

Storm Babet, 18 to 21 October 2023

Storm Babet brought exceptional rainfall to parts of eastern Scotland with 150 to 200mm falling in the wettest areas and the Met Office issuing two red warnings for rain. For the county of Angus - coinciding with this red warning area - 19 October 2023 was, by a wide margin, the wettest day on record in a series from 1891. Heavy, persistent and widespread rain also affected much of England, Wales and Northern Ireland from 18th to 20th, with 100mm falling fairly widely. This was the third-wettest independent 3-day period for England and Wales in a series from 1891, while the Midlands provisionally recorded its wettest 3-day period on record. This rain came on top of very wet weather earlier in October with some central and eastern parts of England and Scotland recording more than twice the October whole-month average rainfall in the first three weeks of the month.

Babet also brought some very strong winds, gusting at over 50Kt (58mph) across north-east England and much of Scotland. A blocking area of high pressure over Scandinavia prevented Babet clearing the UK eastwards into the North Sea and as a result these wind speeds were sustained for a prolonged period. The persistent heavy rain and strong wind resulted in atrocious weather conditions for a sustained period, with a gust of 67Kt (77mph) at Inverbervie (Kincardineshire) and winds gusting at over 100Kt (115mph) across Scotland's mountain summits.

Impacts

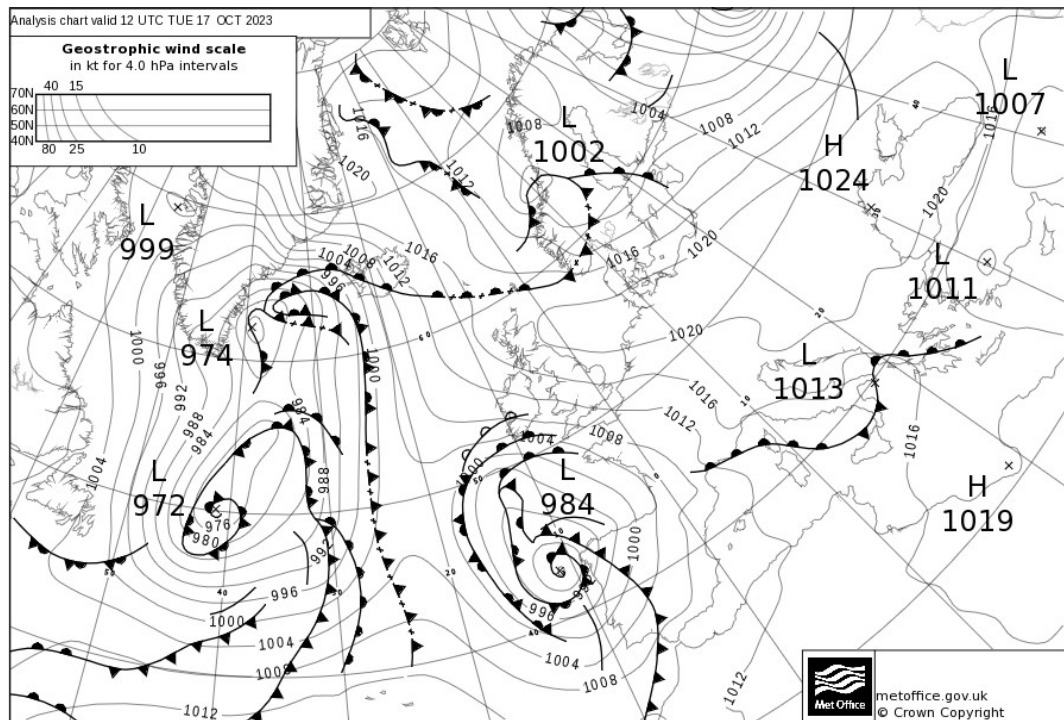
Storm Babet resulted in the most severe and widespread disruptive weather impacts of 2023 so far. Multiple severe flood warnings were issued by the Environment Agency (EA) and the Scottish Environment Protection Agency (SEPA). At least seven people were reported to have died as a result of the storm. In Scotland, hundreds of homes and businesses were flooded with the town of Brechin severely affected after defences were overtopped by the river South Esk. The main A90 trunk road was closed between Forfar and Brechin after storm Babet damaged a bridge, and schools across Angus were closed. Scottish farmers were reported to have lost crops, with some sheep also washed away by floodwater, and around 30,000 homes in northern Scotland lost power during the storm.

Over 1000 homes in England were also affected by flooding across Yorkshire, the East Midlands and the Humber area. In Chesterfield (Derbyshire), around 400 homes were flooded while 500 homes were evacuated in Retford (Nottinghamshire) and widespread flooding affected other areas such as the Stafford and Wrexham areas, while Derby's Museum of Making was flooded. In Suffolk, a major incident was declared due to flooding. Rail services on the East Coast were severely affected due to flooded lines and Kings Cross station in London was temporarily closed due to concerns with overcrowding. Other rail services in Scotland and northern England were cancelled or severely disrupted. Leeds Bradford airport closed after an aircraft skidded off the runway during the storm. 45 workers were airlifted off a North Sea drilling platform after it lost anchors during the storm. Sections of railings were destroyed at Sunderland's pier by large waves.

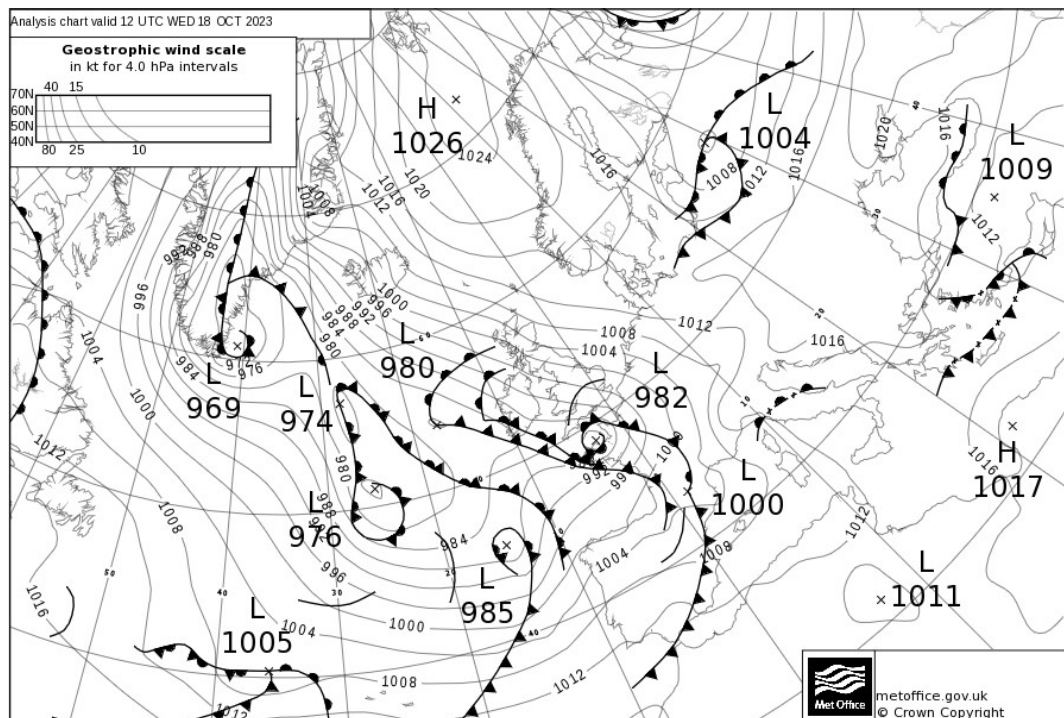
Weather data

The sequence of analysis charts at 1200UTC 17th, 18th, 19th and 20th show storm Babet tracking north to the UK. Atlantic storm systems affecting the UK in the autumn and winter months normally track west to east, driven by the jet stream, clearing eastwards fairly quickly. In contrast, this storm was on an unusual track from south to north, enabling it to pick up additional moisture as it crossed the Bay of Biscay. Babet was also unable to clear eastward into the North Sea due to a blocking area of high pressure across Scandinavia. The rain-bearing fronts therefore remained stationary across eastern Scotland for a prolonged period before moving back across England and Wales.

