

Heavy and persistent rain, October 2021

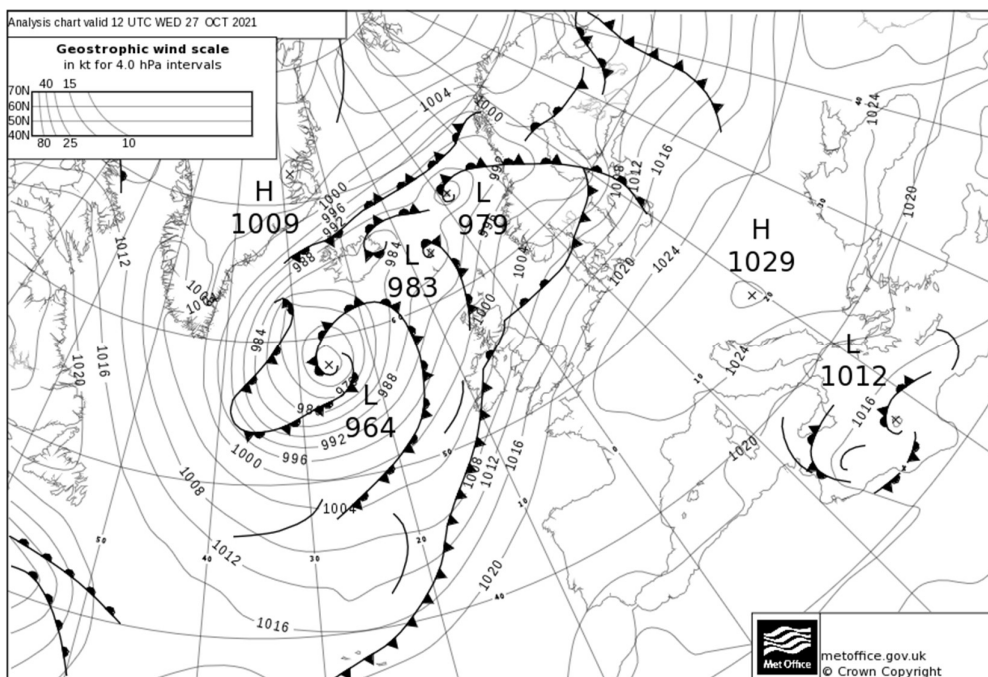
A slow-moving frontal system brought unusually heavy and persistent rain to parts of northern England and southern Scotland from 26th to 29th October 2021. The wettest weather was across the Lake District fells, where over 400mm of rain fell in the last six days of the month. On 27th, two rain-gauges recorded daily totals of over 200mm in an event known as a 'warm-conveyor' where rainfall is greatly increased across high ground as moist air is forced to rise. This event was very similar in characteristic to the extreme rainfall events of December 2015 and November 2009 which brought serious flooding to parts of northern England.

