# Hydrological Summary *for the United Kingdom*

June 2016

## General

After the first week, June was a month dominated by unsettled conditions with localised thundery showers bringing substantial rainfall. For the UK as a whole, rainfall was above average, particularly so in parts of south-east England, the Midlands and eastern Scotland. In contrast, below average rainfall was mainly confined to western Scotland. In response to the wet June, soil moisture deficits decreased and were below average in the vast majority of regions in the UK; June deficits were the second lowest (behind 2012) for the Chalk outcrop, in a series from 1961. Average river flows for June were generally in the normal range or above, with below normal flows confined to some north-western catchments. Flows were notably high, and in some catchments exceptionally so, across much of the English Lowlands and in parts of north-east Scotland. Groundwater levels followed their seasonal recessions at almost all index sites, but generally remained in the normal range or above. Despite the above average rainfall, stocks in the majority of reservoirs fell during June, with large decreases in some western impoundments. However, for England and Wales overall reservoir stocks remain slightly above average. With normal to above normal groundwater levels across the main aquifers and healthy reservoir stocks, the water resources outlook for the rest of the summer remains healthy.

## Rainfall

June started relatively dry and settled, but showers and thunderstorms occurred from the 5th and dominated the rest of June, bringing some intense rainfall (e.g. 40mm recorded in one hour at Kenley (London) on the 7th). In a period from the 11th to the 16th, convective downpours brought significant rainfall around the UK with 39mm at Wattisham (Suffolk) on the 11th, 62mm at Aboyne (Scotland) on the 15th and 50mm at Winterbourne (Midlands) on the 16th; notable sub-daily falls were also recorded, with 33mm in thirty minutes recorded at Wallingford (Oxfordshire) on the 16th. Associated surface water flooding caused a wide range of impacts: schools, roads and a hospital were closed in Birmingham on the 14th, and on the 16th cars were submerged in London while there were transport delays in Sheffield and north Wales. On the 23rd, heavy rain and thunderstorms (with 44mm rainfall in six hours at Farnborough, leading to a 54mm daily total) caused significant disruption in south-east England; trains were delayed at London Waterloo due to lightning strikes and some polling stations for the EU referendum had to be relocated due to surface water flooding. At the national scale, June rainfall totals were above average (147%) and several regions recorded more than 150%. As a whole, north-east Scotland received 196% of average, with >200% across a large swathe of Aberdeenshire. Due to the localised nature of the rainfall, parts of East Anglia, the Midlands, Wales and Northern Ireland also recorded >200% of average. Despite some rainfall deficiencies in May, rainfall for May-June was above average across most of the UK, with below average rainfall confined to the England-Scotland border, parts of north-east England and the far north of Scotland.

## River flows

With settled conditions continuing from late May into early June, recessions dominated river flows in the majority of catchments in the first week. There were modest interruptions to the recessions on the 7th, but many continued to mid-month. Flows on some rivers approached their seasonal minima and new daily minimum flows were recorded on the Eden and Bervie for ten and thirteen consecutive days, respectively. By contrast, on the 15th new June maximum peak flows were recorded on the Don and Dee in north-east Scotland (in records since 1969 and 1972, respectively). Further rainfall in the second half of the month triggered flood alerts and increased river flows, although there were few reported instances of fluvial flooding. New maximum June peak flows were registered on the 23rd on the Colne (in a series from 1960) and on the Stringside on the 26th (in a series from 1966). In the same catchments, new daily maximum flows were also recorded for more than eight consecutive days, demonstrating the prolonged nature of the rainfall in parts of the south-east. Average river flows for June were generally in the normal range or above in England, Wales and eastern Scotland, with notably high flows in many catchments across the English Lowlands. Flows were exceptionally high across East Anglia – the Colne recorded five times the average flow for June, exceeding its previous record by a wide margin (in a series from 1960). In contrast, flows in western Scotland and northern England were low and the Eden recorded its second lowest June average flow (in a series from 1968). For May-June, average river flows show a similar spatial pattern to June, although some larger deficiencies are evident in south-west England, northern England and Northern Ireland – all areas that received below average rainfall in May.

## Groundwater

Soil moisture deficits decreased in June, a reversal of the normal pattern seen at the start of summer, and are substantially below average across much of the UK as a result of the above average rainfall. In the Chalk, levels in the index boreholes fell during June and were generally in the normal range or above, with the exception of Dial Farm where levels continued to rise slightly but remain below the seasonal average. In Yorkshire and central southern England, levels fell more rapidly than is typical for June, dropping from above normal to within the normal range. In the Permo-Triassic sandstones, levels generally fell or were stable, however they continued to rise at Heathlanes and Nuttalls Farm. Levels were in the normal range or above for time of year, substantially so in south-west Scotland where a record June level was recorded at Newbridge. In the Jurassic limestones, levels fell and remained in the normal range at New Red Lion, and above normal at Ampney Crucis. Levels remained above average in the Magnesian Limestone, and were exceptionally high at Brick House Farm. In the Carboniferous Limestone, levels fell to below normal in south-west Wales, and decreased but remained in the normal range in the Peak District. In contrast, levels rose overall in south-east Wales and were notably high for the time of year.

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.

