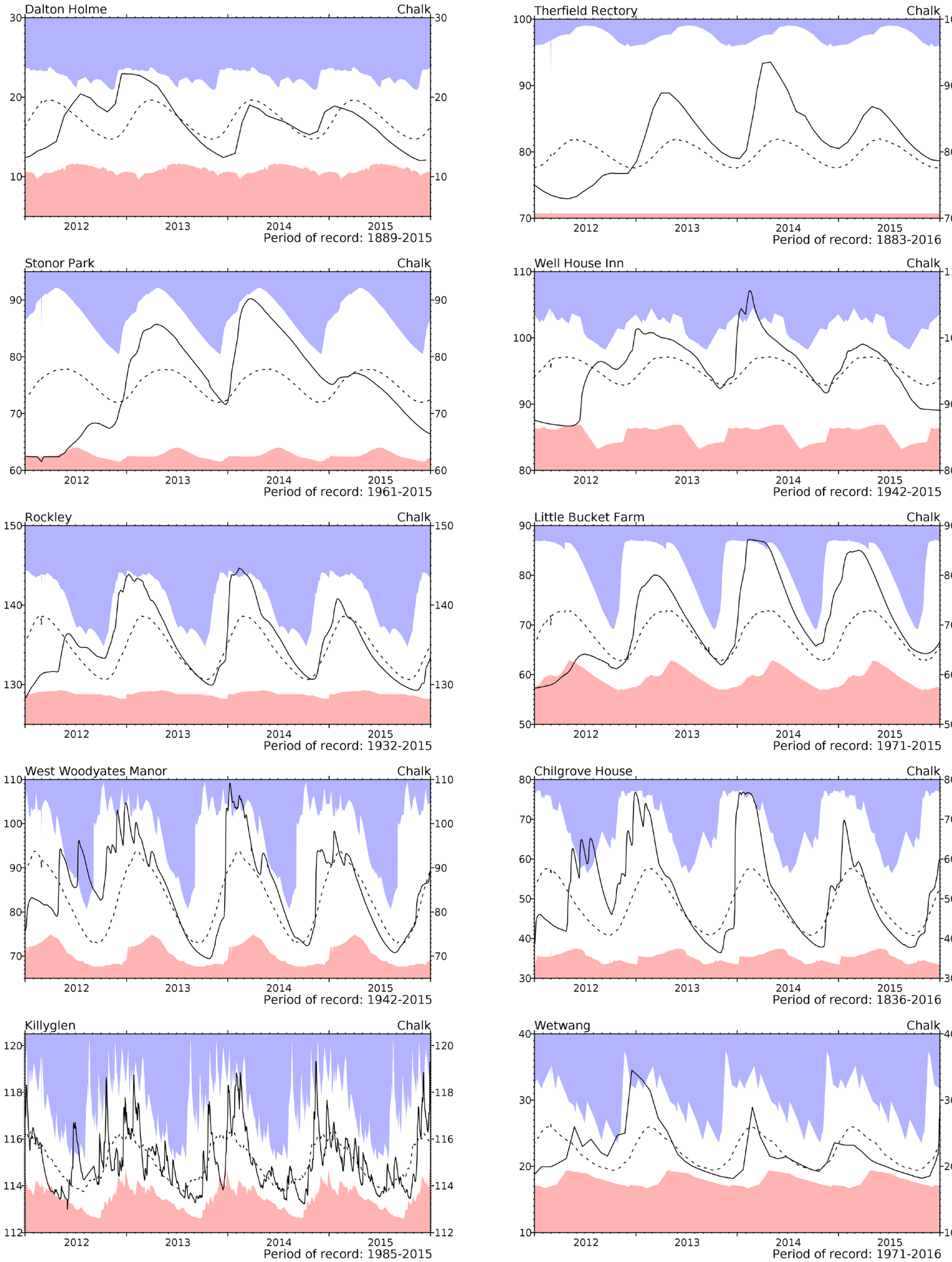






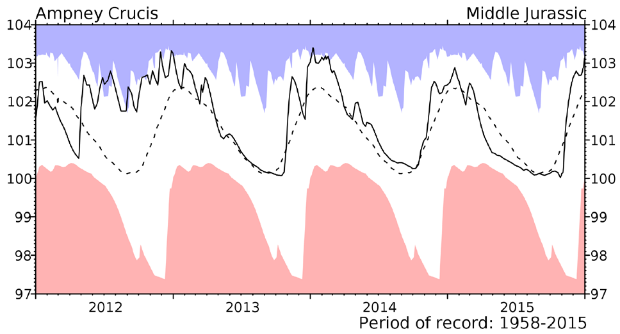


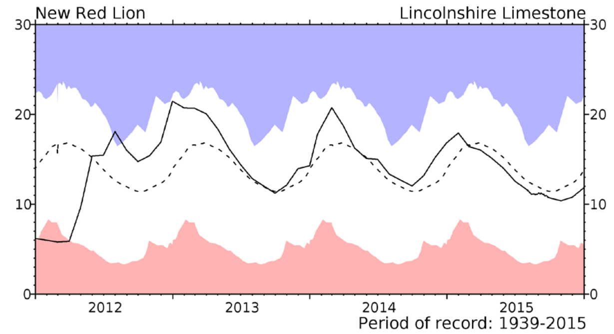
Groundwater . . . Groundwater

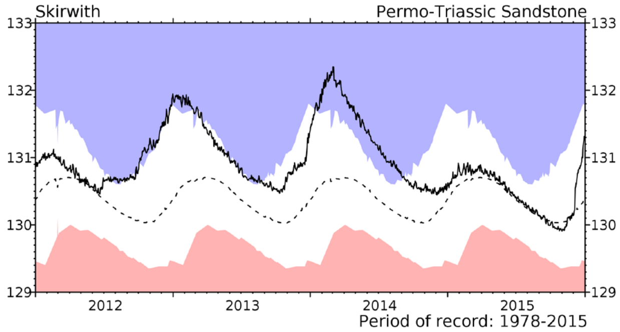


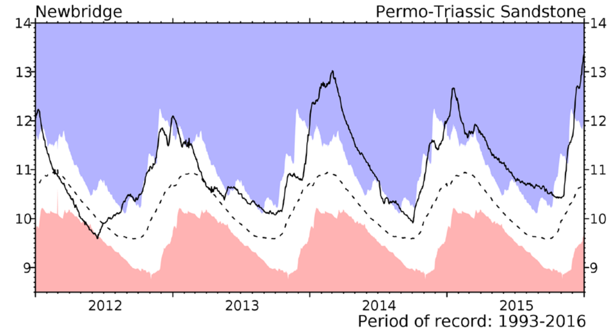
Groundwater levels normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined below overlying impermeable strata. The monthly mean and the highest and lowest levels recorded for each month are displayed in a similar style to the river flow hydrographs. 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. The latest recorded levels are listed overleaf.