Impacts

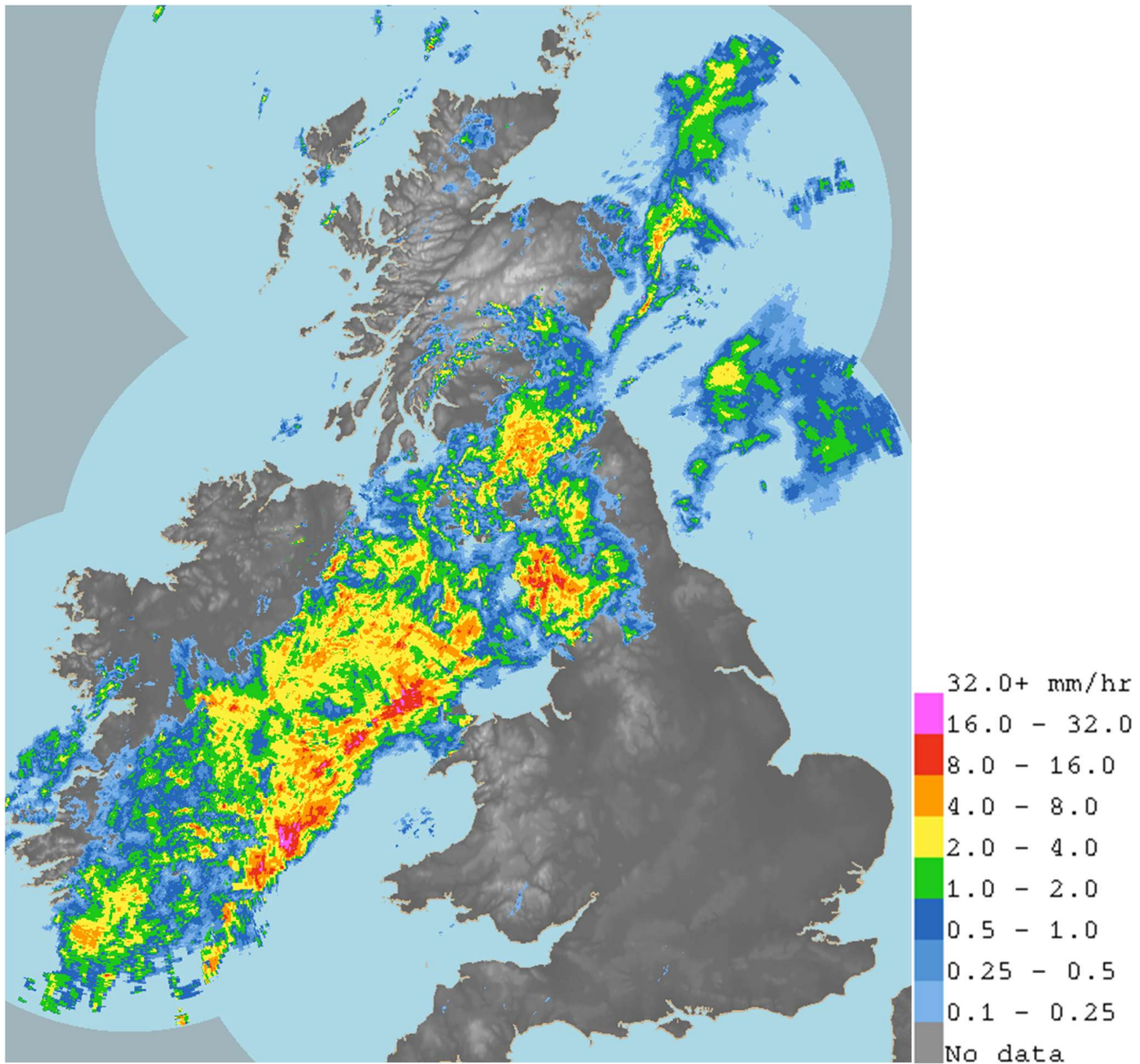
The persistent heavy rainfall brought significant flooding problems across the English Lake District. Around 40 properties were reported to have flooded, but over 1200 protected by flood defences. There was significant travel disruption with roads flooded and cars stranded, and rail passengers asked to avoid the West Coast main line and Cumbria coastal routes. Hillwalkers were advised by mountain rescue services not to head onto the fells during the school half term holiday. In Scotland, a major incident was declared in the Borders town of Hawick due to rising water levels on the River Teviot, with plans in place to evacuate local residents. Overall, however, this weather event was much less significant in terms of flood impacts than December 2015 or November 2009.