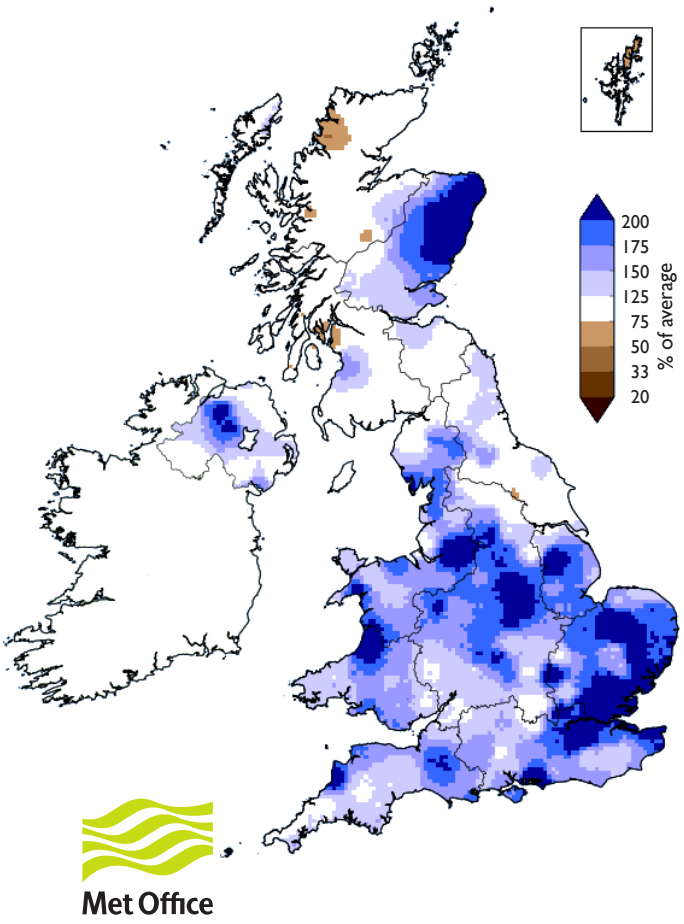
| Area | Rainfall | Jun 2016 | May16 – Jun16 | RP | Jan16 – Jun16 | RP | Oct15– Jun16 | RP | Jul15 – Jun16 | RP |
|---|---|---|---|---|---|---|---|---|---|---|
| United Kingdom | mm | 102 | 166 | | 634 | | 1098 | | 1363 | |
| | % | 147 | 125 | 5-10 | 129 | 50-80 | 132 | >>100 | 126 | >100 |
| England | mm | 101 | 153 | | 506 | | 818 | | 1041 | |
| | % | 163 | 131 | 5-10 | 134 | >100 | 131 | 70-100 | 128 | 25-40 |
| Scotland | mm | 95 | 174 | | 794 | | 1456 | | 1775 | |
| | % | 121 | 115 | 2-5 | 123 | 10-20 | 130 | >100 | 123 | 50-80 |
| Wales | mm | 140 | 228 | | 854 | | 1507 | | 1822 | |
| | % | 170 | 144 | 8-12 | 139 | >100 | 141 | >>100 | 134 | >100 |
| Northern Ireland | mm | 97 | 158 | | 600 | | 1080 | | 1366 | |
| | % | 136 | 113 | 2-5 | 118 | 10-20 | 128 | >>100 | 123 | >100 |
| England & Wales | mm | 106 | 163 | | 554 | | 913 | | 1149 | |
| | % | 164 | 134 | 5-10 | 135 | >100 | 133 | >100 | 129 | 40-60 |
| North West | mm | 130 | 177 | | 701 | | 1367 | | 1619 | |
| | % | 167 | 123 | 2-5 | 135 | 50-80 | 153 | >>100 | 139 | >100 |
| Northumbrian | mm | 79 | 111 | | 497 | | 951 | | 1173 | |
| | % | 130 | 94 | 2-5 | 128 | 15-25 | 151 | >>100 | 142 | >100 |
| Severn-Trent | mm | 110 | 164 | | 489 | | 749 | | 933 | |
| | % | 177 | 142 | 8-12 | 136 | >100 | 131 | 25-40 | 124 | 10-15 |
| Yorkshire | mm | 82 | 129 | | 512 | | 910 | | 1123 | |
| | % | 130 | 109 | 2-5 | 134 | 20-35 | 147 | >>100 | 139 | 40-60 |
| Anglian | mm | 102 | 151 | | 385 | | 552 | | 743 | |
| | % | 188 | 150 | 15-25 | 136 | 40-60 | 123 | 10-15 | 124 | 8-12 |
| Thames | mm | 95 | 160 | | 461 | | 659 | | 857 | |
| | % | 168 | 146 | 10-20 | 140 | >100 | 124 | 8-12 | 124 | 8-12 |
| Southern | mm | 96 | 155 | | 491 | | 717 | | 969 | |
| | % | 173 | 147 | 10-20 | 139 | >100 | 119 | 5-10 | 126 | 8-12 |
| Wessex | mm | 96 | 168 | | 546 | | 795 | | 1047 | |
| | % | 159 | 144 | 8-12 | 136 | >100 | 119 | 5-10 | 122 | 8-12 |
| South West | mm | 105 | 155 | | 661 | | 1071 | | 1413 | |
| | % | 145 | 110 | 2-5 | 119 | 8-12 | 112 | 2-5 | 118 | 5-10 |
| Welsh | mm | 134 | 222 | | 822 | | 1438 | | 1745 | |
| | % | 168 | 143 | 5-10 | 138 | >100 | 140 | >100 | 133 | >100 |
| Highland | mm | 87 | 189 | | 860 | | 1577 | | 1902 | |
| | % | 97 | 113 | 2-5 | 111 | 2-5 | 117 | 10-15 | 110 | 5-10 |
| North East | mm | 129 | 168 | | 632 | | 994 | | 1265 | |
| | % | 196 | 130 | 2-5 | 146 | >>100 | 138 | >100 | 134 | 30-50 |
| Tay | mm | 115 | 176 | | 759 | | 1442 | | 1780 | |
| | % | 167 | 124 | 2-5 | 128 | 10-20 | 145 | >100 | 141 | >100 |
| Forth | mm | 92 | 151 | | 659 | | 1257 | | 1535 | |
| | % | 133 | 111 | 2-5 | 127 | 10-20 | 144 | >>100 | 136 | >100 |
| Tweed | mm | 73 | 119 | | 606 | | 1145 | | 1394 | |
| | % | 112 | 91 | 2-5 | 137 | 25-40 | 157 | >>100 | 147 | >>100 |
| Solway | mm | 86 | 157 | | 853 | | 1605 | | 1938 | |
| | % | 109 | 102 | 2-5 | 136 | 80-120 | 148 | >>100 | 139 | >>100 |
| Clyde | mm | 94 | 197 | | 942 | | 1780 | | 2150 | |
| | % | 105 | 117 | 2-5 | 123 | 10-15 | 134 | >100 | 124 | 40-60 |

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

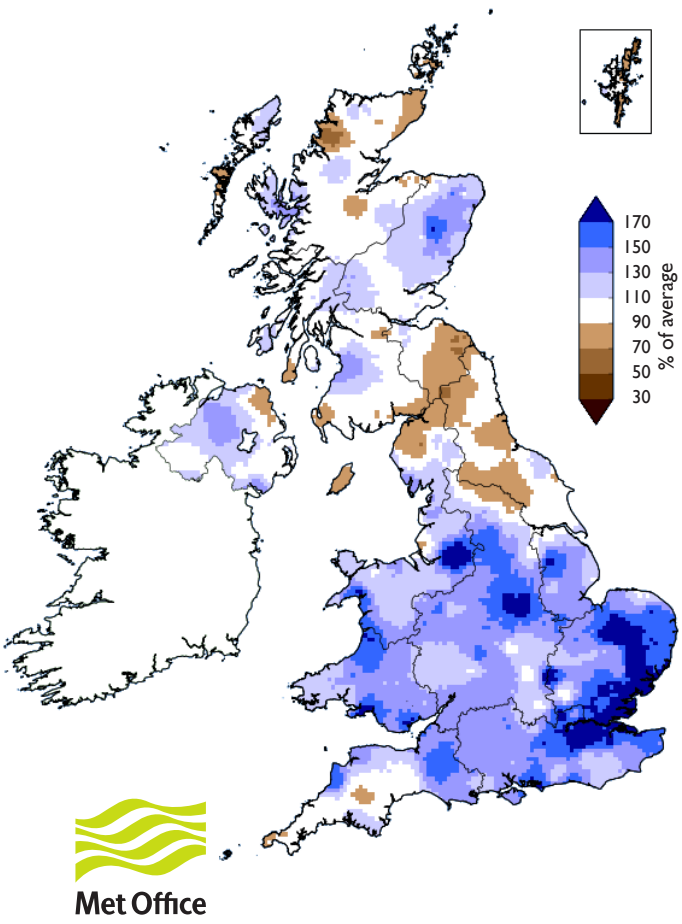
**Important note:** Figures in the above table may be quoted provided their source is acknowledged (see page 12). Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect 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 2016 (inclusive) are provisional.

