New British and Irish Isles late-winter extreme barometric pressure, 29 March 2020

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During 28–29 March 2020, the rapid development of an anticyclone over the North Atlantic resulted in its central mean sea level (MSL) barometric pressure reaching 1055hPa near 59°N 20°W at 0000 UTC on 29 March. As the anticyclone slipped slowly south-eastwards over the following 12 hours, pressure exceeded 1050hPa in western Scotland and the north of Ireland, establishing new records at several long-running sites. Several factors combine to make this event unique in British climatology. Firstly, this was the second occasion during the winter of 2019/20 when 1050hPa was attained within the British and Irish Isles (the first being 19–20 January 2020), following an interval of more than 60 years since the previous such event. No previous winter in at least the last 200 years has seen two such events occur within one season. Secondly, during this event the previous March pressure record for the British and Irish Isles was exceeded, by over 3hPa: no previous event reaching 1050hPa over the British and Irish Isles has occurred so late in the winter season. Remarkably, between them the January and March 2020 events established new long-term high pressure records in all four capital cities within the United Kingdom – in London and Cardiff on 20 January, and Edinburgh and Belfast on 29 March.

Causes and development

An anomalously strong and persistent polar vortex remained in place for much of the first 3 months of 2020, and the intense thermal gradients on the periphery of the vortex resulted in powerful jet streams (speeds well in excess of 150kn on occasion) across the North Atlantic. This in turn led to the development of frequent and intense cyclonic activity, the most noteworthy of these being depression centres of 930hPa between Greenland and Iceland on 8 February, followed by another similar system that deepened to 919hPa south of Iceland on 15 February – close to the lowest on record for the North Atlantic (Burt, 1993). The divergent outflow at upper-troposphere levels from these intense cyclonic systems often accelerated anticyclonic development through convergence at or near the right jet entrance region (for an explanation of why this occurs

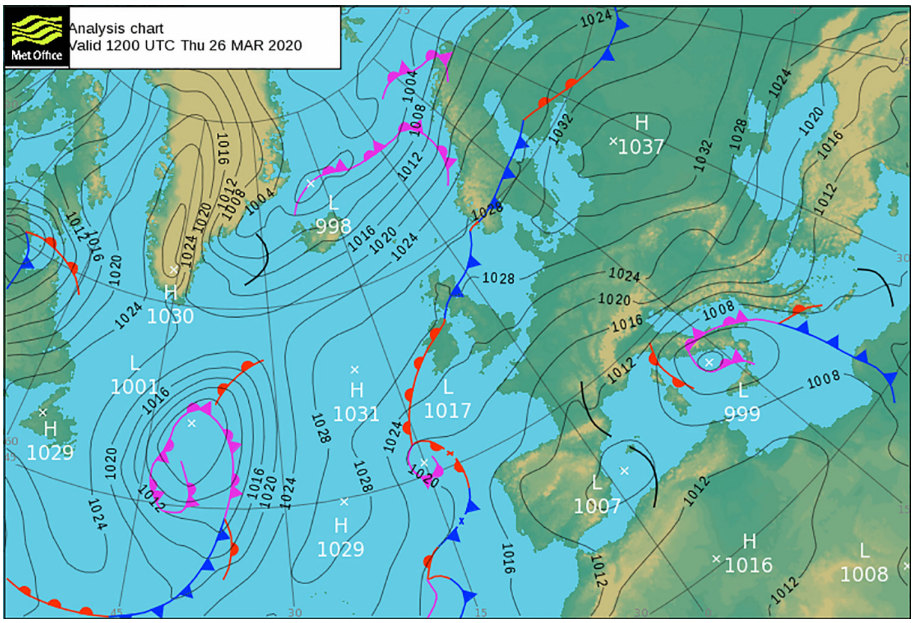

Figure 1. Met Office North Atlantic analysis chart for 1200 GMT 26 March 2020 (Courtesy Met Office: Crown Copyright.)

