

Storm Arwen

Friday 26 November 2021

First named storm of the 2021/2022 season. Named by Met Office (United Kingdom)

Date issued: Thursday 1 September 2022

The following storm analysis is completed for the named storm Arwen. The impact date for Ireland was Friday 26 November 2021, this date is based upon the date of the storm's highest sustained (10-minute mean) wind speed of 96 km/h observed at 21 UTC at Malin Head, Co Donegal.

Storm Arwen developed to the north of Iceland on Thursday 25 November 2021 as an innocuous looking low-pressure system. The Jetstream, which was steered around an intense blocking anticyclone in the mid North Atlantic, interacted with the low-pressure system north of Iceland. This led to the unusual development area and trajectory of the storm. The low-pressure system, which became storm Arwen, engaged with the left exit of the Jetstream and rapidly developed as it dived south south-eastwards towards the east coast of Scotland. A steep pressure gradient developed between the intensifying storm in the North Sea and the blocking anticyclone in the North Atlantic, which pushed the isobars together over Ireland, resulting in northerly gales, reaching storm force 10 at Malin Head, Co

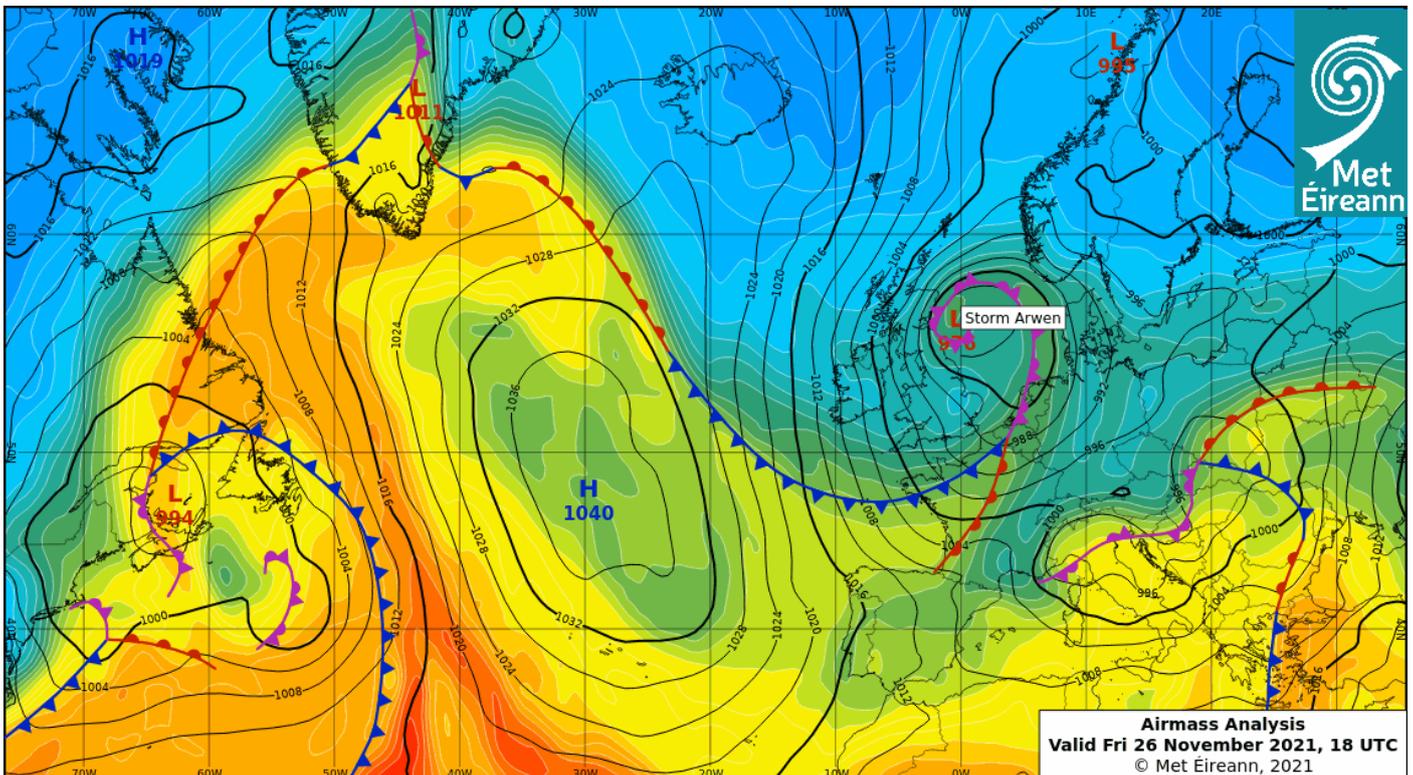


Figure 1. This chart was chosen using the highest gust wind speed 130 km/h at Malin Head, Co Donegal at 22:05 UTC on Friday 26 November 2021.