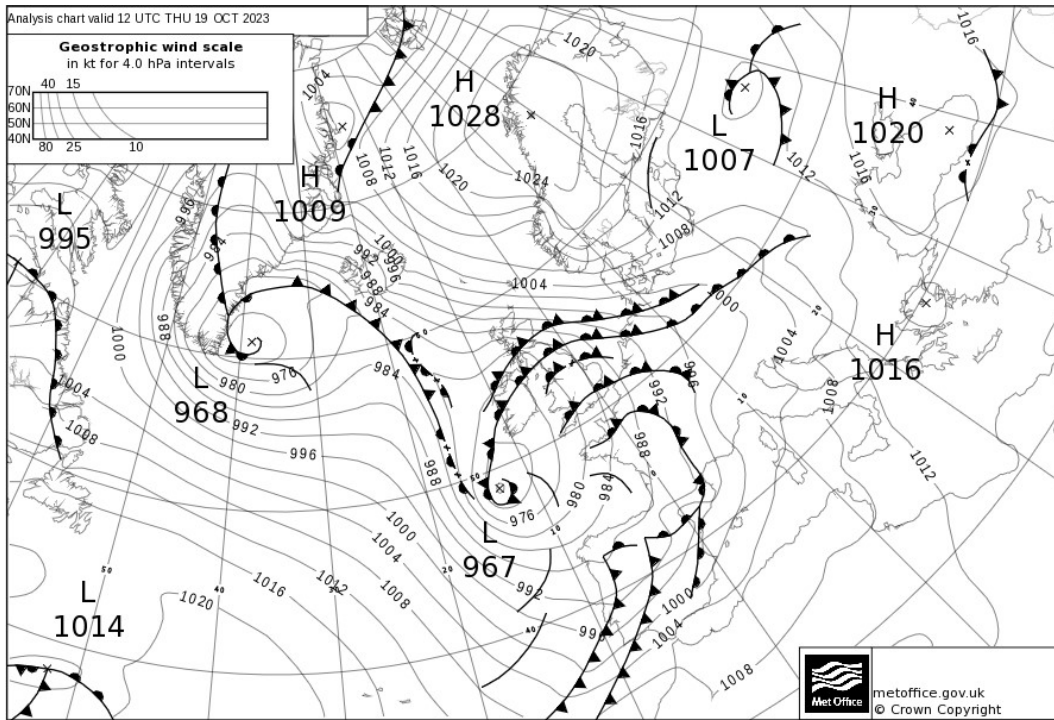
1200UTC 17 October 2023



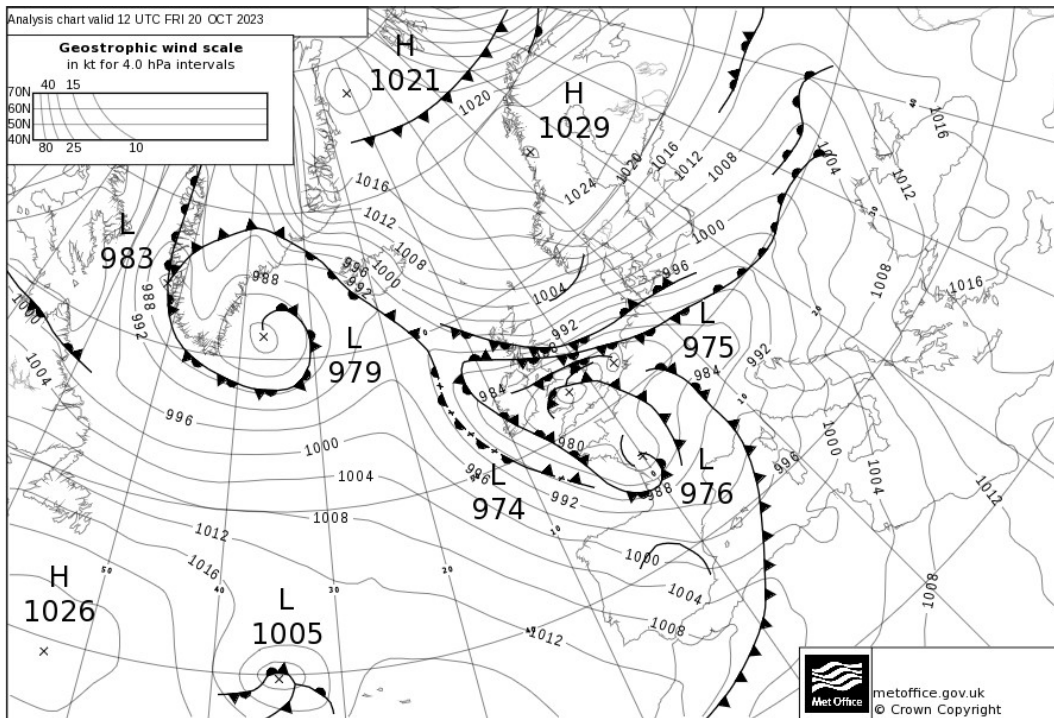
1200UTC 18 October 2023



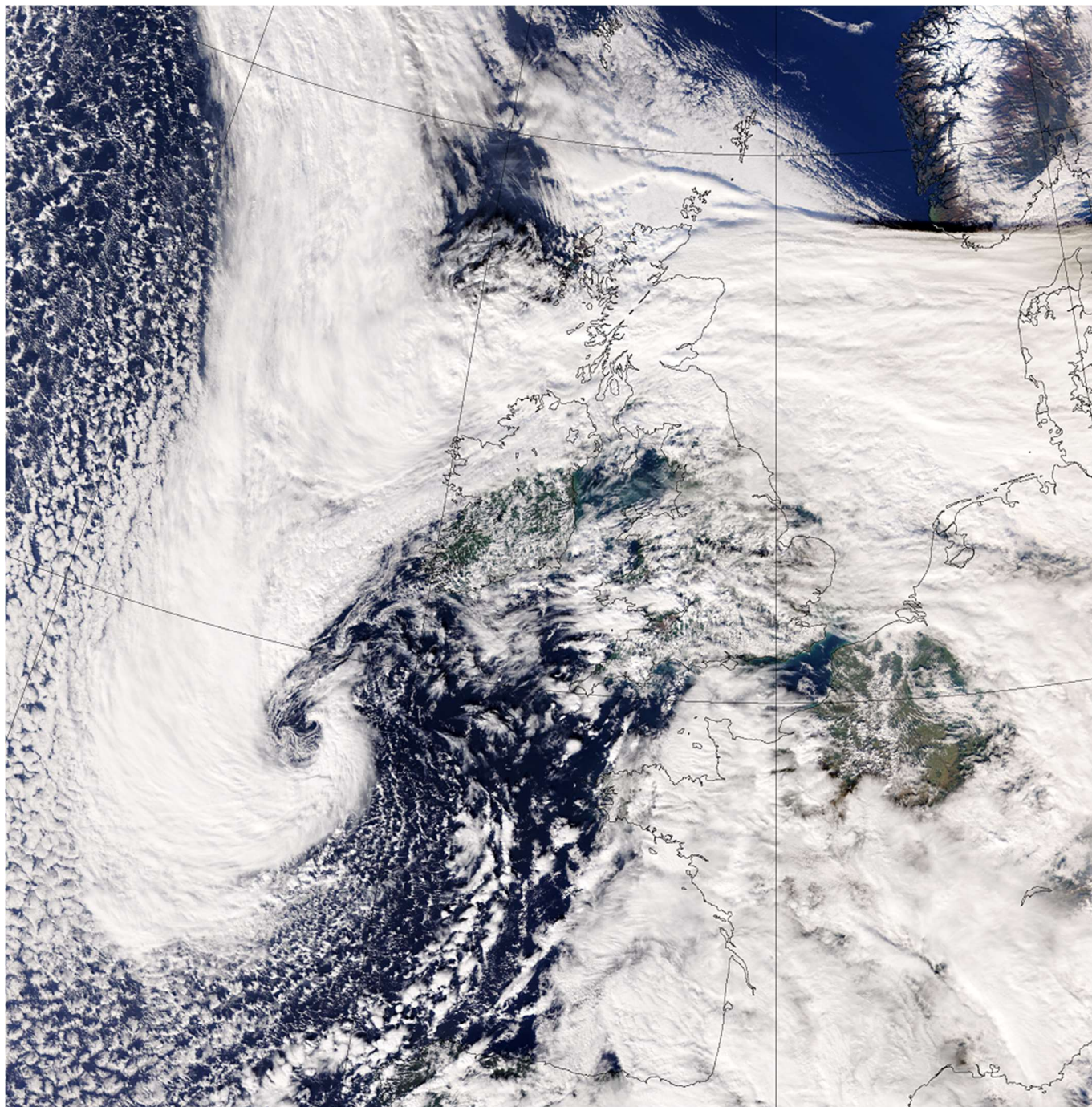
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1200UTC 20 October 2023