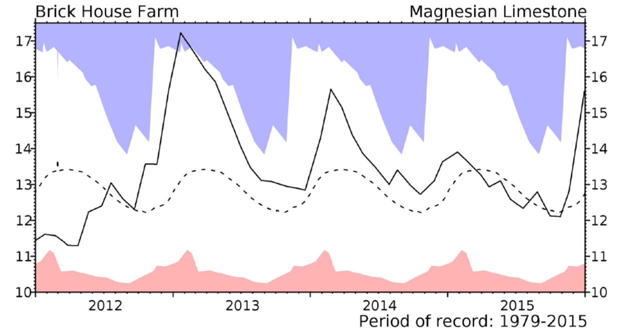
Groundwater ... Groundwater

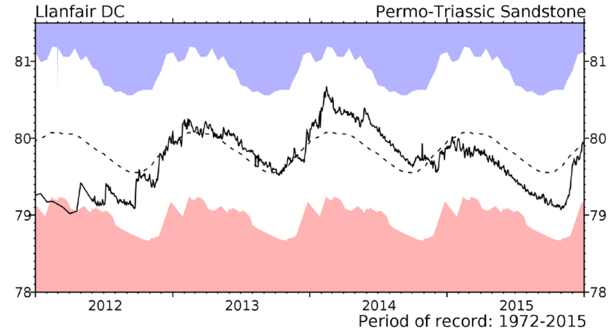


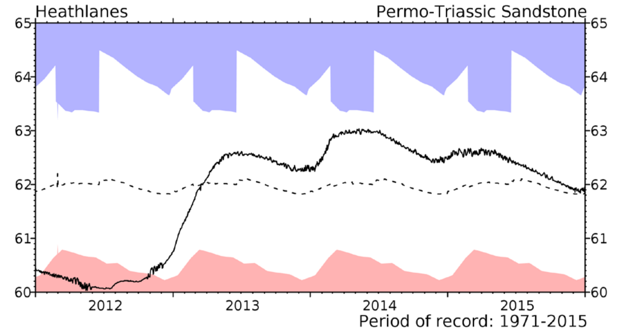


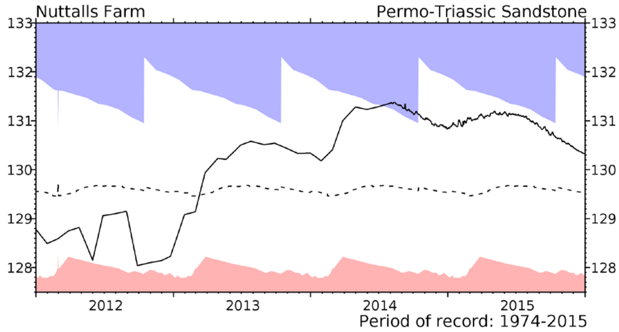


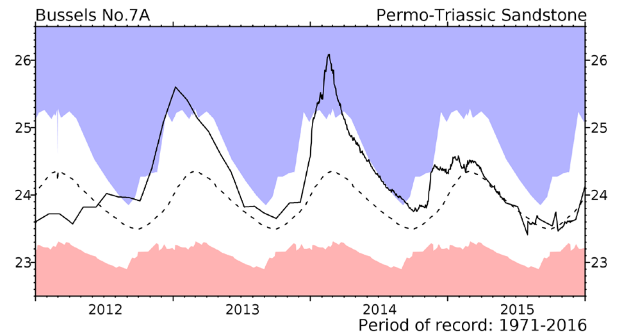


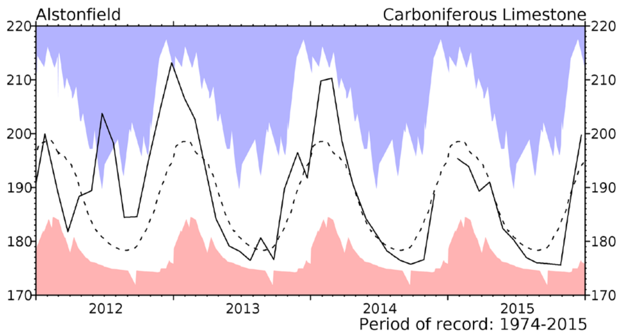










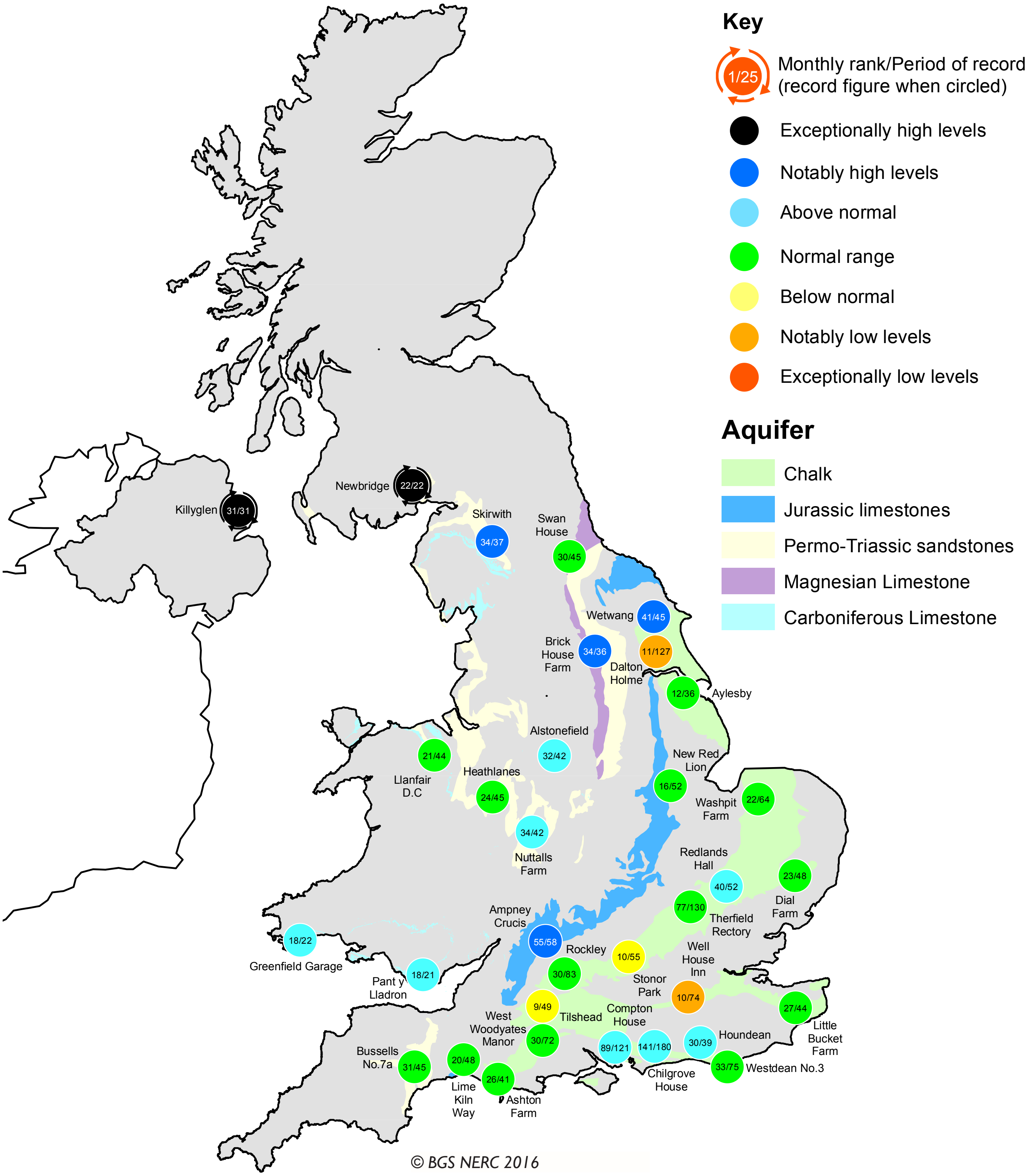


Groundwater levels December 2015 / January 2016

Borehole	Level	Date	Dec av.	Borehole	Level	Date	Dec av.	Borehole	Level	Date	Dec av.
Dalton Holme	12.07	15/12	15.59	Chilgrove House	64.00	05/01	51.91	Brick House Farm	15.58	30/12	12.58
Therfield Rectory	78.60	04/01	77.75	Killyglen (NI)	118.87	31/12	116.02	Llanfair DC	79.93	31/12	79.86
Stonor Park	66.43	31/12	72.21	Wetwang	29.68	04/01	21.81	Heathlanes	61.95	31/12	61.84
Tilshead	80.34	31/12	86.62	Ampney Crucis	103.13	31/12	101.99	Nuttalls Farm	130.33	31/12	129.59
Rockley	133.34	31/12	133.91	New Red Lion	11.81	31/12	13.18	Bussells No.7a	24.23	06/01	23.86
Well House Inn	89.09	31/12	93.53	Skirwith	131.25	31/12	130.38	Alstonefield	199.71	22/12	193.28
West Woodyates	89.31	31/12	87.07	Newbridge	13.43	03/01	10.70				