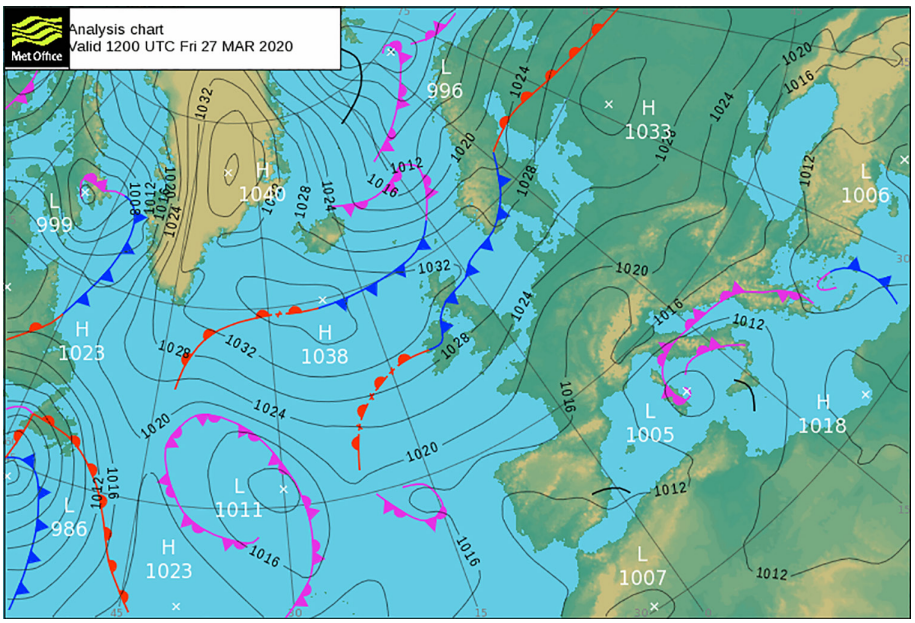

Figure 2. As Figure 1 but for 24 hours later, 1200 UTC 27 March 2020, showing the rapid development of the anticyclone in intensely cold air over Greenland. (Courtesy Met Office: Crown Copyright.)

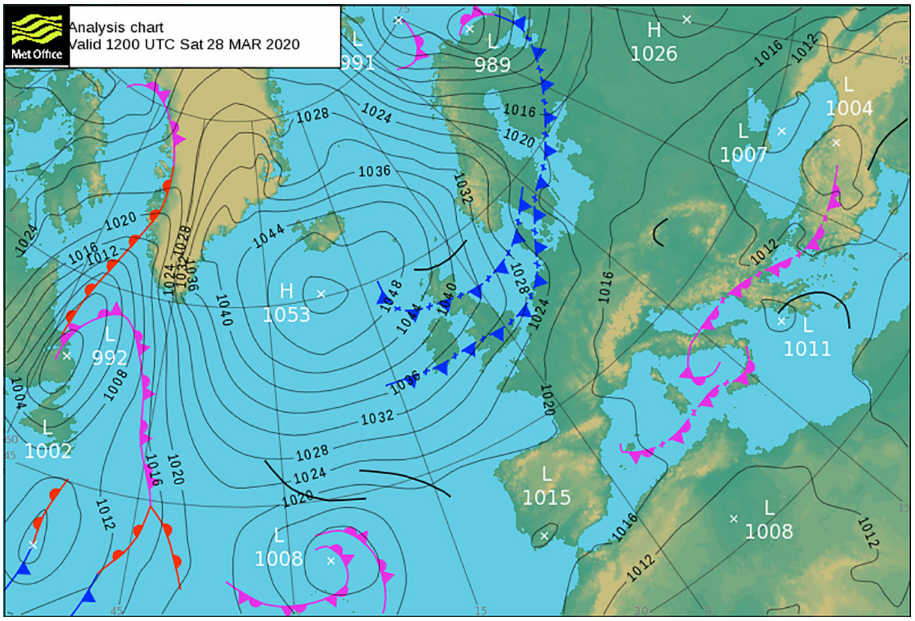

Figure 3. As Figure 2 but for 24 hours later, 1200 UTC 28 March 2020. The anticyclone has continued its rapid development while moving southeast and absorbing an existing area of high pressure, and has now become the dominant synoptic feature over the North Atlantic. (Courtesy Met Office: Crown Copyright.)

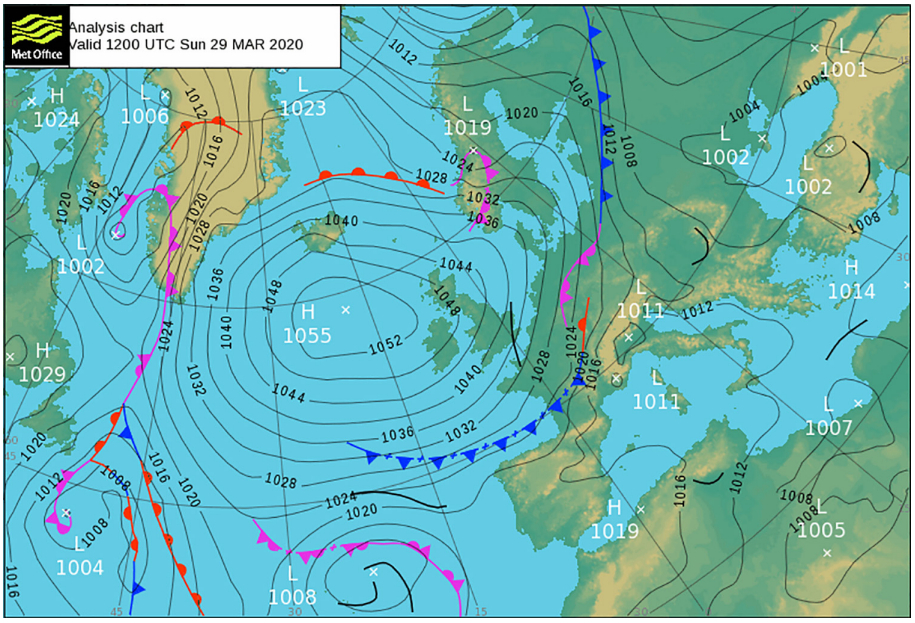

Figure 4. As Figure 3 but for 24 hours later, 0000 UTC 29 March 2020. The anticyclone is almost stationary, with its centre near 59°N 18°W, and has reached its peak central pressure of 1055hPa. The highest pressures over the British and Irish Isles were reached around the time of this chart. (Courtesy Met Office: Crown Copyright.)