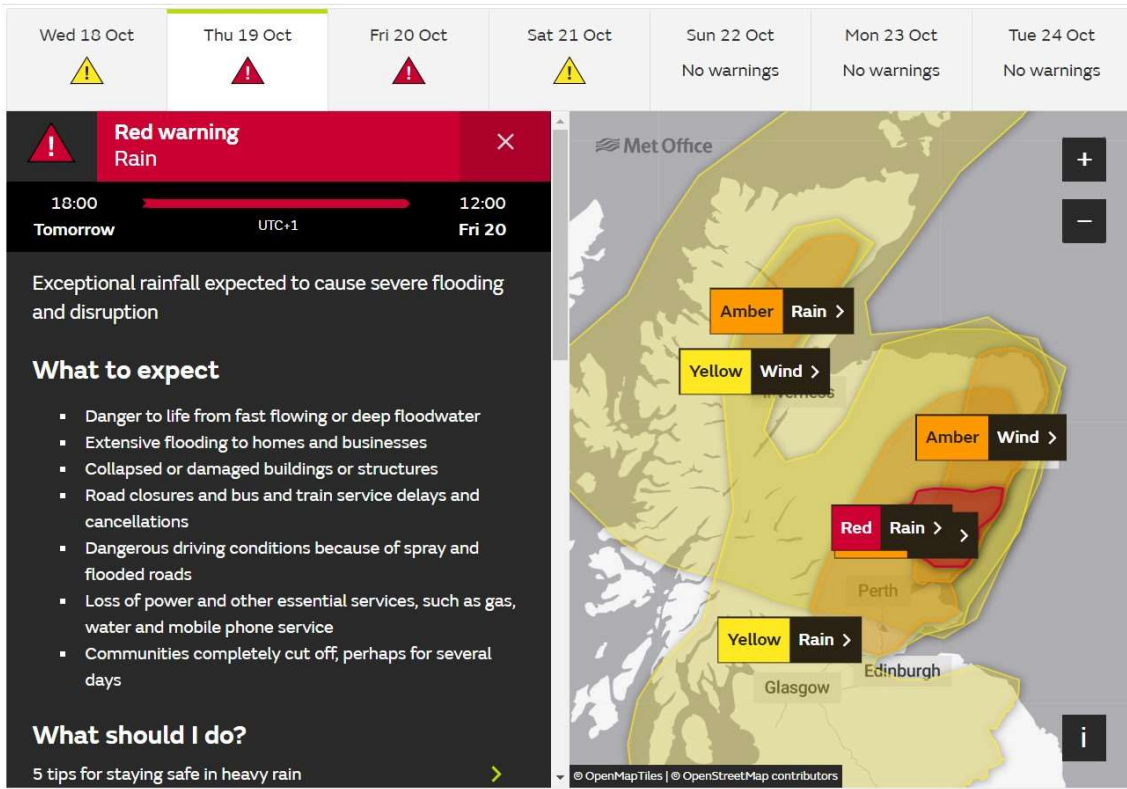


The satellite image at 1309UTC 19 October 2023 shows occluded fronts draped across Scotland bringing prolonged heavy rainfall in a south-easterly flow, with the centre of storm Babet to the south-west of Ireland. The snow-covered mountains and fiords of Norway can be seen under the blocking area of high pressure to the north-east, in the top right corner of the image. Image copyright Met Office / NOAA / NASA.

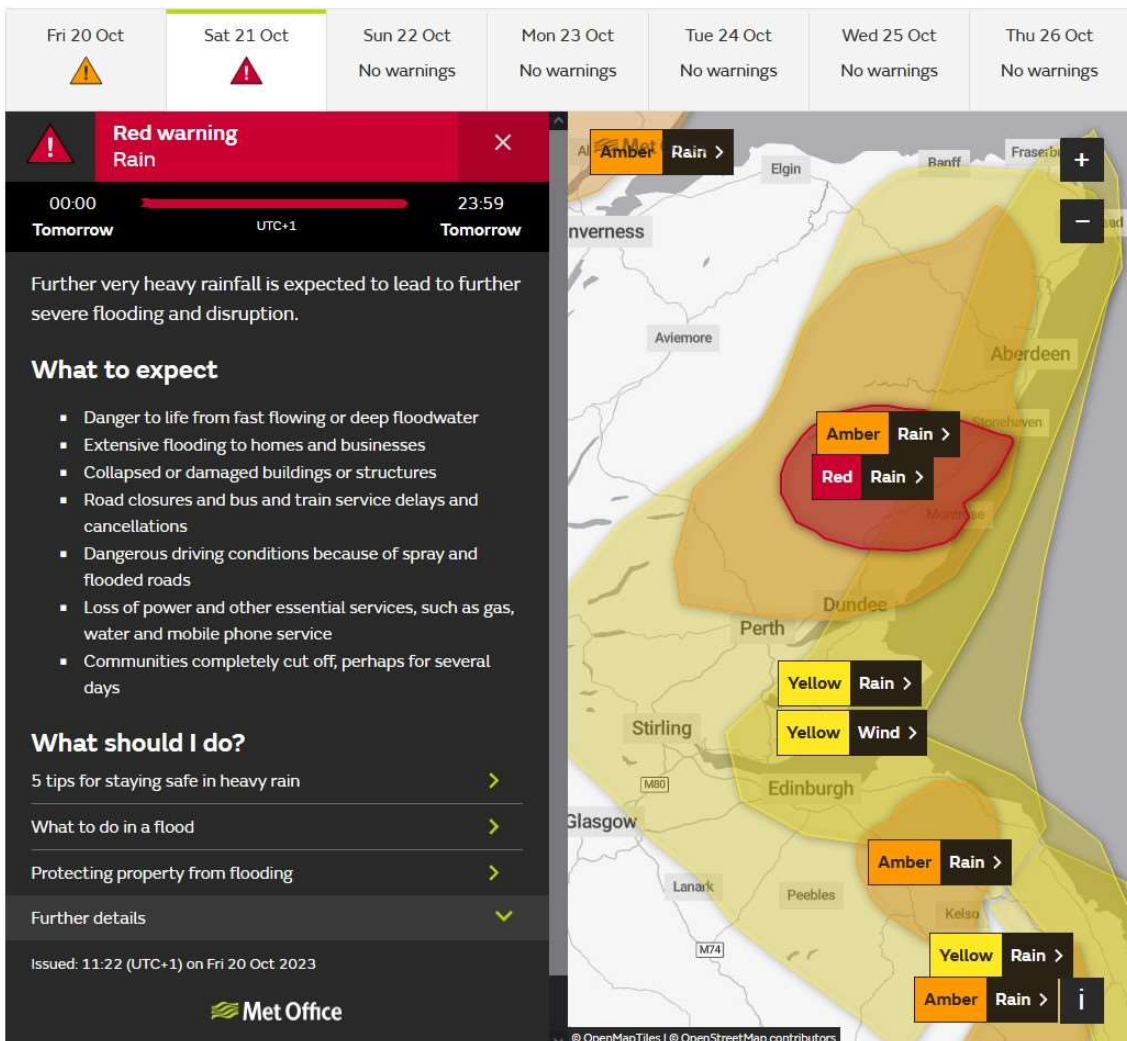


The Met Office issued two red warnings for persistent heavy rain across eastern Scotland for 19th to 20th, and 21st October, with several other amber warnings for rain and wind covering Scotland, Northern Ireland, Wales and parts of northern England as well as more widespread yellow warnings. The last time the Met Office issued a red warning for rain was from storm Dennis in mid-February 2020, covering parts of South Wales.

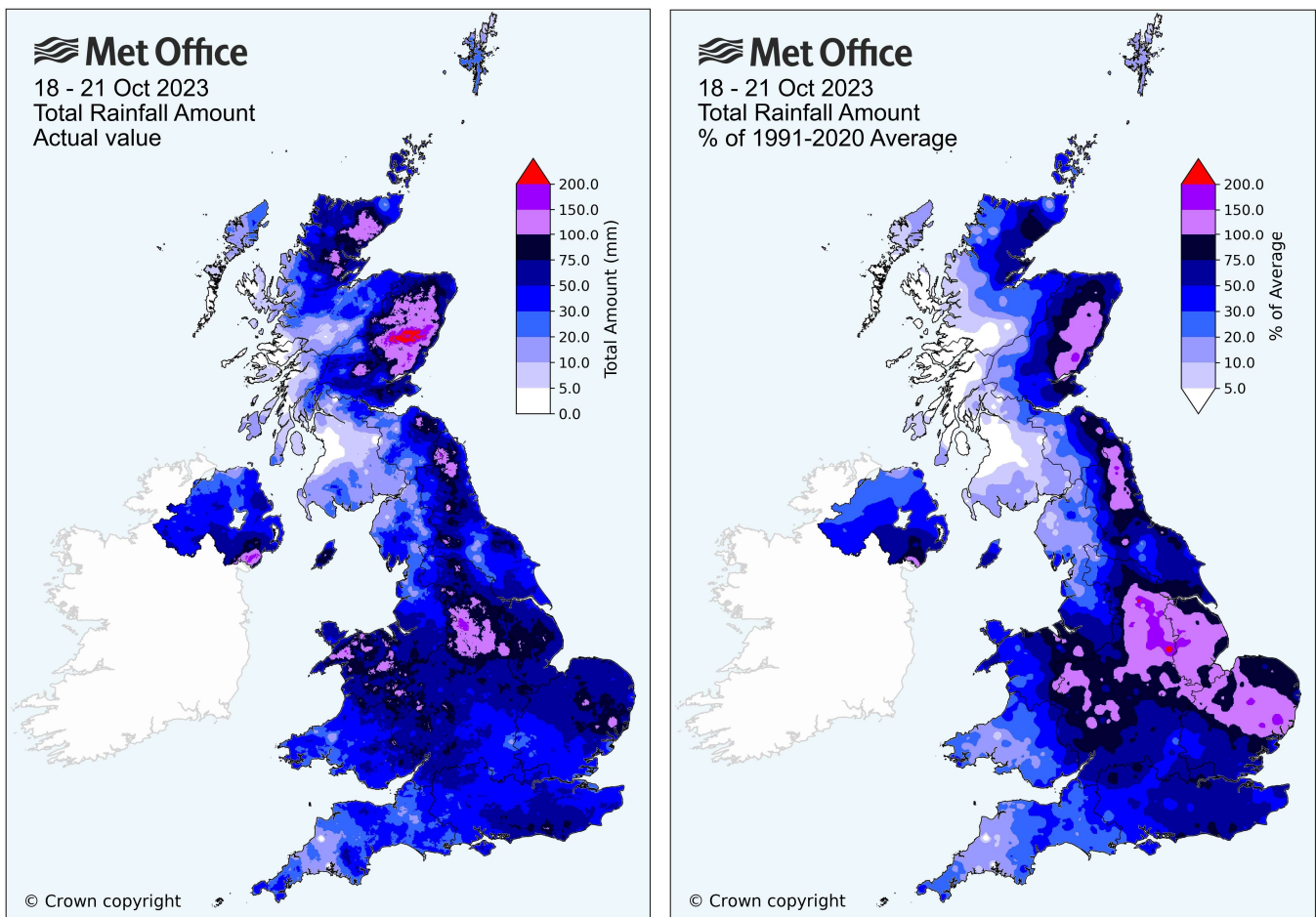
The image below shows the Met Office red warning issued for parts of eastern Scotland from 1800BST Thursday 19 October to 1200BST Friday 20 October 2023