Weather data

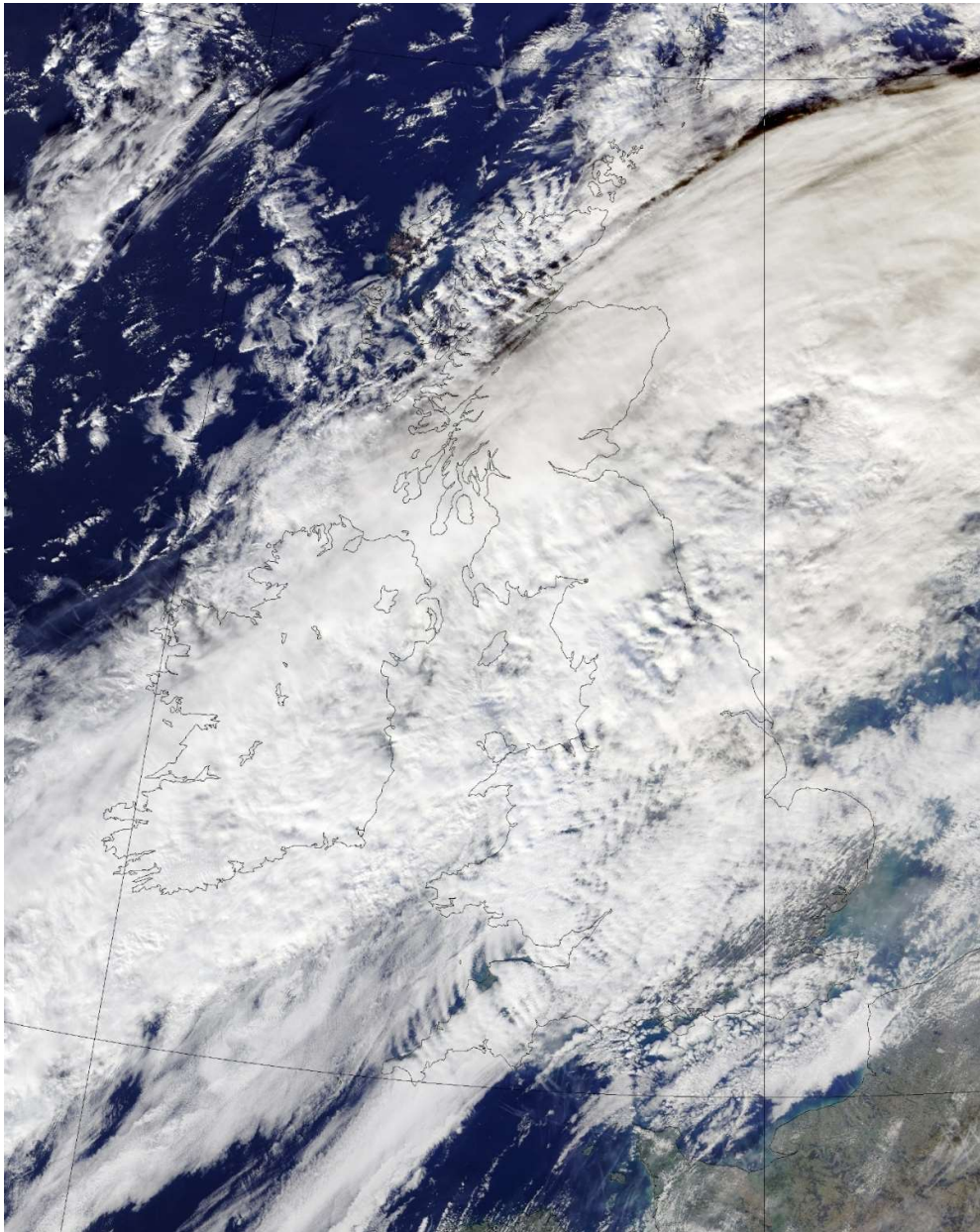
The analysis chart at 1200 UTC 27 October 2021 shows a deep area of low pressure centred in the north Atlantic, with an associated front across Northern Ireland and southern Scotland. This front was largely stationary over this area for around 36 hours.