# *Rainfall . . . Rainfall . . .*

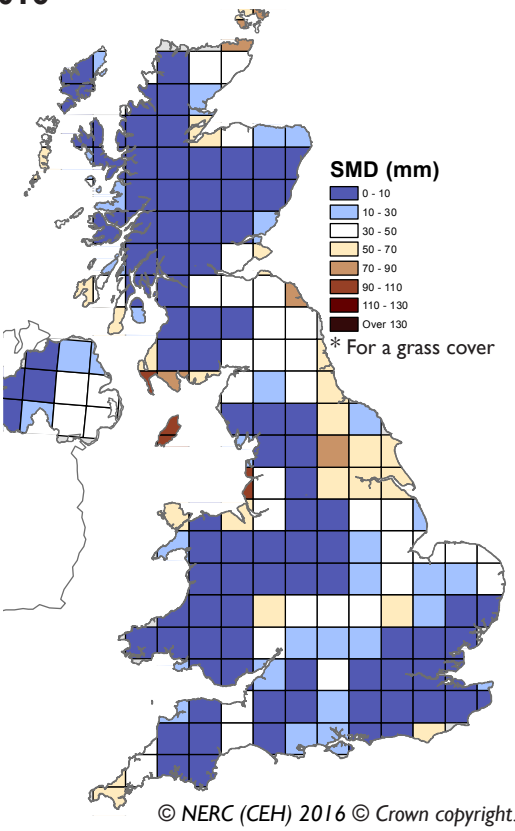
**June 2016 rainfall**
**as % of 1971-2000 average**




**May 2016 - June 2016 rainfall**
**as % of 1971-2000 average**




**MORECS Soil Moisture Deficits***
**June 2016**





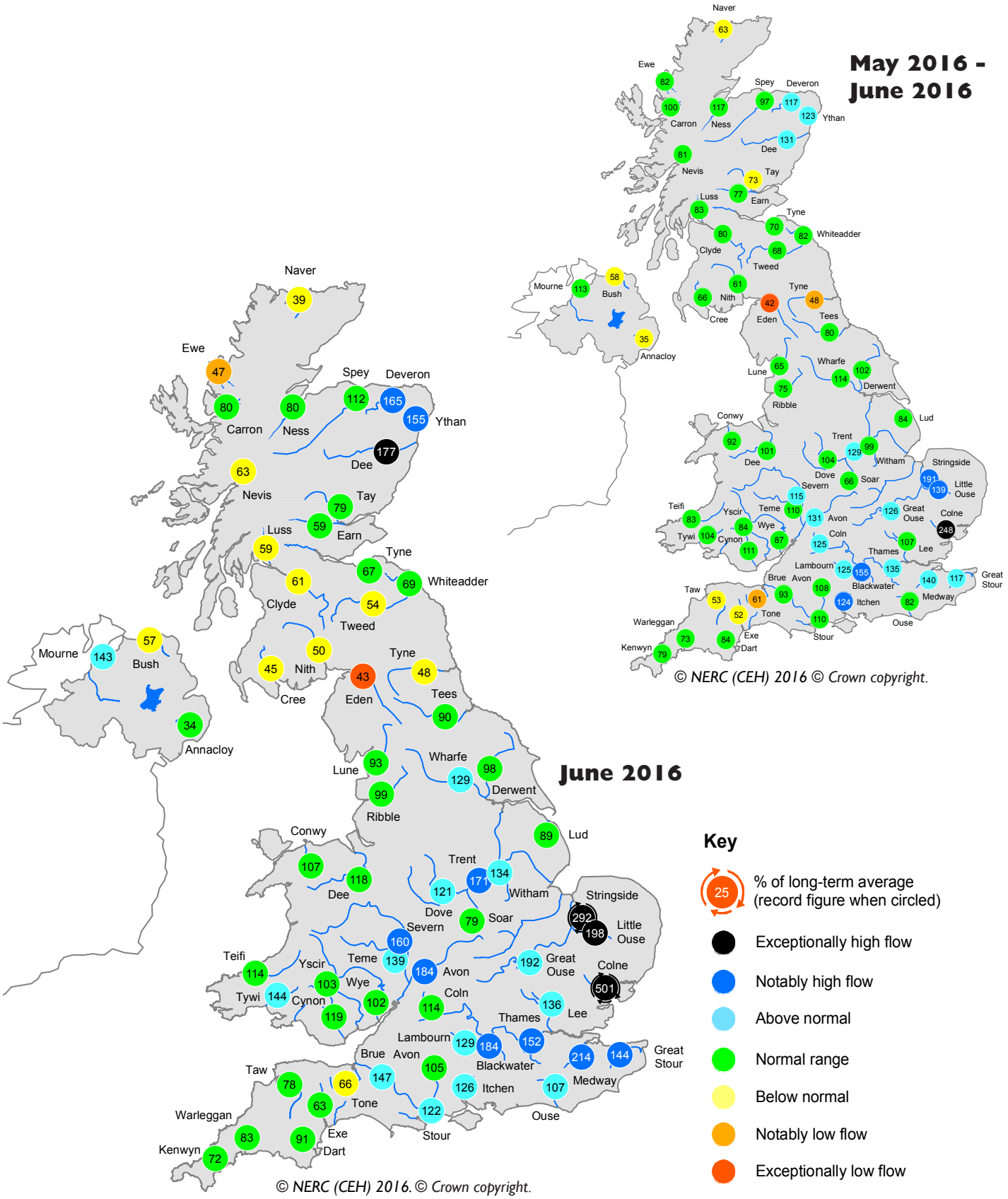

**Met Office**
**3-month outlook**
**Updated: June 2016**

For July-August-September, the forecast for UK precipitation suggests that the chances of above- and below-average rainfall are fairly balanced. The probability that UK precipitation for July-August-September 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 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.

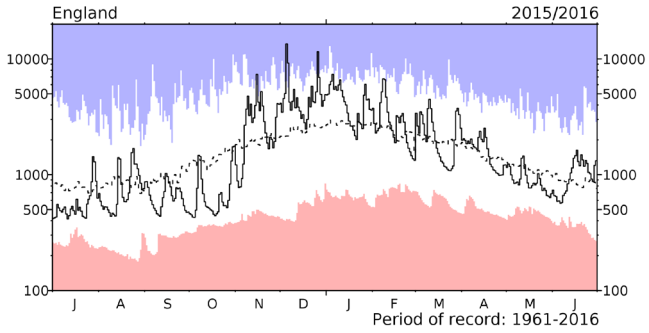
# *River flow . . . River flow . . .*

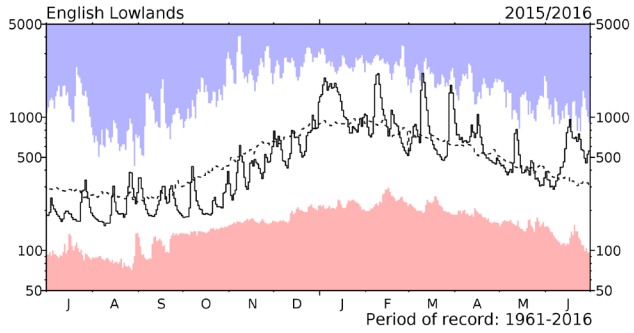


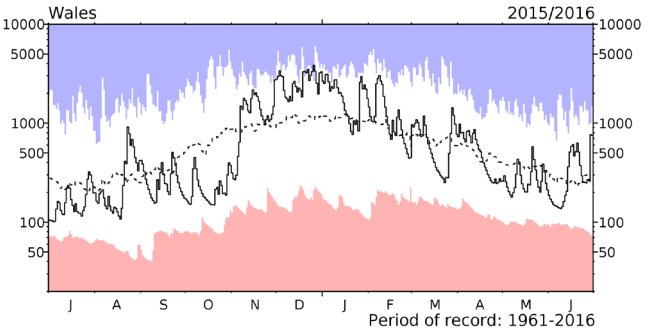

## River flows

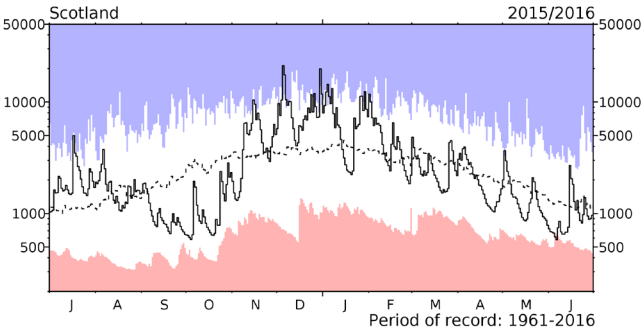
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much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

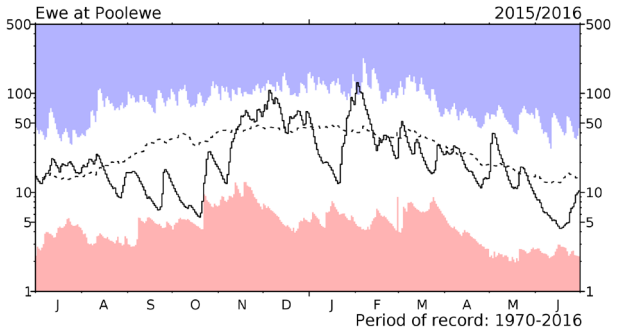
# River flow . . . River flow . . .