see, e.g. McIlveen, 2010, Chapter 7), and as a result, several North Atlantic anticyclones reached or surpassed 1035–1040hPa between January and March. This meant that the pressure gradient across the North Atlantic exceeded 100hPa on several occasions. One such intense anticyclone developed very rapidly over 18–20 January, the barometer surpassing 1050hPa over southern England, northern France and Belgium on 19–20 January (Burt, 2020), giving London its highest barometric pressure in over 300 years.

On 22–23 March 2020, another intense cyclone developed off the east coast of the USA and moved rapidly northeast towards the Denmark Strait (between Iceland and Greenland), subsequently deepening to 955hPa. As this system matured and slowed, the jet stream flow buckled as an upper ridge amplified west of Greenland during 26–27 March, and a surface anticyclone began to build over Greenland in very cold air on the northern side of the upper ridge. The newly formed anticyclone centre first appeared on the UK Met Office North Atlantic anal-

Figure 5. Location of places referred to in the text.

ysis at 1200 UTC on 26 March with a centre of 1030hPa over southern Greenland (Figure 1). As the upper ridge slowed and became stationary over Greenland, the new anticyclone continued to intensify, and by 1200 UTC on 27 March, the centre lay over central Greenland at 1040hPa (Figure 2). Pressure continued to build in mid-Atlantic, and over the following 12 hours, the two anticyclonic centres merged as the anticyclone over Greenland built southwards and eastwards, amalgamating with and quickly absorbing the developing mid-Atlantic system. By 0000 UTC 28 March (not shown), the system had become the dominant synoptic feature over the North Atlantic, with twin centres of 1051hPa located just south of Iceland and close to 60°N 21°W. At 1200 UTC 28 March (Figure 3), the anticyclone centre lay close to 60°N 22°W, with a central pressure of 1053hPa. Outflow of the very cold air within its circulation is evident from the long double cold fronts over the eastern Atlantic, with strong and cold northerly or northeasterly winds affecting the British Isles; 1000–500hPa thickness values were just 517 dam at both Thorshavn (Faeroes) and Lerwick (Shetland) at this time.

Over the subsequent 24 hours, the anticyclone continued to drift a little further south and east. At 0000 UTC on 29 March, the centre lay close to 59°N 20°W, its central pressure having reached its maximum of 1055hPa; at this time, the 1048hPa isobar extended over the whole of western and northwestern Scotland. At Stornoway, the MSL barometer stood at 1050.2hPa at midnight. During 29 March, the centre began to migrate slowly westwards, maintaining its peak central pressure at or close to 1055hPa. The highest barometric pressures over the

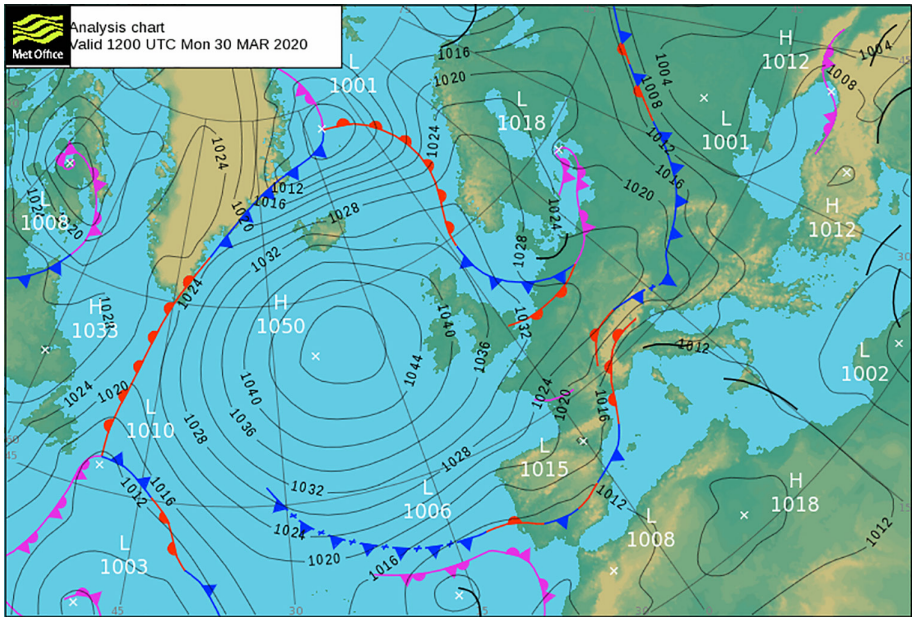

Figure 6. As Figure 4 but for 24 hours later, 1200 UTC 30 March 2020, the anticyclone centre having drifted a little west and south and begun to decline. (Courtesy Met Office: Crown Copyright.)