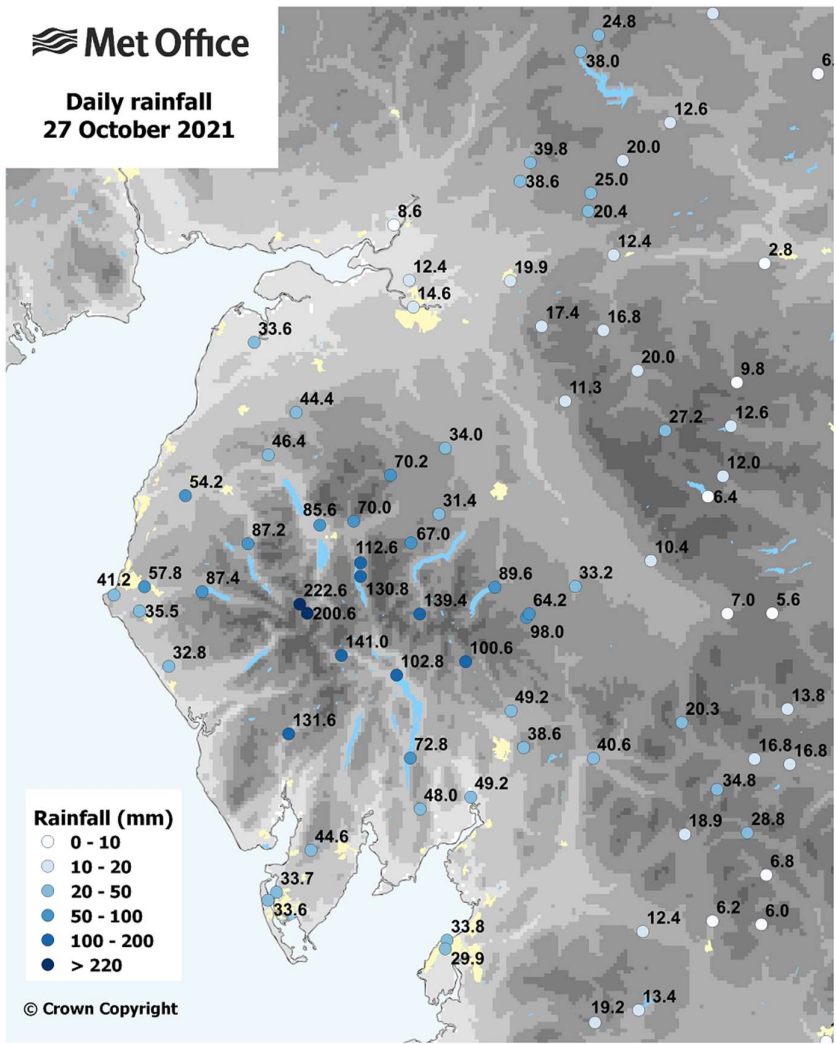
The rain-radar image below at 1900 UTC 27 October 2021 shows persistent heavy rain across north-west England, south-west Scotland and Northern Ireland, with the heaviest rain over land focussed across the Cumbrian fells.