Levels in metres above Ordnance Datum

Groundwater…Groundwater

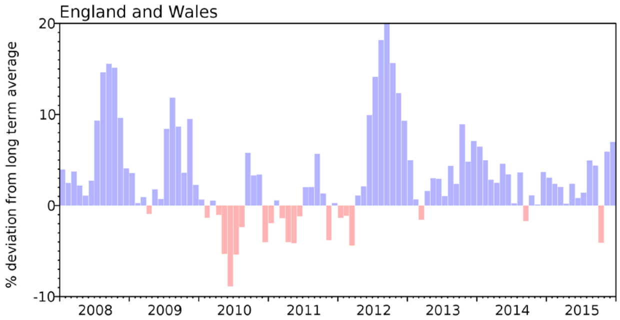


Groundwater levels - December 2015

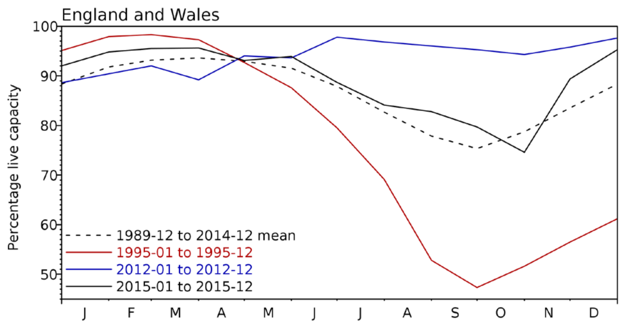
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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)	2015 Oct	2015 Nov	2015 Dec	Dec Anom.	Min Dec	Year* of min	2014 Dec	Diff 15-14
North West	N Command Zone	•	124929	50	84	100	13	51	1995	93	7
	Vyrnwy		55146	75	96	100	8	35	1995	99	1
Northumbrian	Teesdale	•	87936	68	94	100	11	41	1995	99	1
	Kielder		(199175)	81	98	97	6	70	1989	98	-1
Severn-Trent	Clywedog		44922	80	87	97	13	54	1995	86	11
	Derwent Valley	•	39525	50	81	100	11	10	1995	96	4
Yorkshire	Washburn	•	22035	69	93	96	11	23	1995	87	10
	Bradford Supply	•	41407	59	87	100	10	22	1995	96	4
Anglian	Grafham		(55490)	96	86	86	2	57	1997	70	16
	Rutland		(116580)	81	79	87	5	60	1990	83	4
Thames	London	•	202828	81	90	96	9	60	1990	94	2
	Farmoor	•	13822	93	89	78	-12	71	1990	89	-10
Southern	Bewl		28170	59	62	70	-3	34	2005	73	-3
	Ardingly		4685	57	68	91	6	30	2011	100	-9
Wessex	Clatworthy		5364	61	98	100	9	54	2003	100	0
	Bristol	•	(38666)	66	75	92	14	40	1990	78	14
South West	Colliford		28540	77	83	92	14	46	1995	79	13
	Roadford		34500	80	85	96	18	20	1989	82	14
	Wimbleball		21320	65	74	92	9	46	1995	83	9
	Stithians		4967	64	74	98	21	33	2001	57	41
Welsh	Celyn & Brenig	•	131155	79	98	100	7	54	1995	96	5
	Brianne		62140	96	100	100	3	76	1995	98	2
	Big Five	•	69762	76	79	82	-8	67	1995	93	-11
	Elan Valley	•	99106	68	100	100	3	56	1995	100	0
Scotland(E)	Edinburgh/Mid-Lothian	•	96518	68	86	100	9	60	1998	83	17
	East Lothian	•	9374	83	100	100	4	48	1989	100	0
Scotland(W)	Loch Katrine	•	110326	80	98	99	9	75	2007	96	3
	Daer		22412	83	99	100	3	83	1995	99	1
	Loch Thom	•	10798	100	100	100	3	80	2007	100	0
Northern Ireland	Total+	•	56800	87	96	99	12	61	2001	92	7
	Silent Valley	•	20634	89	98	100	15	39	2001	85	15

( ) 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.

Location map…Location map

NHMP

The National Hydrological Monitoring Programme (NHMP) was started in 1988 and is undertaken jointly by the Centre for Ecology & Hydrology (CEH) 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 CEH) and National Groundwater Level Archive (NGLA; maintained by BGS), including rainfall, river flows, borehole levels, and reservoir stocks.

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 Rivers Agency 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 http://www.metoffice.gov.uk/climate/uk/about/methods

Long-term averages are based on the period 1971-2000 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: 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

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