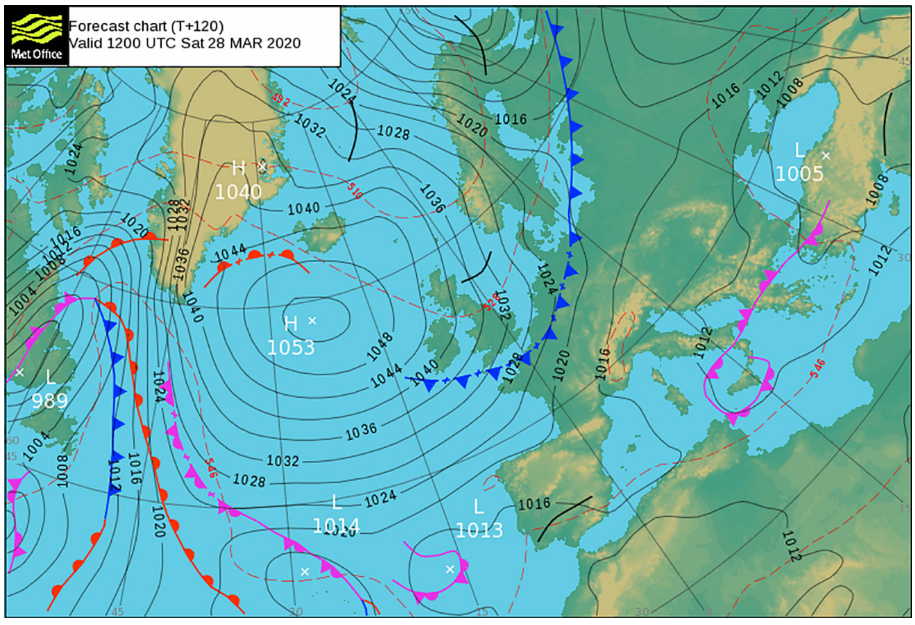

Figure 7. Met Office 120h North Atlantic surface forecast chart for 1200 GMT 28 March 2020, issued more than 60h prior to the synoptic situation depicted in Figure 1. The position and central pressure of the intense anticyclone, and the other surface features including fronts, are in almost perfect agreement with the analysis chart from 5 days later, as shown in Figure 3. (Courtesy Met Office: Crown Copyright.)

British and Irish Isles, namely, 1051.hPa at Tiree at 0900 and 1000 UTC, 1051.2hPa at South Uist at 0900 UTC and 1051.3hPa at Malin Head at 1100 UTC, were recorded about the time of the chart in Figure 4. (Locations are shown on Figure 5.) Cold northerly or northeasterly winds continued to blow across the British Isles, particularly strong on east and northeast-facing coasts, where gusts of 40kn or more occurred widely. Eastern and southeastern England saw showers of sleet, snow and hail during the day, despite the barometer remaining at or above 1040hPa.

Thereafter, the anticyclone continued its slow movement west-southwestwards, and began to weaken; Figure 6 shows the synoptic situation at 1200 UTC on 30 March, by which time the central pressure had declined to 1050hPa. It continued to drift slowly southwestwards, eventually losing its identity in mid-Atlantic on 3–4 April.

Was the event forecast?

As was the case in the winter's first extreme anticyclone in January 2020 (Burt, 2020), the event was well forecast several days in advance. Figure 7 shows the Met Office T+120 (5 day) forecast chart valid for 1200 UTC on 28 March 2020 for comparison with the subsequent analysis in Figure 3. This forecast was issued at 2229 UTC on 23 March, well before the anticyclone had begun to form over Greenland. The forecast position and intensity of the anticyclone were extraordinarily close to the subsequent analysis, despite this event being well outside previous North Atlantic climatology for so late in the winter.

The anticyclone over the British and Irish Isles, 29 March 2020

Figure 4 depicts the Met Office North Atlantic analysis at 1200 UTC on 29 March 2020, at about the closest approach of the centre of the anticyclone to the British and Irish Isles. Table 1 lists MSL pressures for a selection of synoptic stations in Scotland and the north of Ireland, where pressures surpassed 1048hPa, for the period 2100 UTC 28 March to 1500 UTC 29 March 2020. Figure 5 shows the locations of places referred to.