The satellite image below on 27 October 2021 shows most of the UK swathed in cloud from the frontal system in a mild south-westerly flow, with some clearer skies across the far north-west of Scotland and south-east England. Image copyright Met Office / NOAA / NASA.



The map below shows daily rainfall totals on 27 October 2021 (0900 UTC 27th to 0900 UTC 28th) across the English Lake District and North Pennines. Around 100mm fell widely on 27th across the Lake District fells with 150 to 200mm in the wettest areas and the two wettest locations, Honister Pass and Seathwaite each recording over 200mm in one rain-day (09-09 UTC). In the 24-hour period to 0200 UTC 28 October 2021, Honister Pass recorded 298.8mm of rain, the highest 24-hour accumulation during this event. In contrast, the coastal strip between the Lake District fells and the Irish Sea received around 30mm, while areas in the rain-shadow around Carlisle and the Vale of Eden received 10 to 20mm. The map illustrates the extreme orographic enhancement of the rainfall during this event due to the 'warm conveyor' mechanism.

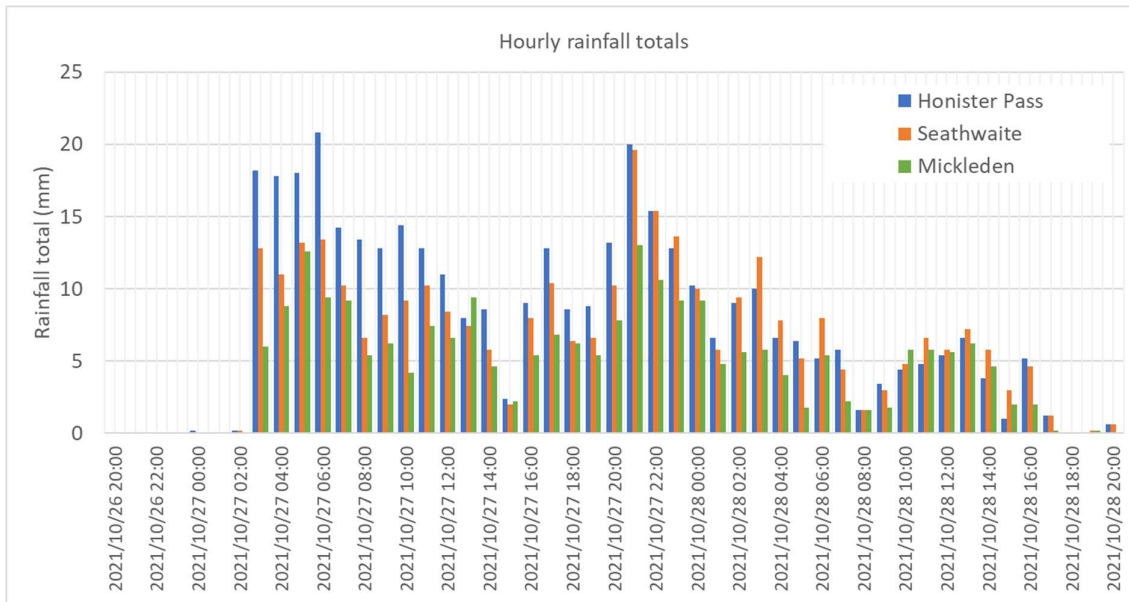


The chart below shows hourly rainfall totals at three of the wettest stations, Honister Pass, Seathwaite (Borrowdale) and Mickleden (Langdale). Rainfall totals for these stations are listed in the table below. At Honister Pass, 369.0mm of rain fell in a 38-hour period from 0300 UTC 27th October to 1600 UTC 28th October, 88% of the October 1981-2010 long-term average. The chart below of hourly rainfall totals at this three stations through this event shows the sustained nature of the rainfall at typically around 5 to 10+mm per hour.

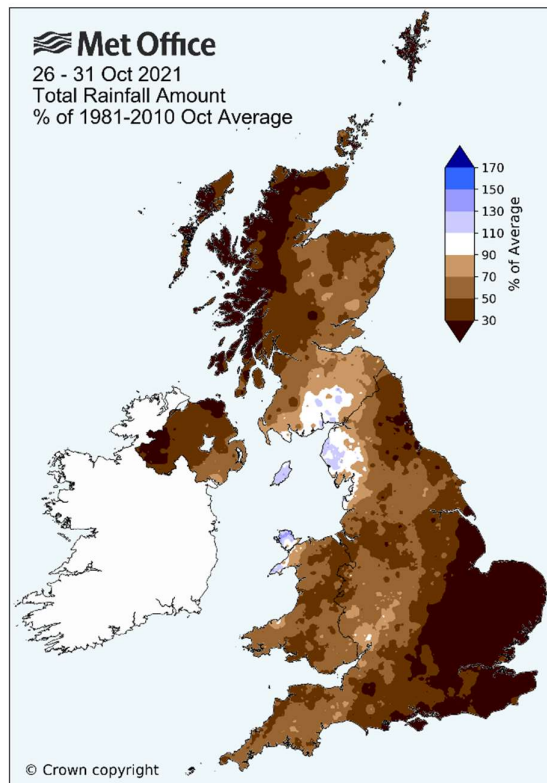
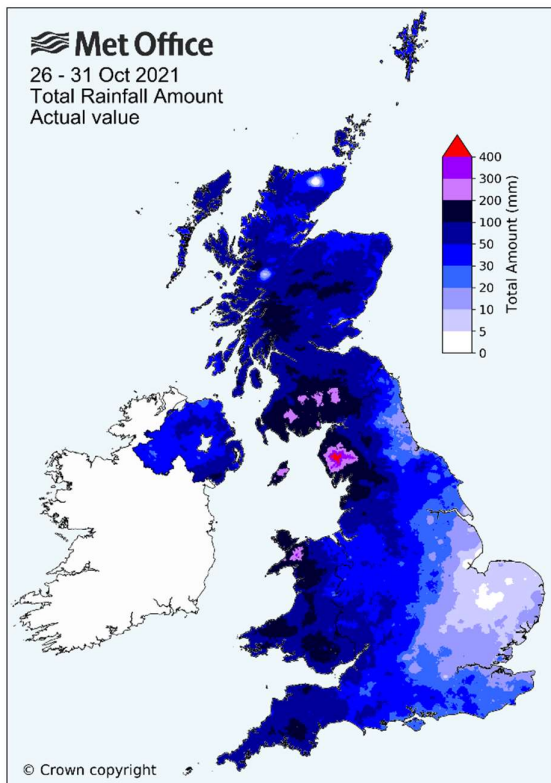
Duration	Honister Pass	Seathwaite	Mickleden
27 Oct*	222.6	200.6	141.0
26-27 Oct*	343.0	276.8	199.0
26-28 Oct*	399.2	340.8	258.6
38-hours**	369.0	313.8	230.6
October 1981-2010 average	417.6	383.8	431.1