The image below shows the Met Office red warning issued for Saturday 21 October 2023

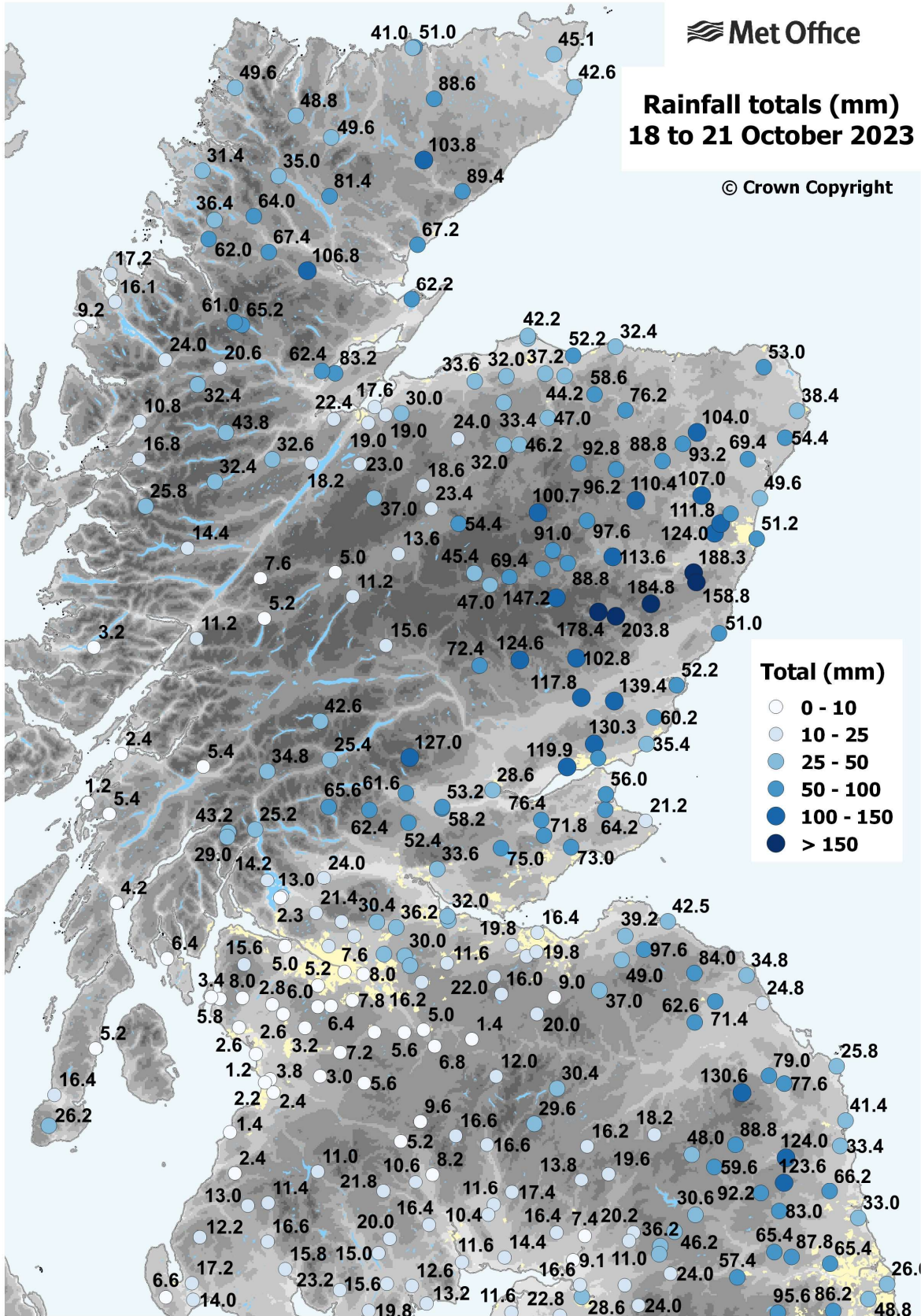


The maps below show the accumulated daily rainfall for the 4-day period 18 to 21 October 2023 from storm Babet as actual totals in mm (left) and percentage of the October whole-month average (right). Large swathes of the UK received over 50mm of rain, with 75 to 100mm widely across eastern Scotland, the Pennines, North Wales, the Mourne Mountains of Northern Ireland and parts of the West Midlands, East Anglia and south-east England, and over 100mm in the wetter locations (in some places over 150mm). The process used to generate the maps attempts to take topographical influences into account, and this shows a significant area of eastern Scotland receiving over 200mm (shaded in red). Much of the Midlands, East Anglia, south Pennines, Northumberland and eastern Scotland received over the whole-month average rainfall, with significantly more than this in some areas.



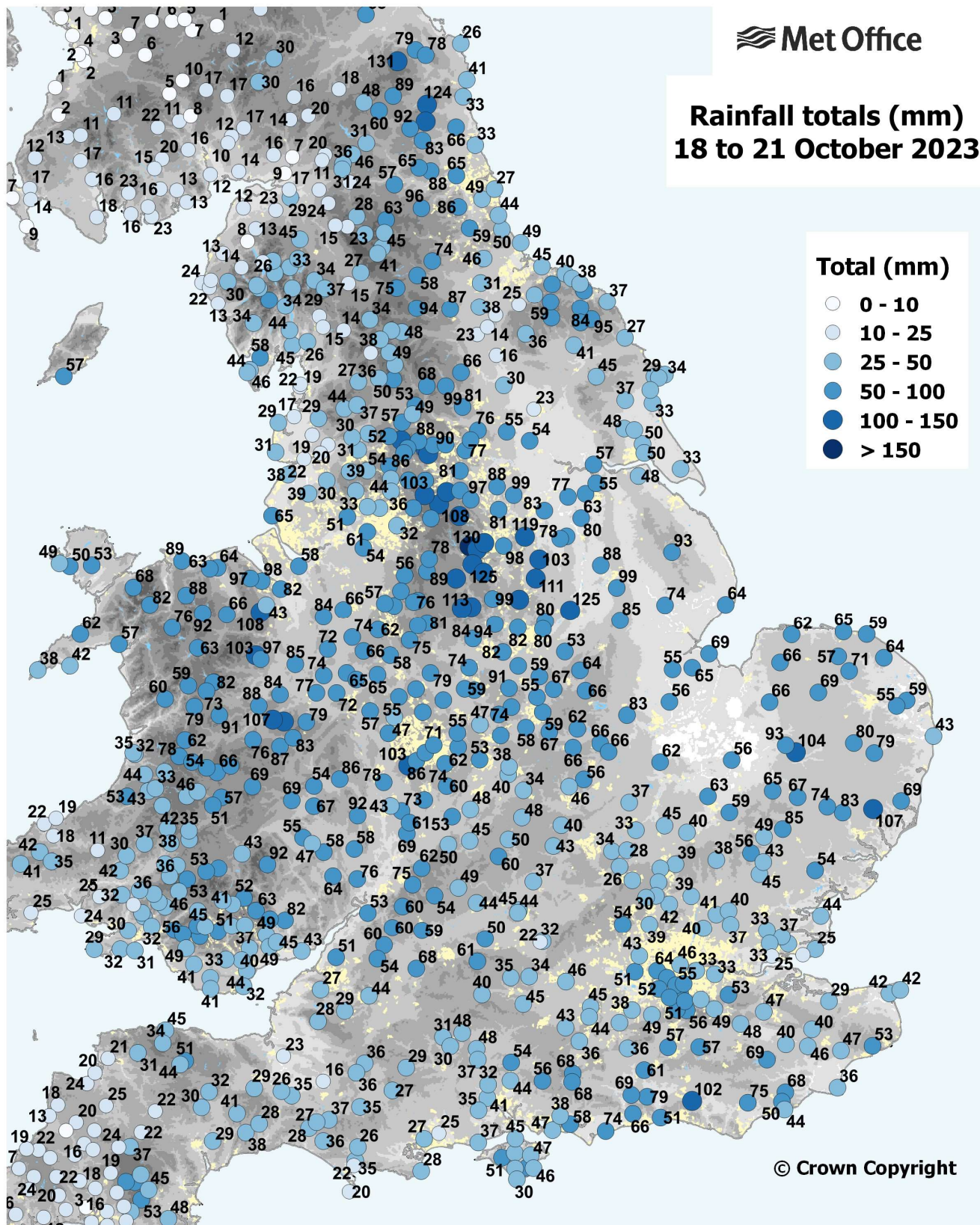
The map below shows rainfall accumulations from 18th to 21st (0900UTC 18th to 0900UTC 22nd) recorded at stations across Scotland. Data are from Met Office weather stations plus other rain gauges operated by SEPA and volunteer observers. The wettest locations in eastern Scotland recorded totals of 150 to 200mm. The wettest day of this period was 19th October, with some exceptional daily totals including 168.4mm at Waterside, Glen Esk and 151.6mm at Invermark Bridge (both in Angus) and 131.8mm at Charr (Kincardineshire) from the persistent heavy rainfall.