The first report of MSL pressure reaching or surpassing 1050hPa from a station within the British and Irish Isles was from Stornoway at 0000 UTC on 29 March, when 1050.2hPa was reported (Table 1). At South Uist Range, the pressure reached 1050.3hPa at 0100 UTC and 1050.6hPa at 0200 UTC before declining slowly, thereafter rising once more to 1050.4hPa at 0600 and thence to 1051.2hPa at 0900 UTC, the highest value reported from any site in the UK during this event. This represents a new record for the site for the period of the composite digital observation record with nearby Benbecula, extending back to 1957 (Table 1). In Ireland, Malin Head reached 1050.0hPa at 0700 UTC and thereafter rose slowly to 1051.3hPa at 1100 UTC, the highest value attained at any site in the British and Irish Isles on this occasion and a new site record since observations commenced there in May 1955 (and it was within 1hPa of the Irish national extreme, namely, 1051.9hPa recorded at Valentia on 29 January 1905 – Burt, 2007)[1]. At Malin Head, the barometer remained continuously at or above 1050hPa for nine consecutive hours (0700–1500 UTC on 29 March) and at or above 1040hPa for 62 consecutive hours, only falling below this level after 2300 UTC on 30 March. Figure 8 plots the hourly MSL barometric pressures recorded at Malin Head during 24–31 March 2020.

[1]Offshore, the M4 Donegal buoy at 55.0°N 10.0°W (Figure 5) reported 1051.9hPa at 1200 UTC on 29 March according to Met Éireann (https://www.met.ie/provisional-report-on-new-atmospheric-pressure-records-for-land-and-sea, accessed 24 April 2020).

Table 1

Reported MSL pressures (hPa), for the period 2100 UTC 28 March to 1500 UTC 29 March 2020, from a selection of synoptic stations, mostly located within the 1049hPa isobar on Figure 9. Values reaching or surpassing 1050hPa are shown in bold; the highest reported hourly pressure at each site is underlined. New site records are indicated: see also Table 2.

		Wick	Kinloss	Aberdeen Dyce	Edinburgh Gogarbank	Stornoway	South Uist Range	Tiree	Islay: Port Ellen	Glasgow Bishopton	Belfast Aldergrove	Malin Head	Claremorris	Belmullet	Mace Head
New site record		*x*	*x*		*x*		*x*	*x*		*x*	*x*	*x*			
	WMO IIiii	*03075*	*03066*	*03091*	*03166*	*03026*	*03023*	*03100*	*03150*	*03134*	*03917*	*03980*	*03970*	*03976*	*03963*
2020	*Time UTC*	*39m*	*7m*	*65m*	*57m*	*9m*	*10m*	*12m*	*17m*	*59m*	*81m*	*20m*	*24m*	*31m*	*23m*
28 March	2100	1047.3	1047.4	1045.1	1044.7	1049.3	1048.6	1046.7	1045.3	1045.1	1043.6	1045.0	1042.3	1043.7	1041.7
	2200	1047.5	1047.8	1045.6	1045.4	1049.7	1049.3	1047.6	1046.0	1045.9	1044.3	1045.8	1042.9	1044.3	1042.2
	2300	1047.9	1048.4	1046.2	1045.6	1049.8	1049.5	1048.2	1046.9	1046.4	1045.1	1046.6	1044.0	1045.0	1043.0
29 March	0000	1048.0	1048.5	1046.6	1046.2	**1050.2**	1049.9	1048.7	1047.4	1046.9	1046.0	1047.1	1044.7	1045.7	1043.8
	0100	1048.6	1048.8	1046.7	1046.6	**1050.3**	**1050.3**	1049.2	1048.1	1047.6	1046.5	1047.9	1045.3	1046.2	1044.4
	0200	1048.5	1049.1	1047.0	1046.7	**1050.3**	**1050.6**	1049.6	1048.1	1047.7	1046.9	1048.1	1045.9	1046.8	1044.9
	0300	1048.3	1049.0	1047.1	1047.0	**1050.2**	**1050.2**	1049.8	1048.7	1048.0	1047.0	1048.4	1046.3	1047.2	1045.3
	0400	1048.2	1049.0	1047.1	1047.1	**1050.0**	**1050.2**	1049.9	1048.8	1048.1	1047.4	1048.6	1046.7	1047.5	1045.7
	0500	1047.7	1048.7	1047.1	1047.0	1049.9	1049.9	**1050.0**	1049.2	1048.2	1047.5	1049.0	1047.3	1047.9	1046.1
	0600	1047.5	1048.6	1047.3	1047.4	1049.5	**1050.4**	**1050.2**	1049.4	1048.4	1047.9	1049.4	1048.0	1048.4	1047.0
	0700	1047.7	1049.0	1047.7	1048.0	1049.7	**1050.5**	**1050.6**	1049.9	1048.8	1048.4	**1050.0**	1048.5	1049.3	1047.8
	0800	1047.7	1048.9	1047.8	1048.4	1049.9	**1050.9**	**1050.8**	**1050.5**	1049.5	1048.9	**1050.6**	1049.0	1049.8	1048.4
	0900	1047.3	1049.1	1047.6	1048.5	1049.5	**1051.2**	**1051.1**	**1050.5**	1049.6	1049.4	**1050.8**	1049.3	**1050.1**	1048.7
	1000	1046.5	1048.8	1047.4	1048.7	1049.3	**1050.9**	**1051.1**	**1050.6**	1049.5	1049.6	**1051.0**	1049.4	**1050.4**	1048.8
	1100	1045.9	1048.1	1047.2	1048.7	1049.1	**1050.8**	**1050.8**	**1050.7**	1049.2	1049.8	**1051.3**	1049.3	**1050.5**	1048.7
	1200	1045.2	1047.7	1046.5	1048.3	1048.9	**1050.7**	**1050.7**	**1050.2**	1048.8	1049.7	**1051.0**	1049.3	**1050.6**	1048.9
	1300	1044.7	1047.0	1046.2	1047.8	1048.3	**1050.5**	**1050.5**	**1050.0**	1048.3	1049.3	**1050.8**	1049.0	**1050.5**	1048.8
	1400	1044.2	1046.3	1045.4	1047.4	1047.9	1049.8	**1050.3**	1049.8	1047.9	1049.0	**1050.5**	1048.5	**1050.1**	1048.4
	1500	1043.5	1046.0	1044.5	1046.5	1047.5	1049.3	1049.7	1049.6	1047.2	1048.6	**1050.4**	1048.4	**1050.3**	1048.1