*Rain-day totals 09-09 UTC

**Total from 0300 UTC 27th to 1600 UTC 28th



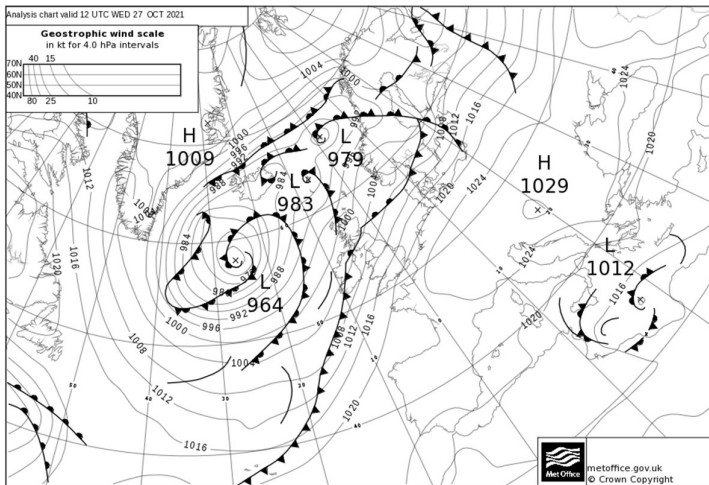
The charts below show 6-day rainfall totals from 26 to 31 October 2021 as (left) – actual totals in mm and (right) – totals as a percentage of the October 1981-2010 long term average. 100mm fell widely across western upland parts of the UK through this period, with 200mm or more across parts of Snowdonia, the English Lake District and Southern Uplands. Over 400mm fell across the wettest parts of the Cumbrian fells. In these areas, more than the October whole-month long-term average fell in the last 6-days of the month. In contrast areas either side of the front in north-west Scotland and south-east England were very much drier.



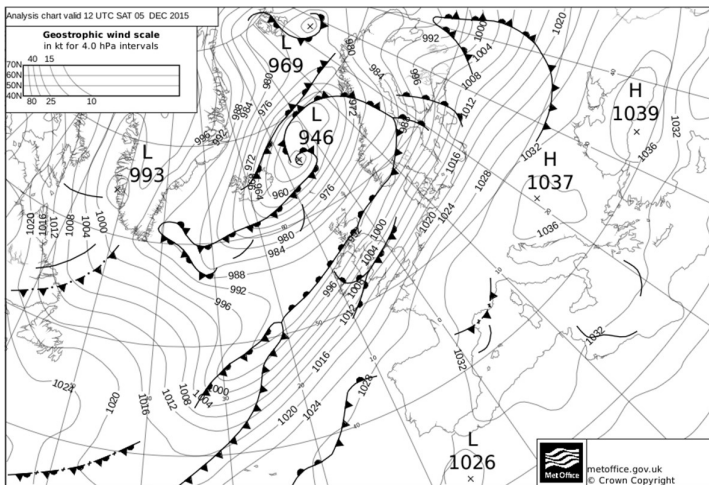
The analysis charts below compare the 27 October 2021 rainfall event with 5 December 2015 (storm Desmond) and 19 November 2009 – all of which resulted in exceptional rainfall across the Cumbrian fells with more than 200mm falling locally. For each of these events, a deep area of low pressure was situated in the north Atlantic with an associated front draped across southern Scotland forming the boundary between colder air to the north and milder air to the south. This

front was associated with an 'atmospheric river' bringing moisture laden air from the subtropics and resulted in prolonged heavy rainfall to upland areas in this moist south-westerly flow as the air was forced to rise - the 'warm-conveyor' mechanism. This mechanism was also apparent during the Carlisle flood event of January 2005.

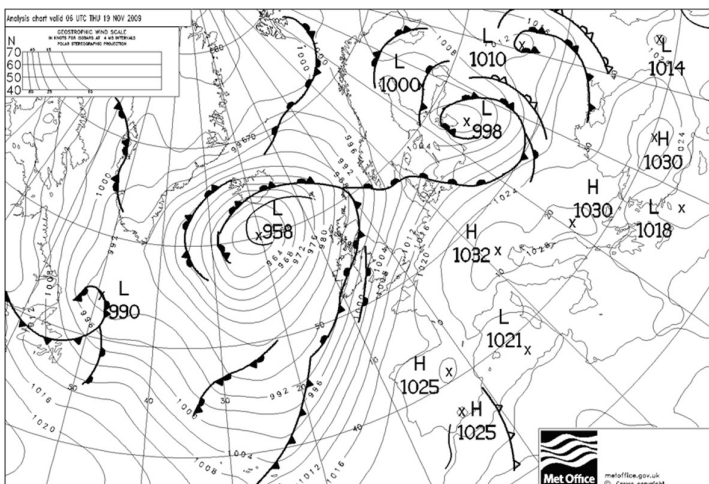
1200 UTC 27 October 2021 (222.6mm at Honister Pass)