This map illustrates the influence of the topography on the rainfall totals, with totals inland 2 to 4 times wetter in the hills than on the coast: for example 51.0mm at Inverbervie on the Kincardineshire coast compared to 184.8mm at Charr, some 25km inland. This orographic enhancement of rainfall more typically occurs from rain-bearing Atlantic fronts in a westerly flow (for example affecting the West Highlands) – where rainfall totals such as this would be notable but not exceptional. However, for storm Babet this same enhancement of rainfall occurred but in a more unusual south-easterly flow – with the result that the highest rainfall totals occurred across one of the climatologically driest parts of Scotland.

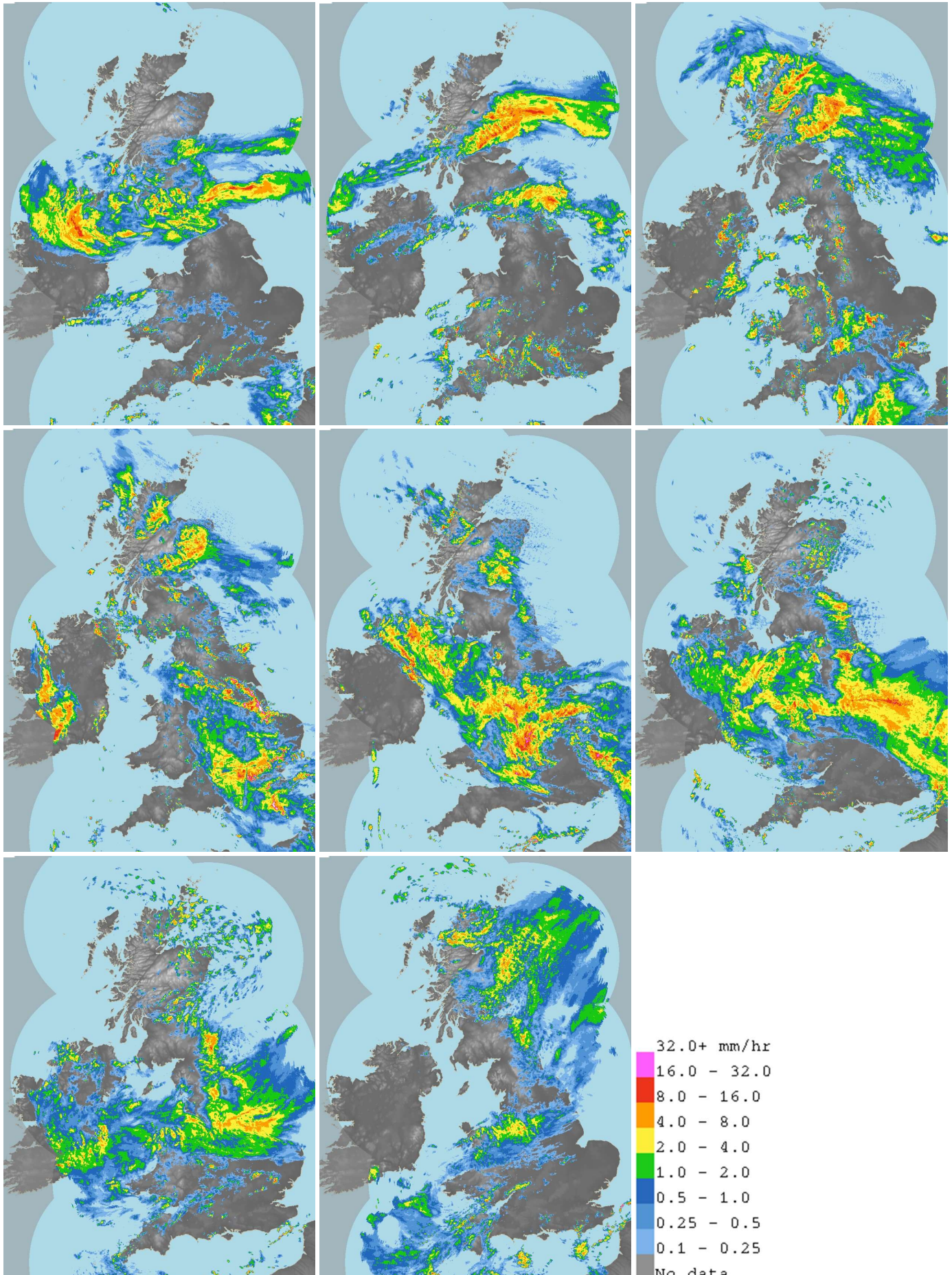


The map below for the same period shows totals across England and Wales and illustrates the widespread nature of the rain from storm Babet, with 50 to 75mm falling widely and 100mm in the wettest locations across parts of East Anglia, north-east Wales, the south Pennines and hills of Northumberland, with totals in the south Pennines fairly widely 100 to 120mm and locally over 150mm. This map shows stations operated by the Met Office, Environment Agency (EA) and Natural Resources Wales (NRW), plus volunteer observers.

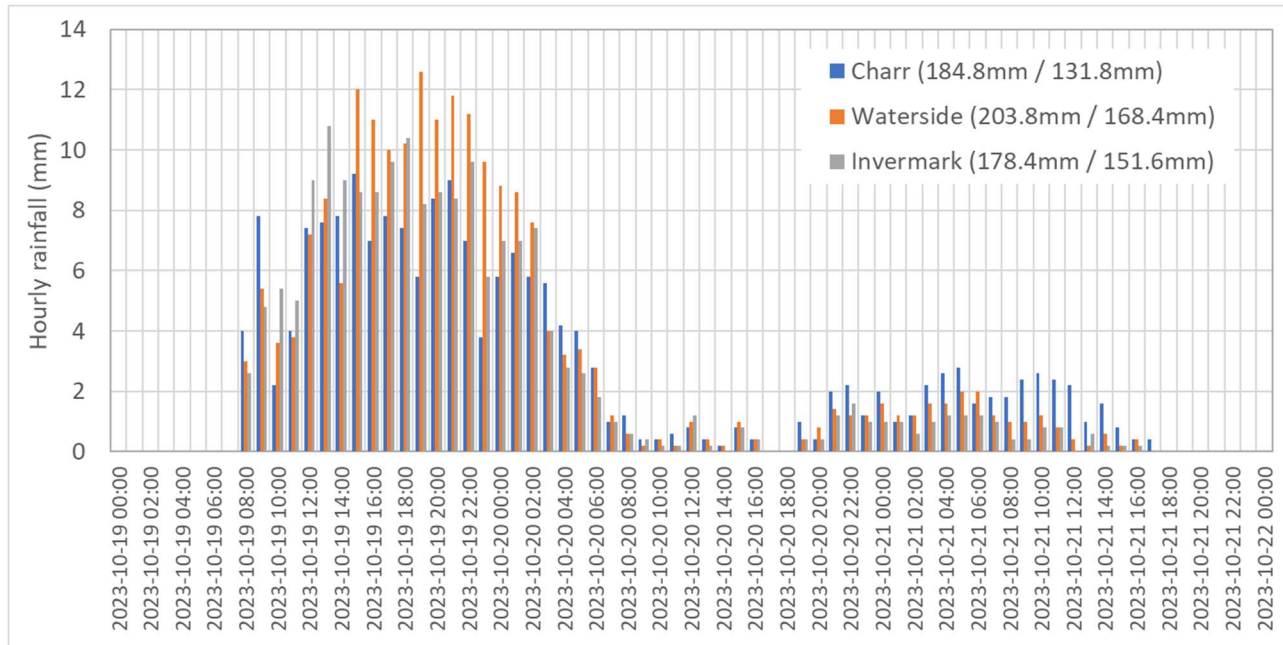
Many long-running stations in England recorded their wettest October day on record, including 61.4mm at Sheffield on 20th (139 years), 46.8mm at Waddington, Lincolnshire on 19th (76 years), 45.8mm at Lyneham, Wiltshire on 19th (66 years), 48.2mm at Wattisham, Suffolk on 19th (63 years), 46.0mm at Charsfield, Suffolk on 19th (57 years) and 56.4mm at Fylingdales, North Yorkshire on 20th (47 years). Records in Scotland included 129.5mm at Fettercairn Glensburgh, Kincardineshire on 19th (49 years) and 117.8mm at Durris, Kincardineshire on 19th (34 years).