Donegal on Friday 26 November. While the strongest of the winds from storm Arwen occurred along the east coast of the UK, where most of the impacts were felt, a large area covering most of the UK and Ireland saw very strong northerly winds between the storm center, just off the east coast of England and the anticyclone to the west of Ireland. A very cold polar maritime air mass accompanied the northerly gales, which brought widespread wintry showers across the country. On Saturday 27 November, Ireland lay in a strong to gale force northerly airflow as storm Arwen tracked southwards down along the east coast of England. During Saturday 27th, the storm continued to drift away to the South before decaying across northern France later on Saturday.

The storm touched the shores of east Scotland late Friday 26th with the most significant weather conditions for Ireland were felt in the North and Northwest of the country and in the Irish Sea. Ireland lay in a strong to gale force northerly airflow between an anticyclone of 1043 hPa in the mid-Atlantic and a complex depression of 987 hPa centred between Scotland and Norway. Storm Arwen brought showers that fell heavy at times in the North as sleet and snow over hills and mountains. Scattered showers remained countrywide until 6:00 pm (local time). After which, the scattered showers were confined to the North and the West of the country. The highest gusts of up to 70 knots (129.64 km/h) was recorded at Malin Head, Co. Donegal and the highest sustained (10-min mean) wind speed was also recorded at Malin Head, Co. Donegal. In Finner Co. Donegal 5.6 mm of daily rain was observed. On Saturday the 27th Ireland lay in a strong to gale force northerly airflow as Storm Arwen tracked southwards down the east of England with a central pressure of 979 hPa. Showery day, wettest in West, Southwest and North and driest in Southeast and East. Scattered heavy showers during midnight until 7:00 am (local time). The showers continued through the afternoon. By evening these showers turned more scattered.

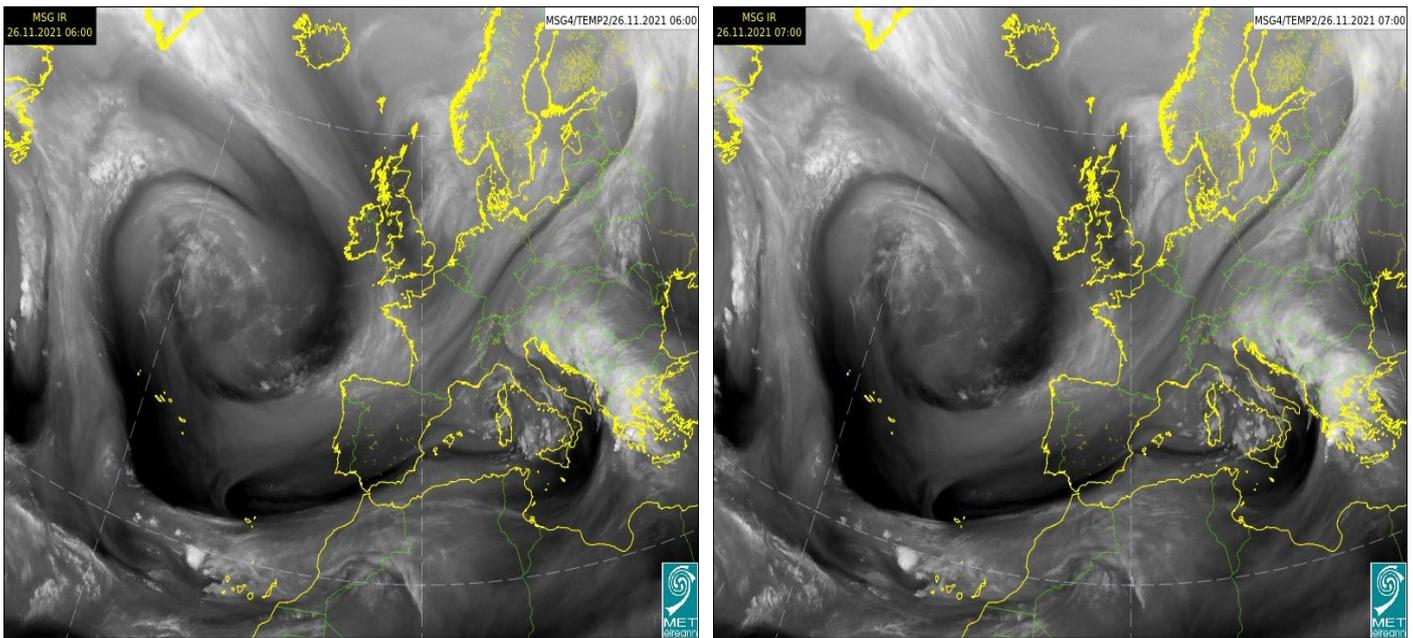


Figure 2 and 3. Satellite images closest to hour (0600 UTC) of the lowest mean sea level pressure 998.5 hPa at Malin Head, Co Donegal on Fri 26 Nov 2021