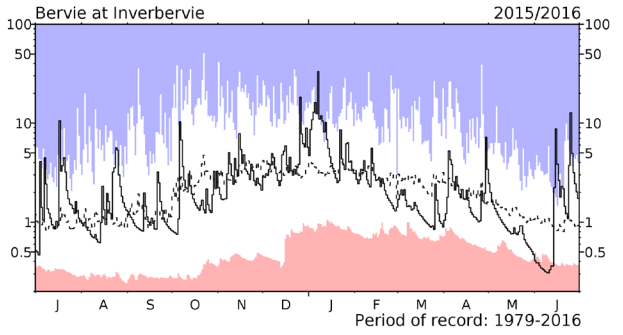


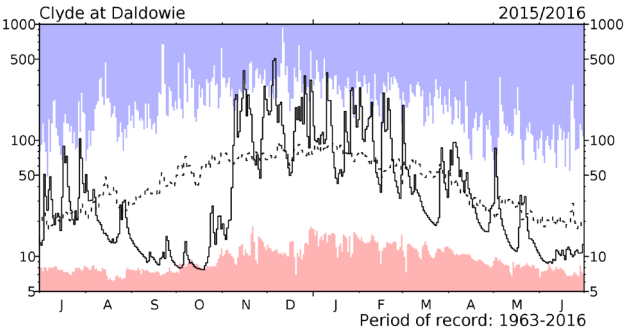



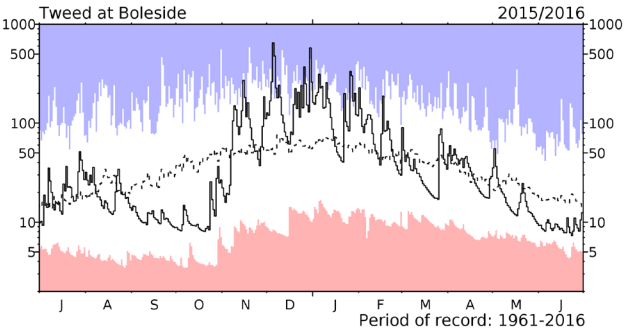



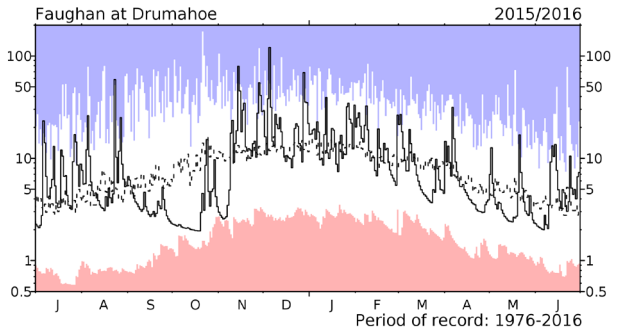



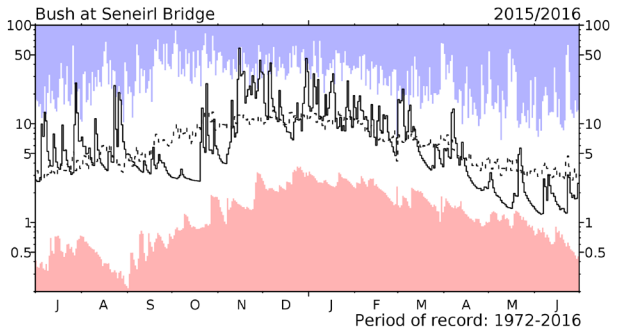



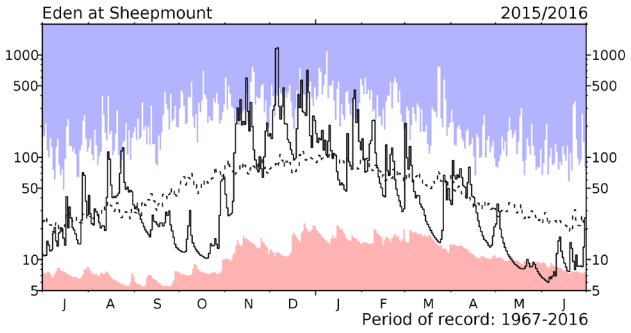



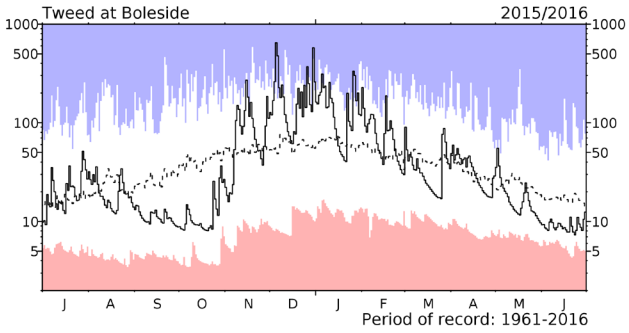



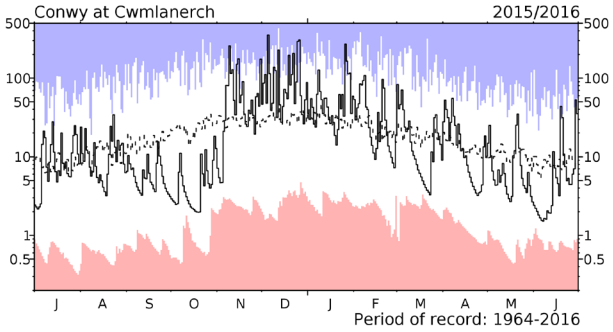

## River flow hydrographs

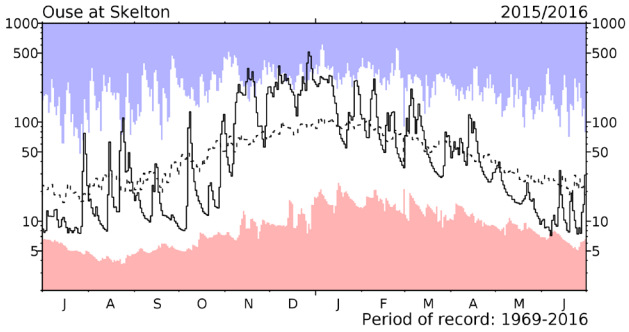
The river flow hydrographs show the daily mean flows together with the maximum and minimum daily flows prior to July 2015 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. Mean daily flows are shown as the dashed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

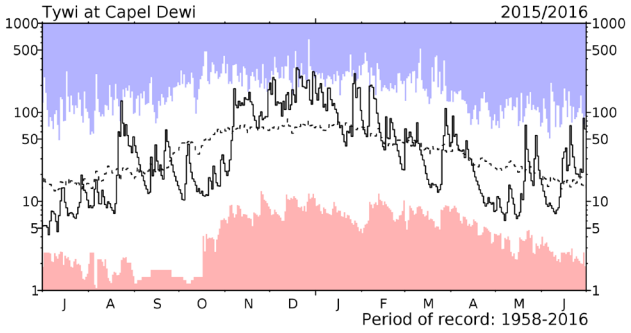
# River flow . . . River flow . . .