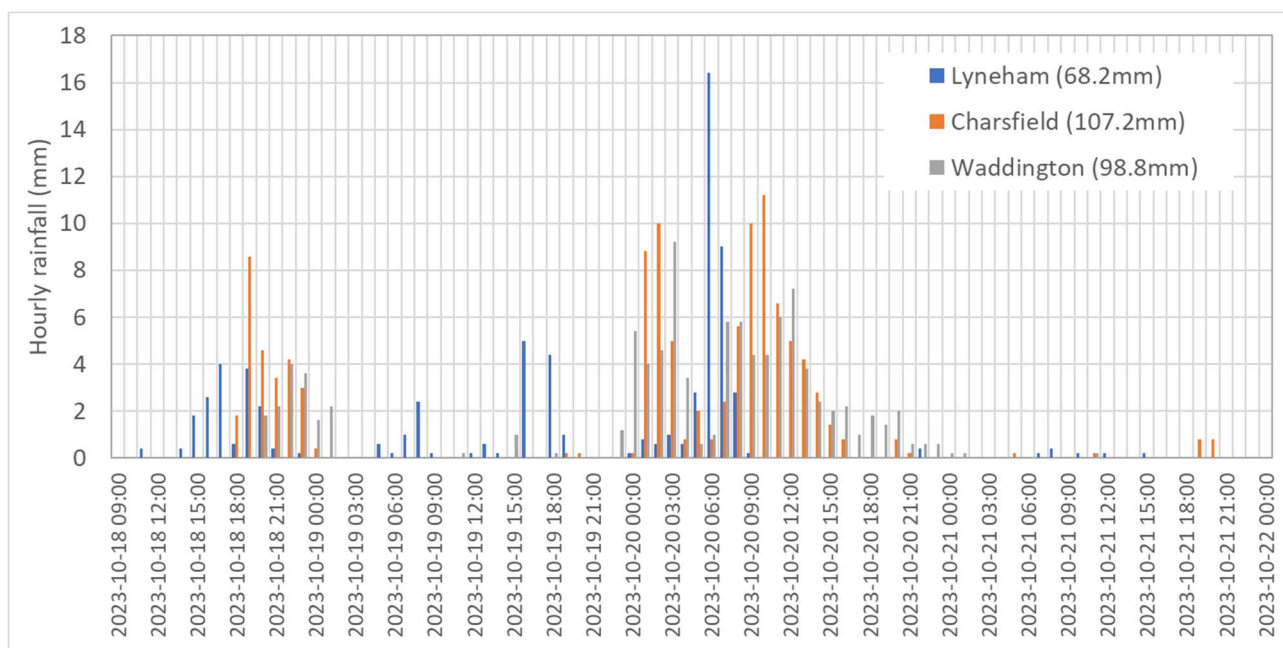
The following sequence of rain-radar images at 6-hour intervals from 0600UTC 19 October 2023 to 0000UTC 21 October 2023 show the heavy rainfall across northern England and Northern Ireland moving north to affect eastern Scotland through this period, with further widespread heavy rain then spreading back to affect much of England and Wales through the 20th.

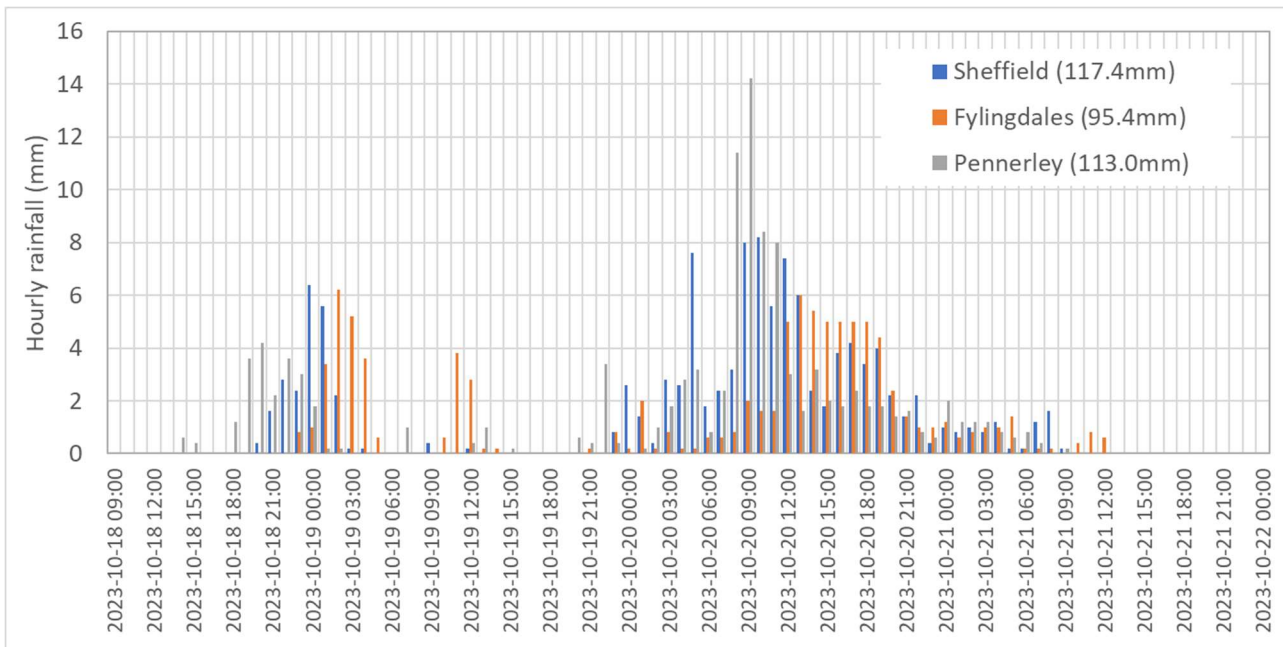


The chart below shows hourly rainfall totals at three of the wettest rain gauges operated by SEPA in Angus and Kincardineshire in the red warning area, with totals for the four-day period 0900UTC 18th to 0900UTC 22nd October 2023 and for the rain-day 19th in the legend. Rainfall totals during the main rain event were typically around 5 to 10mm per hour, sustained for a period of around 20 to 24 hours – mostly falling within the rain-day 19 October 2023. Sustained frontal rainfall of this type is more typically characteristic of upland areas in the north and west of the UK – such as Snowdonia, the English Lake District or West Highlands – but not eastern Scotland.

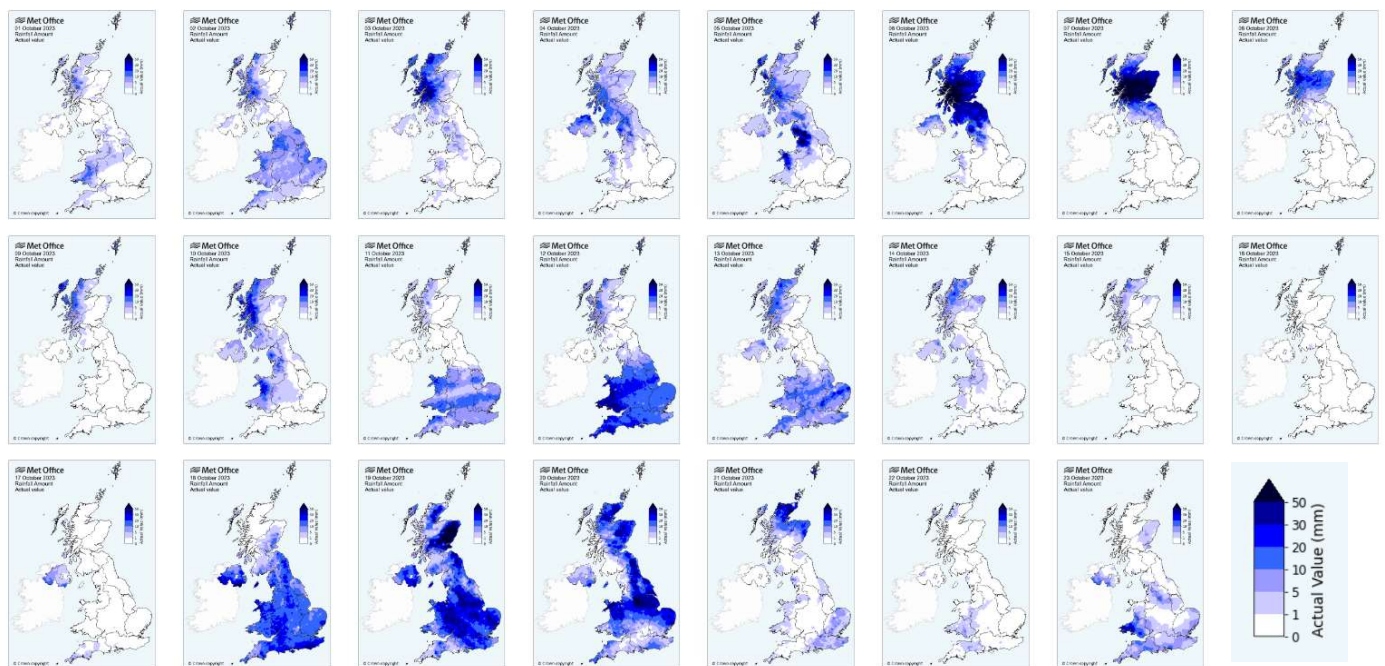


The charts below show hourly rainfall for (top) Lyneham (Wiltshire), Charsfield (Suffolk) and Waddington (Lincolnshire) and (bottom) Sheffield, Fylingdales (North Yorkshire) and Pennerley (Shropshire), with totals for the four-day period 0900UTC 19th to 0900UTC 22nd October 2023 in the legend. After the front moved through during the evening and overnight 18 to 19 October, the main rainfall event occurred during the 20th as heavy extensive rain spread back across England and Wales, this including some heavier bursts.