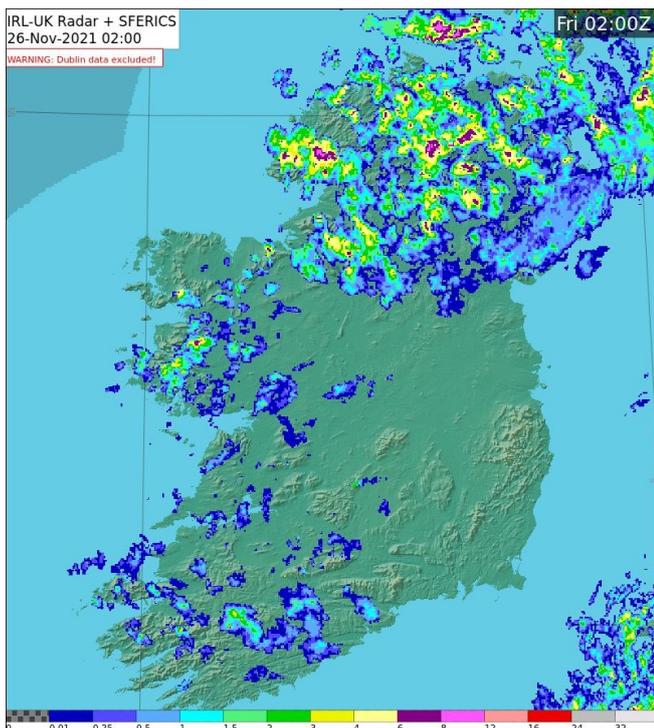


Figure 4. On Fri 26 Nov 2021 in the hour ending 02 UTC 2.2 mm of rain fell at Newport, Co Mayo

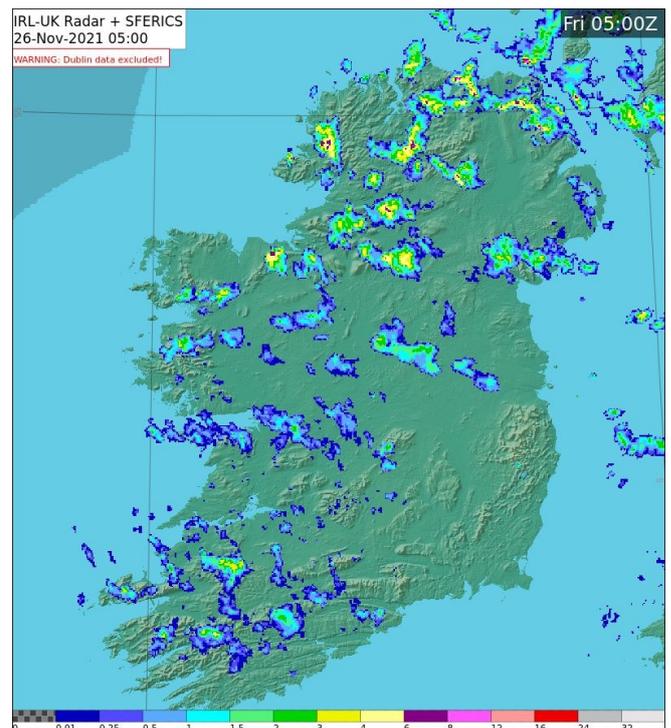


Figure 5. On Fri 26 Nov 2021 in the hour ending 05 UTC 2.6 mm of rain fell at Markree Castle, Co Sligo

Atmospheric mean sea level pressure (hPa)

The minimum hourly mean sea level pressure (MSLP) observed in Ireland during Storm Arwen was 998.5 hPa at Malin Head, Co Donegal on the Friday 26 November 2021. A pressure drop of approximately 35 hPa occurred at Malin Head, Co Donegal over a 24-hour period between 00:00 on Thursday 25 and 12:00 on Friday 26, when the low-pressure centre was positioned to the east of Scotland.