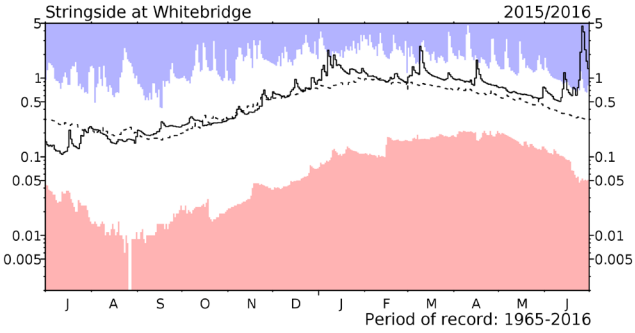


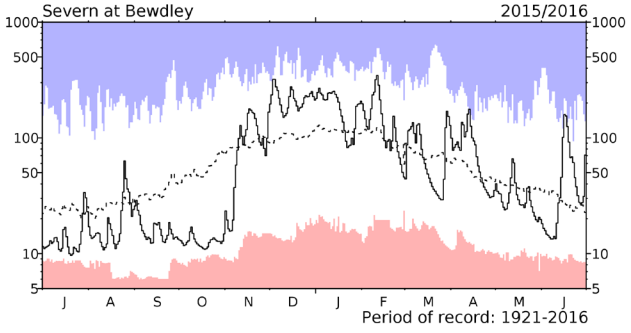



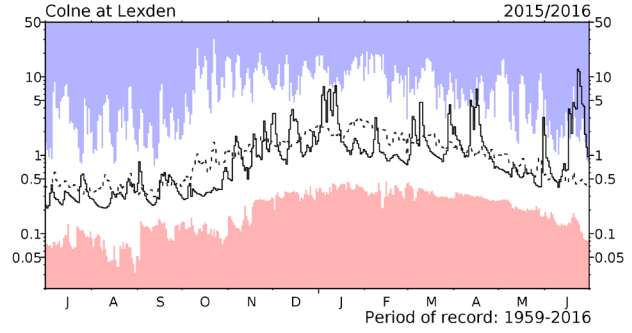



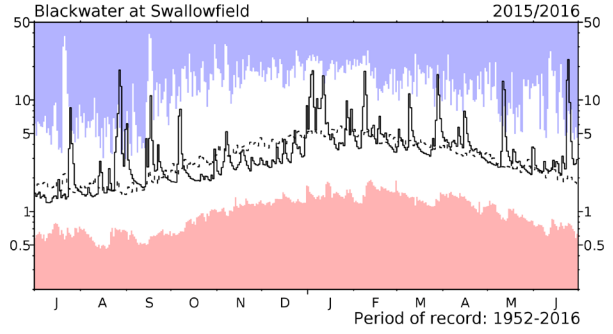



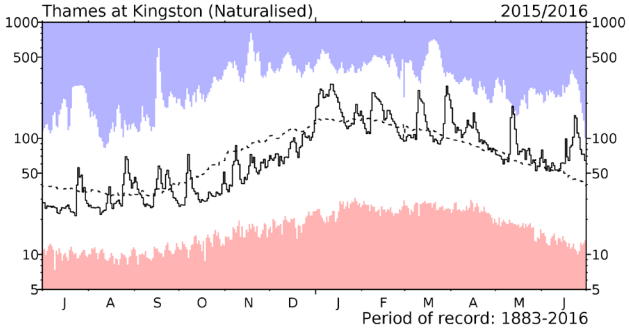



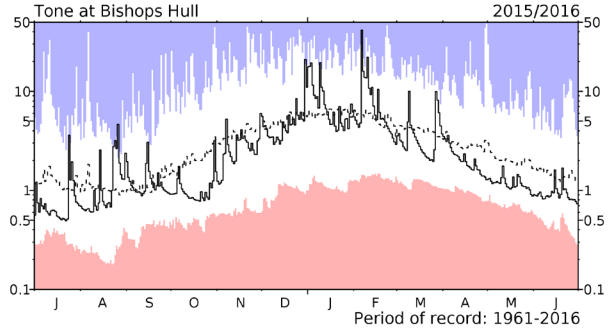



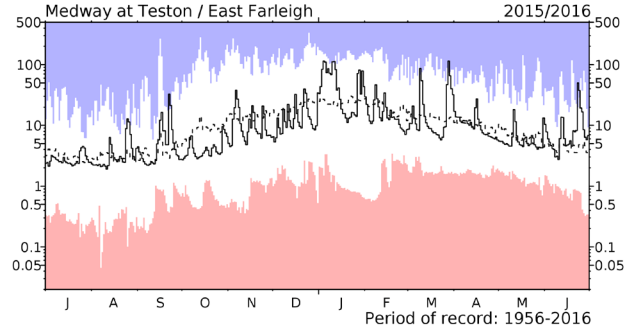



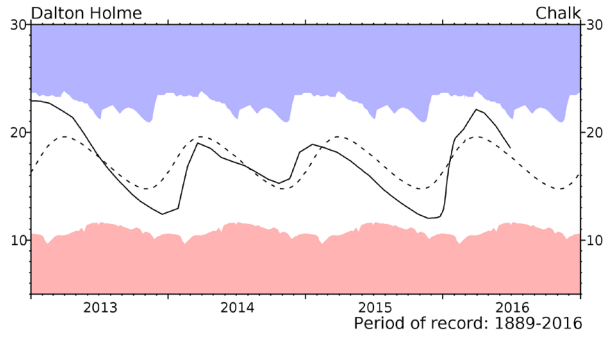



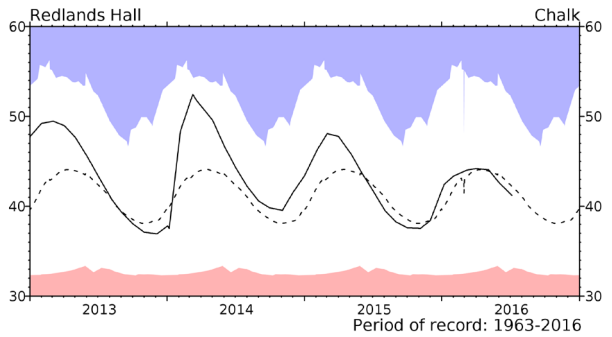



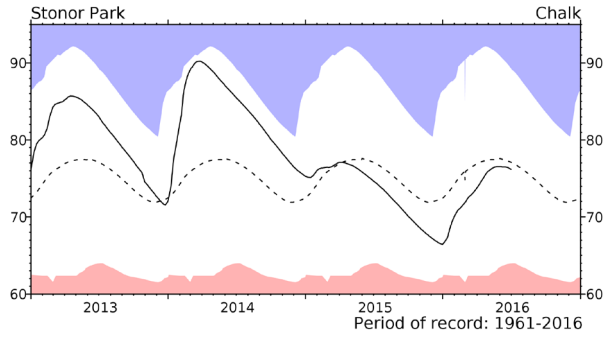



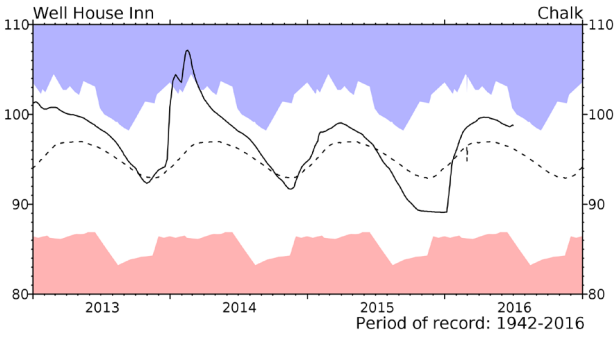



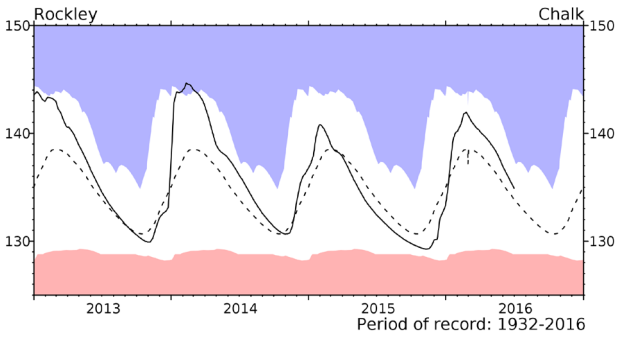