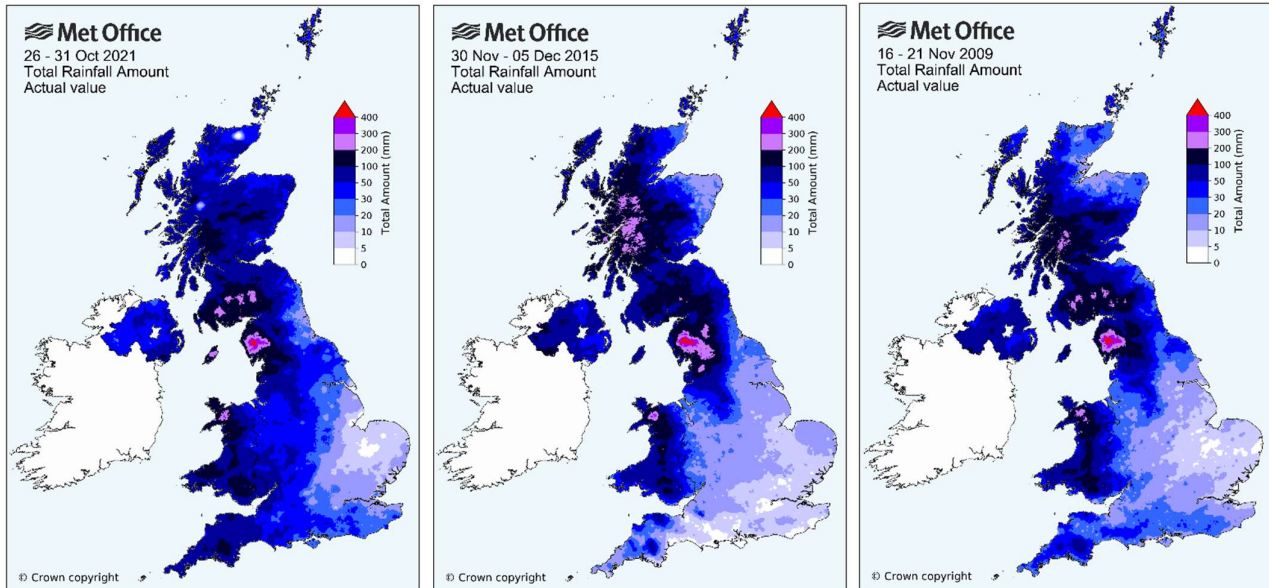
1200 UTC 5 December 2015 (264.4mm at Thirlmere, St John's Beck)



0600 UTC 19 November 2009 (253.0mm at Seathwaite)



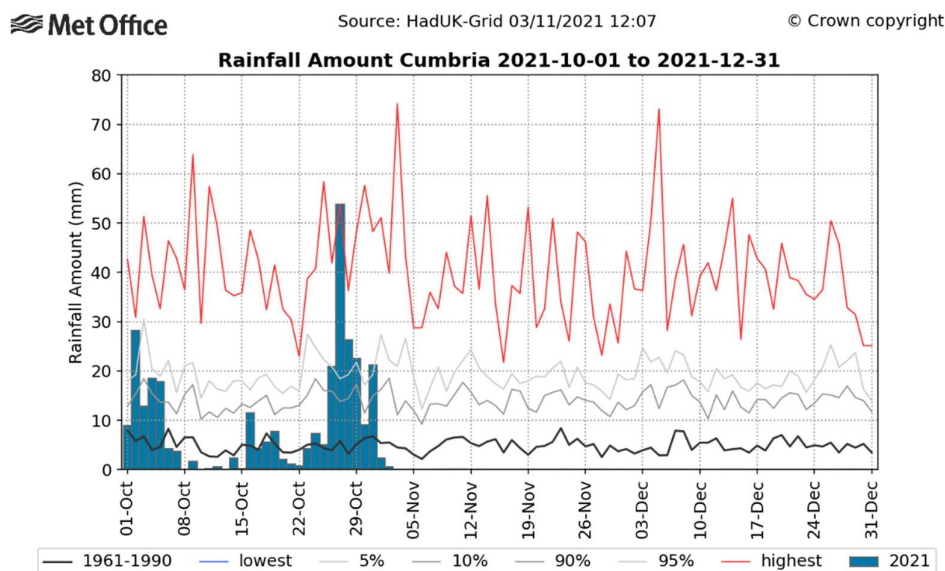
The maps below compare rainfall totals for 6-day periods in October 2021, December 2015 and November 2009 encompassing these rainfall events, with similar rainfall accumulations apparent for each with over 400mm across the Cumbrian fells and over 200mm in western upland areas including parts of Snowdonia, the Southern Uplands and West Highlands.