Source: synoptic reports via Ogimet.com.

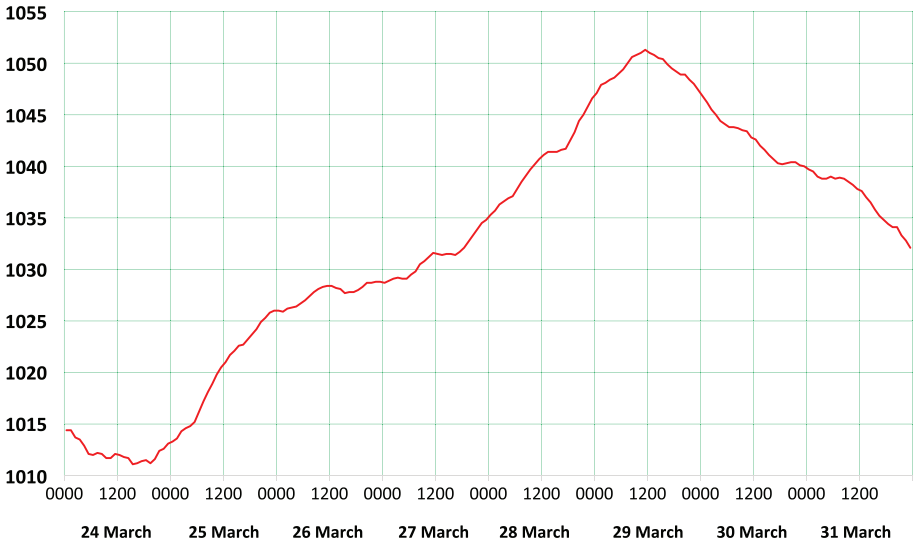

Figure 8. MSL barometric pressure (hPa) at Malin Head (WMO No. 03980) for the period 24–31 March 2020, plotted from hourly synoptic observations. Time is in UTC. The highest value attained, 1051.3hPa at 1100 UTC on 29 March, was the highest barometric pressure recorded anywhere in the British and Irish Isles since December 1926.

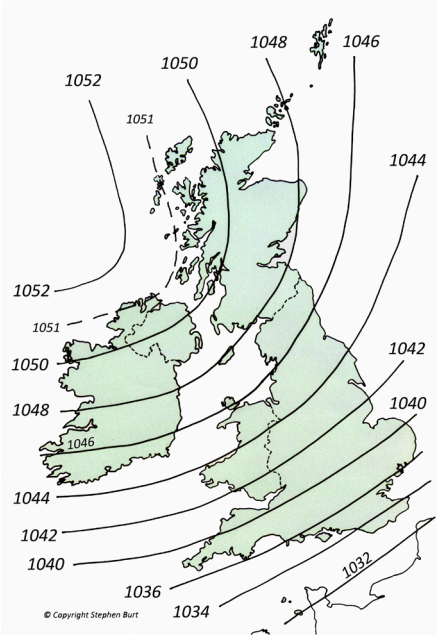

Figure 9. Highest reported MSL barometric pressures on 29 March 2020, in hPa, from hourly synoptic reports. Isobars are plotted at 2hPa intervals.

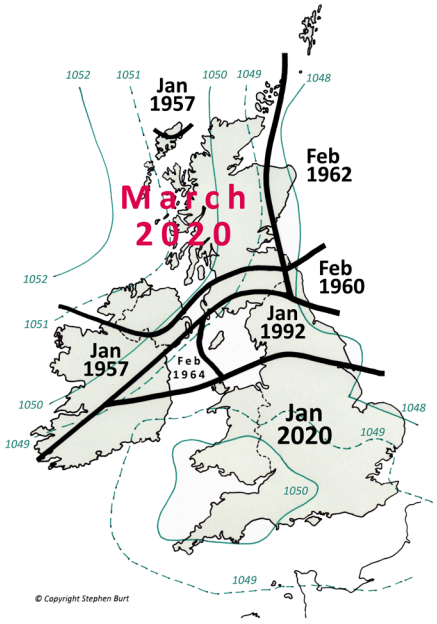

Figure 10. Dates and areas of highest observed MSL pressure since 1949, with isobars (in hPa). Updated from Figure 12 in Burt (2007) to include January and March 2020 events.