# Groundwater…Groundwater

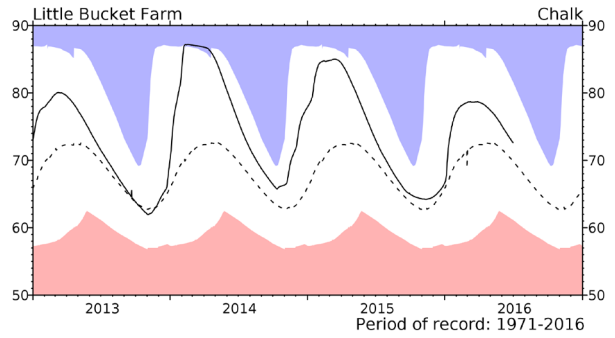


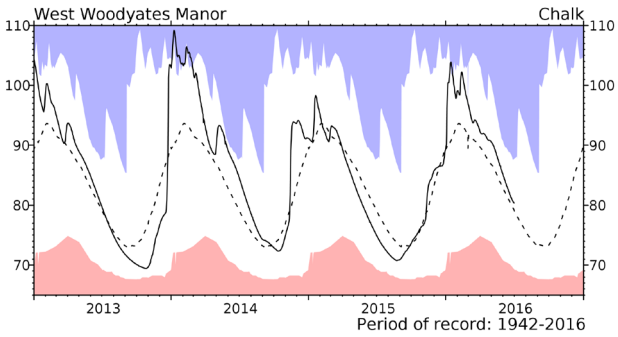



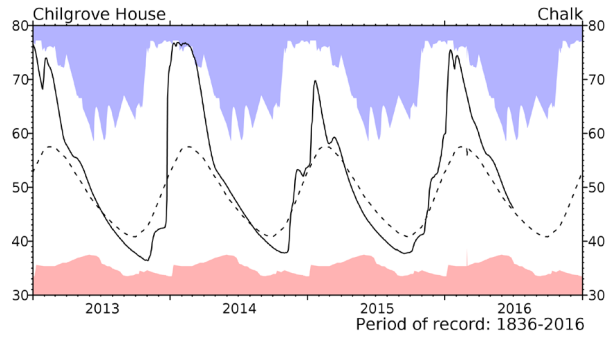



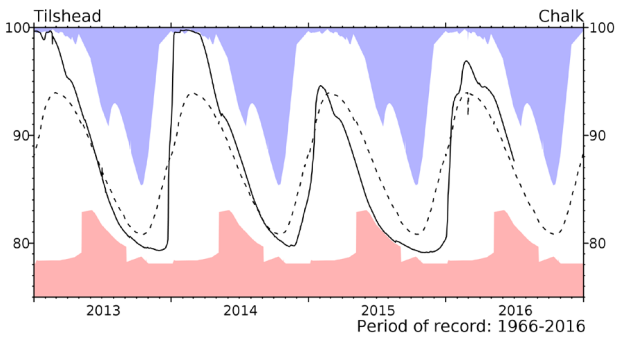



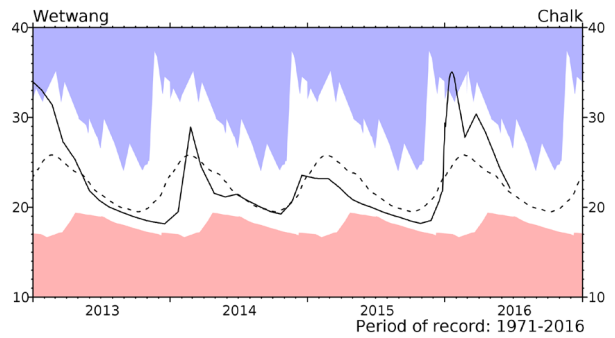



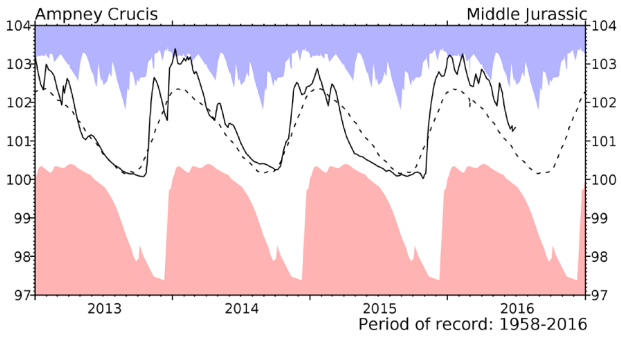



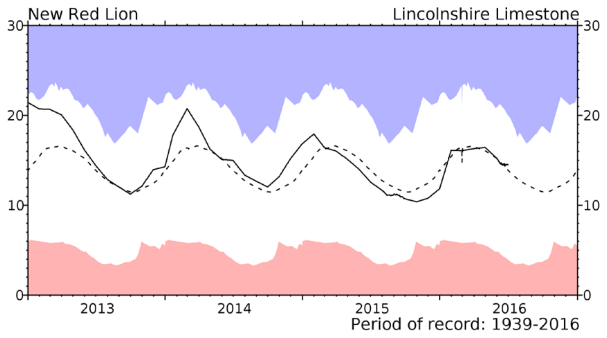



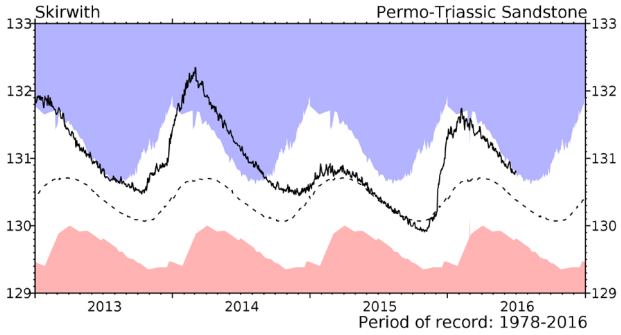



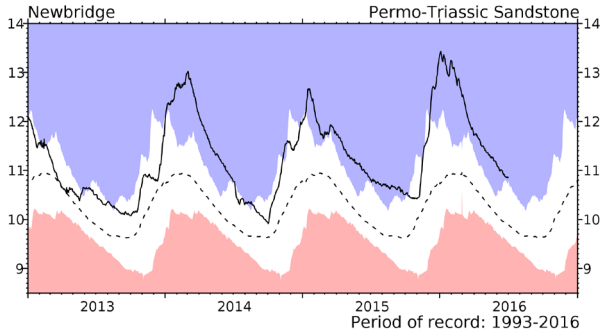

Groundwater levels normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined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