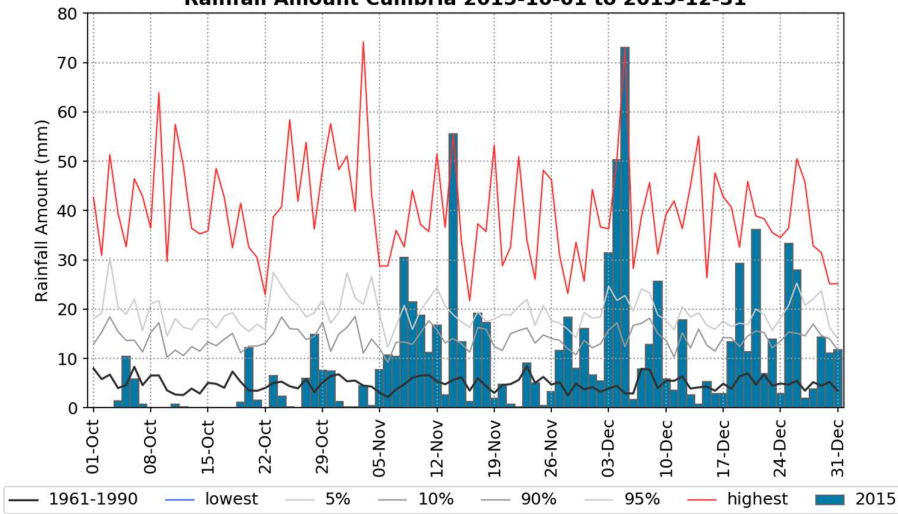
For Cumbria, the 6-day period 26 to 31 October 2021 was the third wettest such 6-day period on record in a daily series from 1891*. An area-average rainfall total of 153.8mm was recorded, 91% of the Cumbria 1981-2010 October long term average, exceeded only by 165.0mm from 16 to 21 November 2009 and 182.8mm from 30 November to 5 December 2015 (the latter including storm Desmond). The charts below compare Cumbria daily rainfall totals from October to December for 2021, 2015 and 2009.

*Based on Cumbria area-average values from the HadUK-Grid dataset.

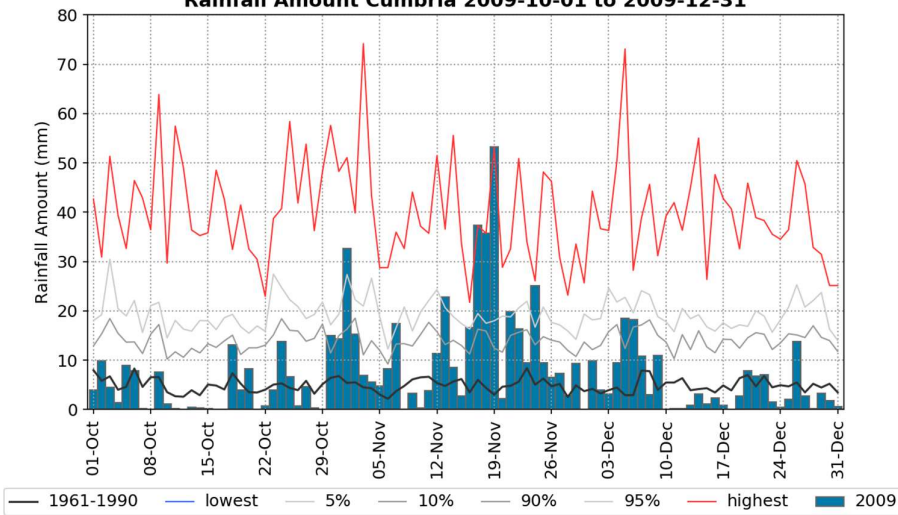
Cumbria daily rainfall series for October to December a) 2021 – b) 2015 – c) 2009. The red line shows the highest daily total for each calendar day based on a daily series from 1891.



Rainfall Amount Cumbria 2015-10-01 to 2015-12-31



Rainfall Amount Cumbria 2009-10-01 to 2009-12-31



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