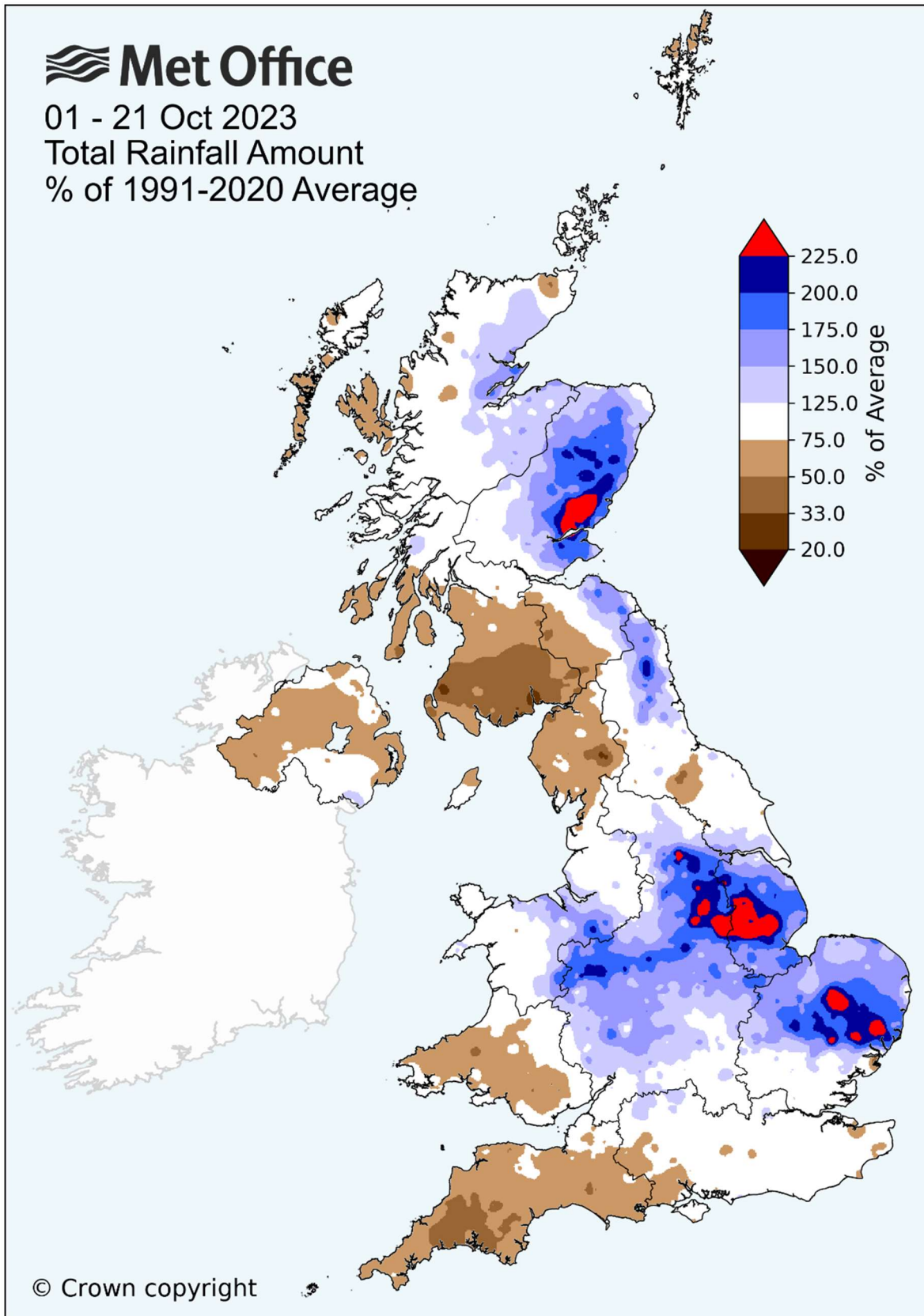




The maps below show daily rainfall totals for each day of October 2023 from 1st to 23rd. The rainfall from 18th to 21st October from storm Babet occurred a week after an area of low pressure brought another very wet period for England and Wales from 10th to 13th in which 40 or 50mm fell widely across Wales, the Midlands and East Anglia, with locally over 70mm, and before that an exceptionally wet period for much of central Scotland from 6th to 7th with 75 to 100mm or more falling fairly widely - this being provisionally the wettest 2-day period on record for Scotland in a series from 1891.

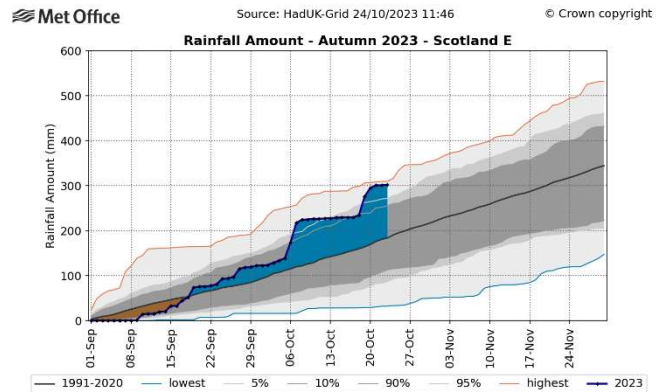
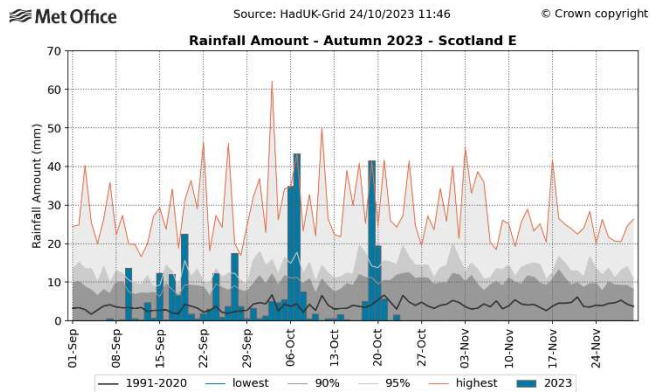


The map below shows rainfall totals across the UK for the first three weeks of October from 1st to 21st as anomalies relative to the 1991-2020 October long-term average. Much of East Anglia, the Midlands, Lincolnshire and south Pennines, parts of Northumberland and much of eastern Scotland received over 150% of the whole-month average rainfall over this period, with significant areas over 200% and locally the wettest areas (shaded in red) more than 225%.

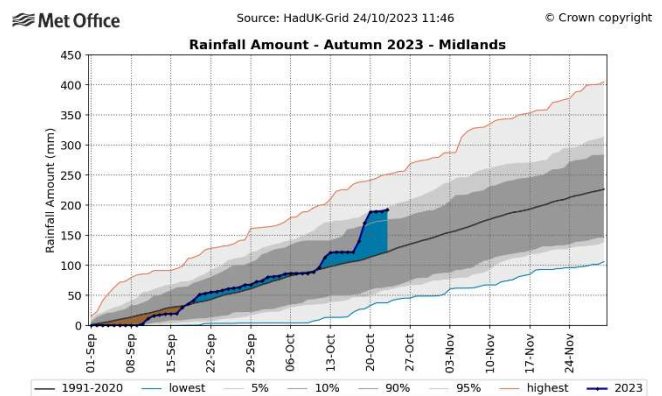
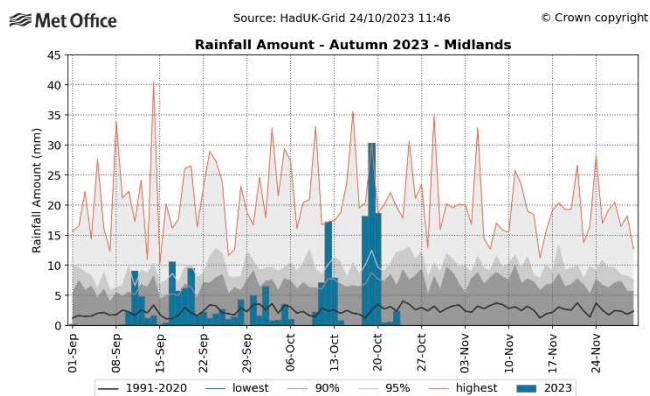


The charts below show daily rainfall totals (left) and accumulations (right) for autumn so far for two climate districts – Eastern Scotland and the Midlands – with the large step increases in rainfall totals associated with these periods of wet weather through October. The shading on the maps show the extremes and percentiles from the historical record.

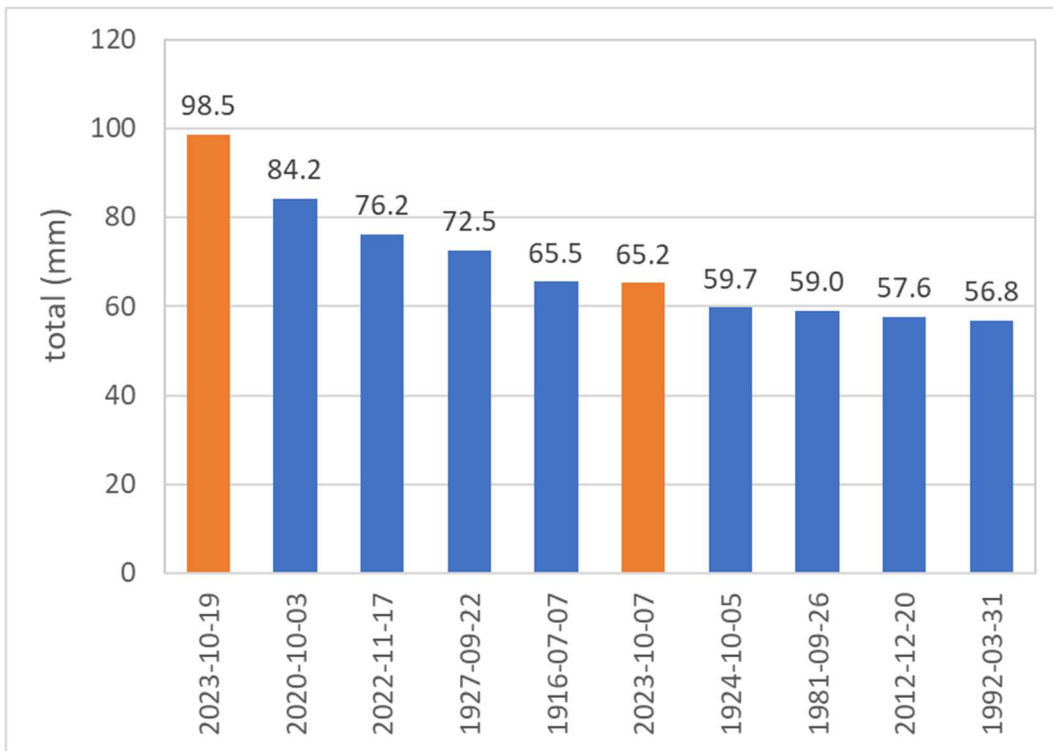
Daily rainfall totals and accumulations – Eastern Scotland