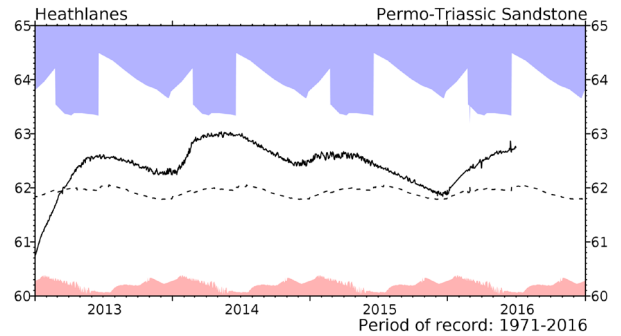
# Groundwater ... Groundwater

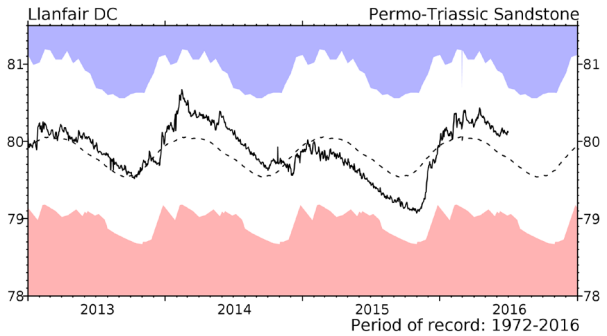


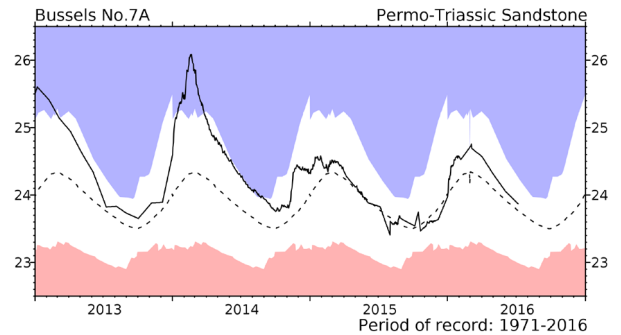



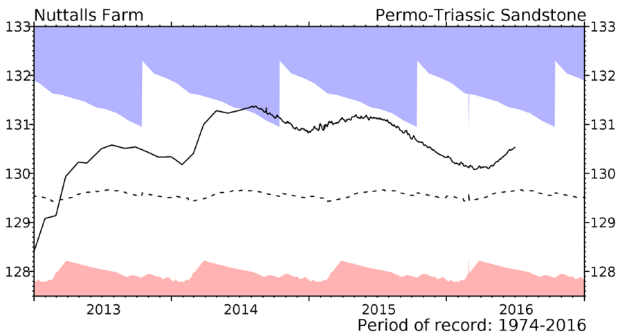



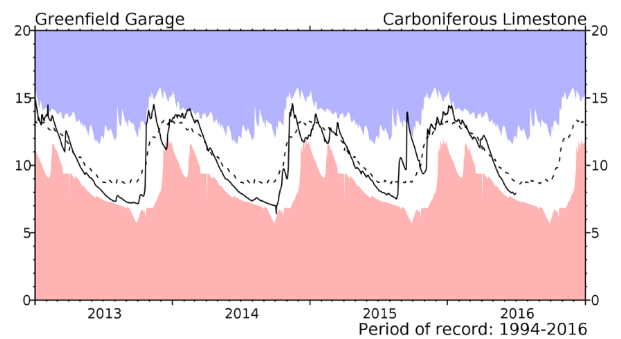



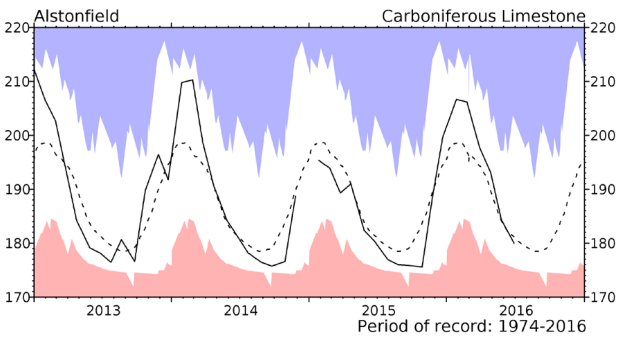



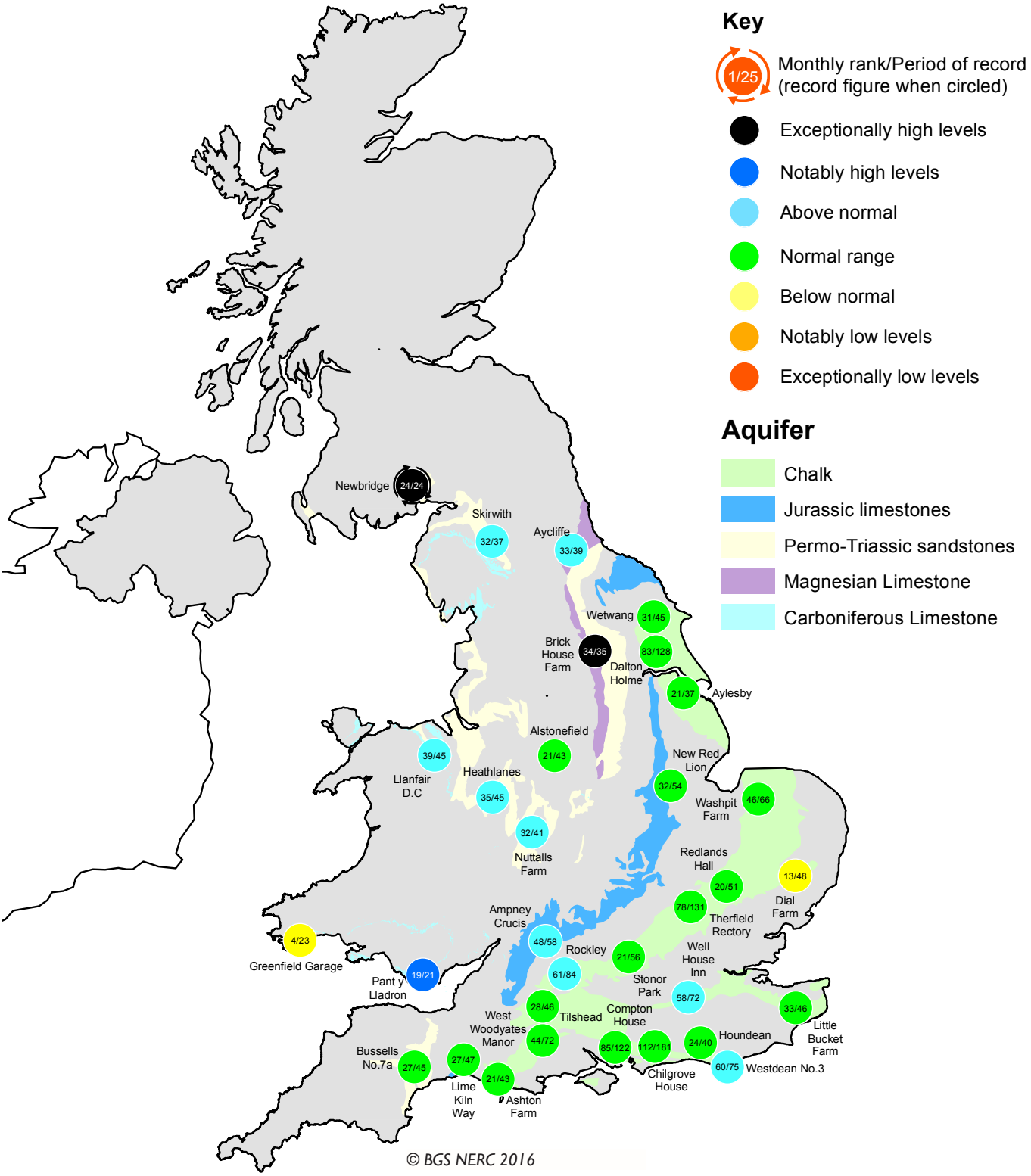




## Groundwater levels June / July 2016

| Borehole | Level | Date | Jun av. | Borehole | Level | Date | Jun av. | Borehole | Level | Date | Jun av. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dalton Holme | 18.55 | 28/06 | 18.08 | Chilgrove House | 46.05 | 30/06 | 46.10 | Aycliffe NRA2 | 82.36 | 23/06 | 80.49 |
| Therfield Rectory | 83.77 | 01/07 | 81.96 | Little Bucket Farm | 72.60 | 30/06 | 71.43 | Llanfair DC | 80.12 | 30/06 | 79.85 |
| Stonor Park | 76.18 | 30/06 | 77.61 | Wetwang | 22.10 | 22/06 | 21.69 | Heathlanes | 62.74 | 30/06 | 62.13 |
| Tilshead | 87.62 | 30/06 | 87.63 | Ampney Crucis | 101.35 | 29/06 | 100.86 | Nuttalls Farm | 130.53 | 30/06 | 129.73 |
| Rockley | 134.89 | 30/06 | 134.58 | New Red Lion | 14.48 | 30/06 | 14.34 | Bussells No.7a | 23.87 | 06/07 | 23.89 |
| Well House Inn | 98.78 | 30/06 | 96.42 | Skirwith | 130.79 | 30/06 | 130.54 | Alstonefield | 179.96 | 28/06 | 181.81 |
| West Woodyates | 80.36 | 30/06 | 81.01 | Newbridge | 10.85 | 30/06 | 10.09 | | | | |

*Levels in metres above Ordnance Datum*

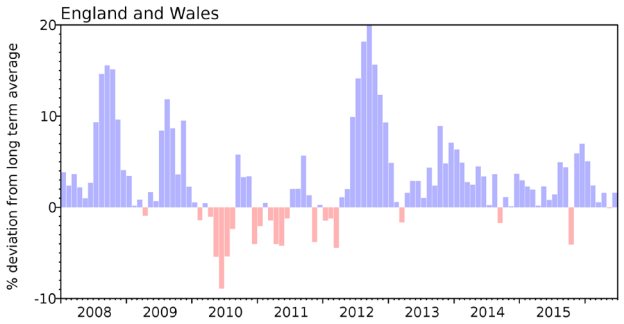



## Groundwater levels - June 2016

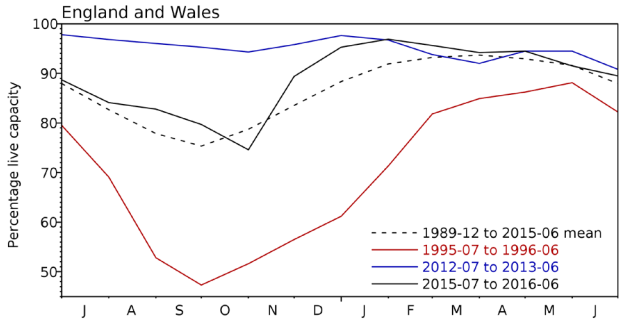
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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) | 2016 Apr | 2016 May | 2016 Jun | Jun Anom. | Min Jun | Year* of min | 2015 Jun | Diff 16-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| North West | N Command Zone | • | 124929 | 85 | 74 | 65 | -7 | 38 | 1984 | 81 | -15 |
| | Vyrnwy | | 55146 | 98 | 96 | 95 | 13 | 58 | 1984 | 91 | 4 |
| Northumbrian | Teesdale | • | 87936 | 91 | 80 | 74 | -7 | 58 | 1989 | 83 | -9 |
| | Kielder | | (199175) | 89 | 90 | 90 | -1 | 71 | 1989 | 90 | -1 |