Climatological significance

Figure 9 shows the highest barometric pressures recorded in the British and Irish Isles on 29 March 2020, based upon hourly synoptic reports: Figure 10 shows both the highest known pressure on post-war record (since 1949) and the date of occurrence of that event[2]. Table 2 compares March 2020 pressure extremes at several long-period sites in northern, northeastern and western Scotland and Northern Ireland: new extremes were established at nine locations, including 70-year records at Glasgow and Belfast, and also in the Republic of Ireland. Table 2 updates Table 2 in Burt (2007) for these areas to March 2020.

The March 2020 event was exceptional for three reasons: its rarity, the establishment of a new March British and Irish Isles pressure extreme, and for its unprecedented lateness in the winter season.

Although this event was the second occasion on which 1050hPa had been attained in the British and Irish Isles in a 10-week period, prior to 19–20 January 2020 this level had not been previously reached since January 1957. This was also the first occasion since at least the year 1800 that 1050hPa has been reached in the British and Irish Isles on two separate occasions within a single winter, and it is also notable that new long-term high-pressure records were established in all four capital cities within the UK – in London and Cardiff on 20 January and Edinburgh and Belfast on 29 March. On this occasion, the Malin Head maximum, 1051.3hPa at 1100 UTC on 29 March 2020, also became the highest MSL pressure recorded anywhere in the British and Irish Isles since 24 December 1926, when 1051.9hPa was recorded at Wick (Burt, 2007). Although extremely high, the highest pressures reported on this most recent occasion fell some way short of the highest on record for the British or Irish Isles, namely, 1053.6hPa recorded at Aberdeen Observatory on 31 January 1902 (Burt, 2006, 2007).

This event established a new British and Irish Isles record barometric pressure for March. Prior to March 2020, the highest March pressure on record for anywhere in the British and Irish Isles appears to have been 1047.9hPa, recorded at Scilly on 3 March 1990 (Met Office *Monthly Weather Report*)[3]. This value was comprehensively exceeded by the Malin Head maximum of 1051.3 hPa on 29 March 2020.

Most extraordinary of all is the extreme lateness of this event in the winter season. Figure 11 shows the highest pressure for all occasions since about 1800 when the MSL pressure has risen to 1048hPa anywhere in the British and Irish Isles, plotted against the date on which it occurred (based on the table in Burt, 2007, updated to 2020). Until 2020, the latest date on which 1050hPa has been attained in over 200 years of records has been 24 February, in 1808, in northeast Scotland. The 28–29 March 2020 event clearly sits well outside the 'envelope' of all previous events of this nature.

[2]All quoted records for this event are from synoptic pressure observations, mostly hourly and from automatic weather stations, as reported. Slightly higher values may have occurred in between synoptic reports at some sites. There are uncertainties of up to perhaps 0.3hPa in the values tabulated and plotted, particularly for upland sites (see boxed text in Burt, 2020 for a longer discussion).

[3]For many years, the highest March MSL pressure recorded in the British and Irish Isles was quoted as 1048.6hPa, recorded at Tynemouth on 9 March 1953. This value originated from the Met Office station data computer archive and is quoted in numerous Met Office publications (e.g. Met Office, 1973: Averages of mean sea level barometric pressure for the United Kingdom 1941–70. Meteorological Office, *Climat. Mem.* 51A and Met Office, 2011: Weather Extremes, National *Meteorological Library and Archive Factsheet 9*) and was duly included in Burt (2007). However, the Tynemouth value has since been found to be incorrect: the online Daily Weather Report available at URL https://digital.nmla.metoffice.gov.uk clearly shows the value to have been amended in red ink from 1048.6 to 1043.6hPa, while the highest pressure recorded anywhere on that occasion was just over 1044hPa.

Table 2

Sites where the highest barometric pressure in March 2020 approached or surpassed the previous extreme at a number of long-period observing sites in the UK and Ireland (typically 60 years or more of computerised hourly or three-hourly observations available in the UK Met Office and Met Éireann data archives. Where two or more stations are bracketed together, the highest and lowest values from the combined record have been used). Values are in hPa; new extremes are shown in bold type. Slightly higher values may have occurred between hourly or 3-hourly observations. All times quoted are UTC. This is an update to Table 2 in Burt (2007).