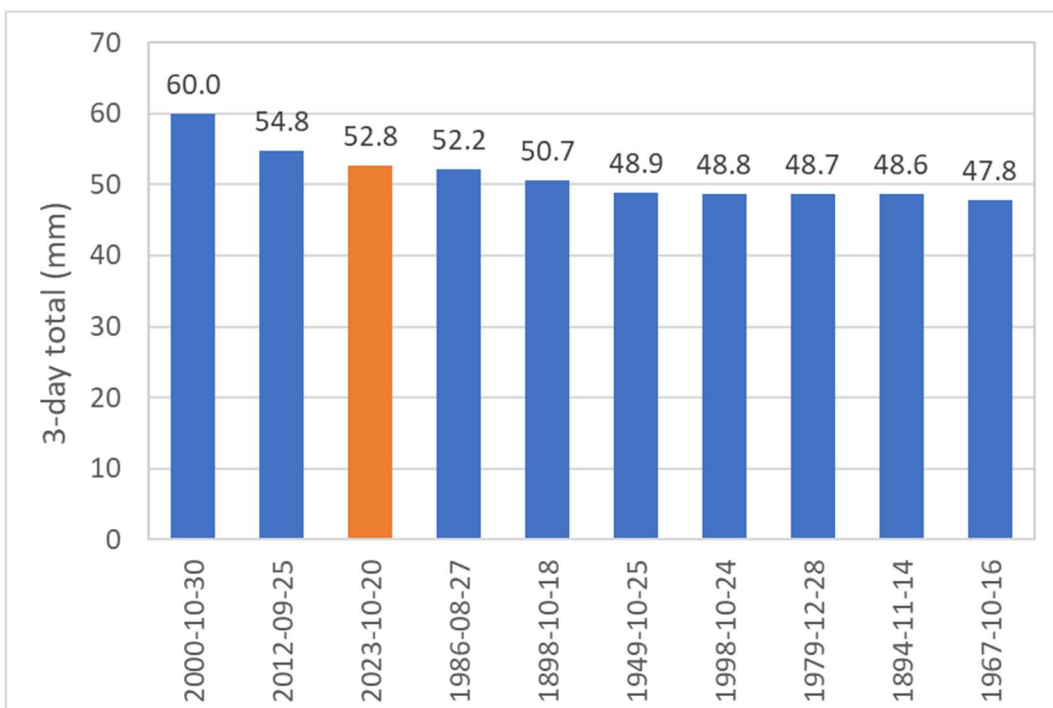
Daily rainfall totals and accumulations - Midlands



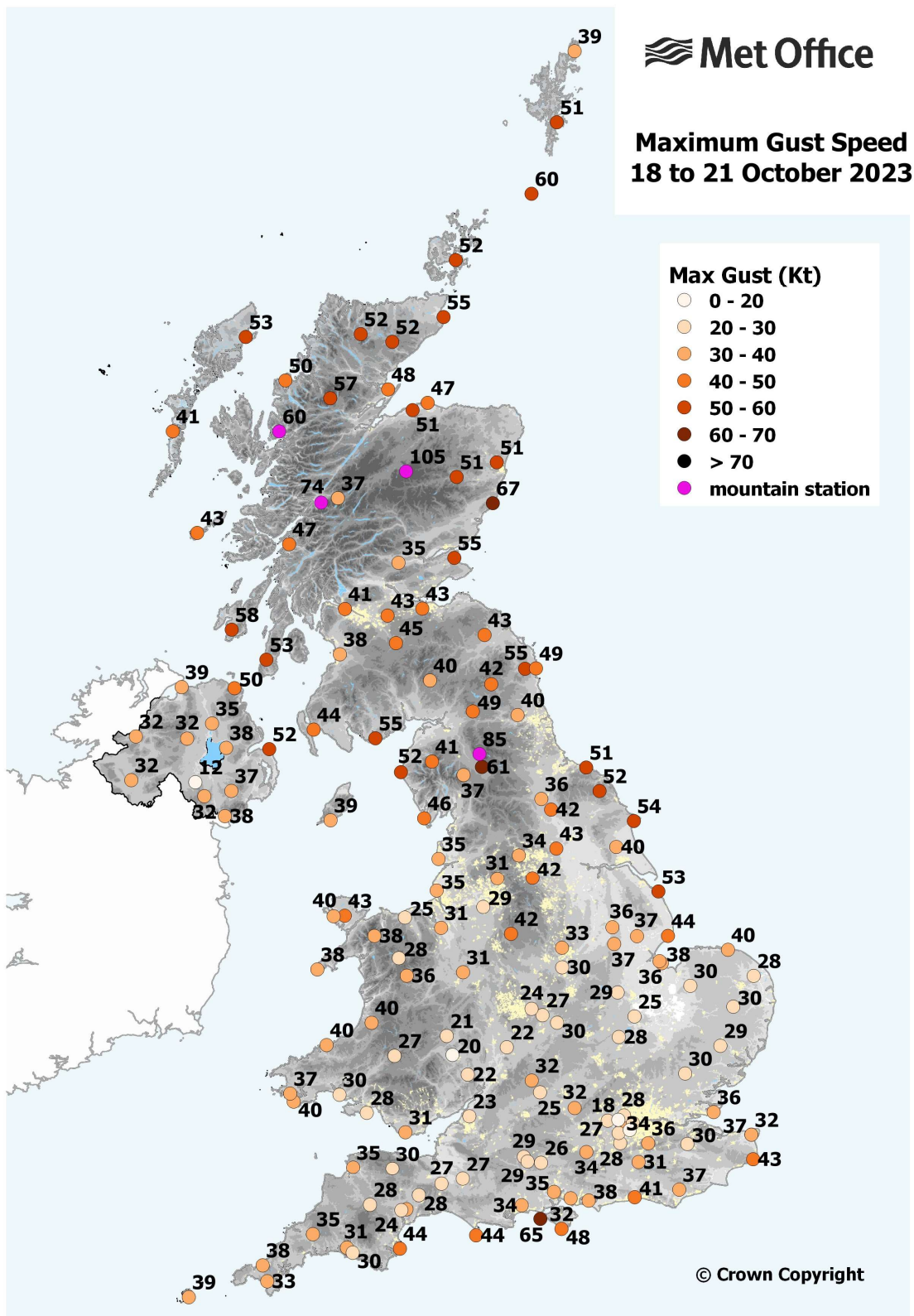
The chart below shows the ten highest daily area-average rainfall totals for the county of Angus, which aligns closely with the red warning area for heavy rain issued by the Met Office. Provisionally, 19 October 2023 was, by a wide margin, the wettest day on record for this county in a series from 1891, with 98.5mm. Remarkably, 7 October 2023 (less than a fortnight previously) was the sixth wettest day, while four of the ten wettest days on record for this county have occurred in the last five years. These statistics in the observations are illustrative of the expected increases in rainfall extremes as the UK's climate continues to warm. (Note that data prior to 1961 are based on a smaller number of stations due to more limited data availability).



For England and Wales overall, the 3-day period 18 to 20 October 2023 was provisionally the third-wettest independent (non-overlapping) 3-day period on record in a daily series from 1891, with 52.8mm of rain falling, 53% of the October whole-month 1991-2020 average, with the only wetter periods on record being 28 to 30 October 2000 and 23 to 25 September 2012. The chart below shows the 10 wettest independent 3-day periods on record for England and Wales in the series. The August 1986 total was associated with ex-hurricane Charley, but all the others are associated with large-scale autumn or winter low pressure systems – with six of these ten events occurring in October. For the climate district of the Midlands the 3-day total of 67.2mm from 18 to 20 October 2023 made this the wettest 3-day period in record for this region (not shown). Events such as these with prolonged, widespread heavy rain will inevitably result in significant flood impacts.



In addition to exceptionally wet weather, storm Babet also brought some very strong south-easterly winds, particularly across northern and eastern Scotland with gusts of over 50Kt (58mph) in exposed coastal locations. Inverbervie (Kincardineshire) recorded a gust of 67Kt (77mph) and this, coinciding with the persistent heavy rain, resulted in atrocious weather conditions. It was particularly windy across Scotland's mountain summits and the crest of the Pennines with gusts of 105Kt (121mph) at Cairngorm Summit (1237masl) and 85Kt (98mph) at Great Dun Fell (847masl). The map below shows maximum gust speeds recorded during storm Babet. Wind speeds were increased over the crest of the hills and on the lee side to the north-west due to an upper-level inversion.



A further feature of this event was the sustained nature of the strong winds, with the fronts stalled across Scotland due to the blocking area of high pressure across Scandinavia. The chart below shows hourly maximum gust speeds at Leuchars (Fife), Inverbervie (Kincardineshire) and Wick Airport (Caithness). Gust speeds were sustained at 40 to 50Kt (46 to 58mph) for a period of at least 48 hours. The prolonged nature of both the heavy rainfall and the strongest winds will have exacerbated the weather impacts experienced from this storm Babet.



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