| Severn-Trent | Clywedog | | 44922 | 99 | 100 | 100 | 8 | 32 | 1976 | 97 | 4 |
| | Derwent Valley | • | 39525 | 99 | 95 | 91 | 10 | 53 | 1996 | 90 | 1 |
| Yorkshire | Washburn | • | 22035 | 91 | 84 | 77 | -3 | 63 | 1995 | 74 | 4 |
| | Bradford Supply | • | 41407 | 93 | 82 | 76 | -3 | 54 | 1995 | 85 | -9 |
| Anglian | Grafham | | (55490) | 95 | 93 | 89 | -4 | 70 | 1997 | 95 | -6 |
| | Rutland | | (116580) | 93 | 94 | 95 | 6 | 75 | 1997 | 90 | 5 |
| Thames | London | • | 202828 | 97 | 97 | 98 | 6 | 85 | 1990 | 86 | 12 |
| | Farmoor | • | 13822 | 98 | 98 | 96 | -2 | 94 | 1995 | 95 | 1 |
| Southern | Bewl | | 28170 | 96 | 94 | 93 | 10 | 52 | 1990 | 84 | 10 |
| | Ardingly | | 4685 | 100 | 100 | 100 | 5 | 82 | 2005 | 89 | 11 |
| Wessex | Clatworthy | | 5364 | 90 | 79 | 76 | -6 | 61 | 1995 | 76 | 0 |
| | Bristol | • | (38666) | 99 | 94 | 89 | 6 | 64 | 1990 | 81 | 8 |
| South West | Colliford | | 28540 | 99 | 96 | 90 | 7 | 51 | 1997 | 85 | 4 |
| | Roadford | | 34500 | 93 | 89 | 90 | 8 | 49 | 1996 | 87 | 2 |
| | Wimbleball | | 21320 | 98 | 90 | 80 | -6 | 63 | 2011 | 87 | -7 |
| | Stithians | | 4967 | 99 | 91 | 81 | 1 | 53 | 1990 | 76 | 5 |
| Welsh | Celyn & Brenig | • | 131155 | 100 | 100 | 97 | 3 | 77 | 1996 | 99 | -2 |
| | Brianne | | 62140 | 99 | 97 | 100 | 7 | 76 | 1995 | 97 | 3 |
| | Big Five | • | 69762 | 94 | 95 | 92 | 7 | 61 | 1989 | 87 | 5 |
| | Elan Valley | • | 99106 | 99 | 93 | 93 | 5 | 68 | 1976 | 91 | 2 |
| Scotland(E) | Edinburgh/Mid-Lothian | • | 96518 | 98 | 94 | 86 | -1 | 54 | 1998 | 89 | -3 |
| | East Lothian | • | 9374 | 100 | 99 | 98 | 4 | 81 | 1992 | 98 | 0 |
| Scotland(W) | Loch Katrine | • | 110326 | 88 | 87 | 76 | -4 | 55 | 2010 | 85 | -9 |
| | Daer | | 22412 | 89 | 84 | 78 | -6 | 62 | 1994 | 88 | -10 |
| | Loch Thom | • | 10798 | 100 | 100 | 100 | 13 | 69 | 2000 | 100 | 0 |
| Northern Ireland | Total+ | • | 56800 | 93 | 86 | 79 | -3 | 61 | 2008 | 86 | -7 |
| | Silent Valley | • | 20634 | 94 | 87 | 79 | 0 | 54 | 1995 | 86 | -7 |

( ) 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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