WMO station ID (03iii), region and station	*Period of record*	*Previous highest Value/date*	*March 2020 highest Value/date*
Northern Scotland			
005 Lerwick	1957-3/2020	1049.1	1046.8
		09 h 23 Feb 1962	00, 01 h 29 March 2020
075 Wick	1957-3/2020	1047.6	**1048.6**
		09 h, 12 h 16 Jan 1957	01 h 29 March 2020
049 Cape Wrath	1957-9/1997	1049.1	**1049.8**
044 Altnaharra	10/1997-3/2020	09 h 16 Jan 1957	01 h 29 March 2020
026 Stornoway	1957-3/2020	1050.4	1050.3
		09 h 16 Jan 1957	01, 02 h 29 March 2020
Northeast Scotland			
066 Kinloss	1959-3/2020	1047.3	**1049.1**
		09 h 23 Feb 1962	01 h 29 March 2020
091 Aberdeen/Dyce	1957-3/2020	1048.7	1047.8
		09 h 23 Feb 1962	08 h 29 March 2020
049 Edinburgh/Turnhouse	1957-10/1999	1048.5	**1048.7**
166 Edinburgh/Gogarbank	11/1999-3/2020	03 h 16 Jan 1957	10, 11 h 29 March 2020
Western Scotland			
022 Benbecula	1957-7/1996	1050.9	**1051.2**
023 South Uist Range	8/1996-3/2020	09 h 16 Jan 1957	09 h 29 March 2020
100 Tiree	1957-3/2020	1050.3	**1051.1**
		09 h 16 Jan 1957	09, 10 h 29 March 2020
140 Glasgow – Renfrew	1949-4/1966		
140 Glasgow – Abbotsinch	5/1966-4/1999	1049.4	**1049.6**
134 Glasgow – Bishopton	5/1999-3/2020	03 h 16 Jan 1957	09 h 29 March 2020
135 Prestwick	1957-1/1997	1049.4	1049.3
136 Prestwick RNAS	2/1997-3/2020	03 h 16 Jan 1957	11 h 29 March 2020
Northern Ireland			
917 Belfast Aldergrove	1949-3/2020	1049.6	**1049.8**
		06 h 16 Jan 1957	11 h 29 March 2020
Republic of Ireland			
980 Malin Head	5/1955-3/2020	1050.6	**1051.3**
		09 h 16 Jan 1957	11 h 29 March 2020
976 Belmullet	9/1956-3/2020	1050.9	1050.6
		08 h 16 Jan 1957	12 h 29 March 2020
970 Claremorris	1950-3/2020	1050.8	1049.4
		09 h 16 Jan 1957	10 h 29 March 2020

Source: Historical data from Burt (2007), 2020 synoptic reports from Ogimet.com.

Summary and conclusions

The development and rapid intensification of an intense anticyclone over the North Atlantic, and its close approach to the British and Irish Isles at its maximum extent on 29 March 2020, resulted in the highest MSL barometric pressure recorded anywhere in the British and Irish Isles since December 1926 and the unique occurrence within a single winter of a second 1050hPa event over the British and Irish Isles. This event occurred more than a month later than any previous such occasion in the British and Irish Isles within the last two centuries and more. New post-WWII site records were established widely in northern, north-east and western Scotland and in Northern Ireland and the north of the Republic of Ireland, while the previous British and Irish Isles March extreme pressure was exceeded by over 3hPa. Remarkably, between them, the January and March 2020 events established new long-term high pressure records in all four capital cities within the UK – in London and Cardiff on 20 January and Edinburgh and Belfast on 29 March.

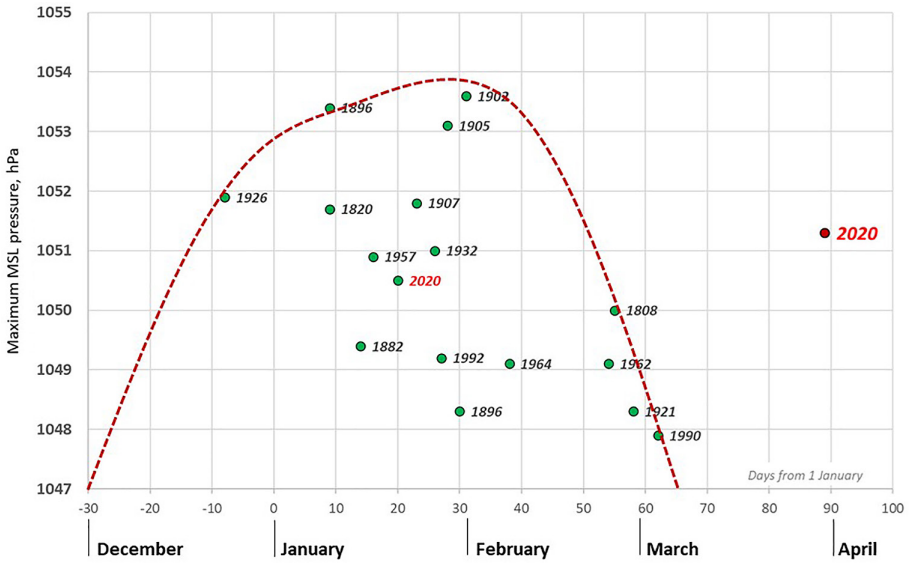

Figure 11. The highest MSL barometric pressures observed anywhere in the British and Irish Isles since about 1800, plotted against the date on which they occurred. The March 2020 event lies well outside the 'envelope' of all previous events within the last 200 years or more. The January 2020 event is also highlighted.

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