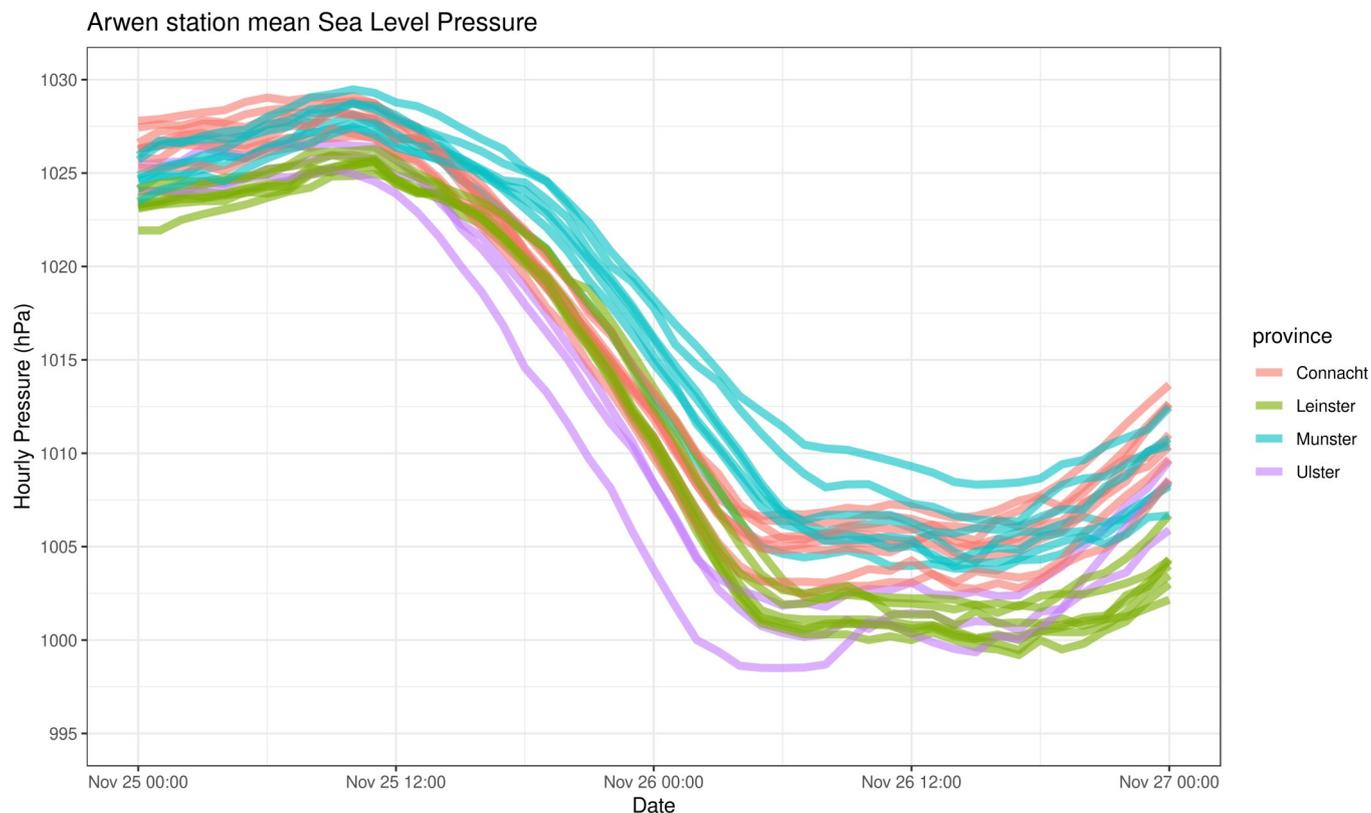


Figure 6: On Sun 25,26 and 17 Jan 2022 mean sea level pressure for all synoptic stations and coloured by provinces

Impacts

Tragedies:

- Three men died as a result of falling trees in the UK, including one man in County Antrim, after his car was hit by a falling tree.

Power Outages:

- An estimated 100,000 homes and businesses lost power in Scottish and Southern Electricity Networks, with over 9,000 homes without power for more than eight days. As a result, the UK Ministry of Defence deployed 297 soldiers in supporting civil authorities conducting door-to-door checks and providing support to the most affected areas.

Travel:

- Travel disruptions were mainly confined to roads and railways. However, ferry services in the Irish Sea and air travel experienced some delays also. ScotRail made a statement that significant disruption to services had occurred on the night of the 26th from falling trees and debris affecting travel the following Saturday morning.

Forestry:

- Tens of thousands of trees were toppled during the storm with Forestry England stating the clear up would take several months. In the UK the impact from the storm on trees in historic gardens wrenched champion trees in Bodnant Garden, Conwy Valley north Wales, where a 140-year-old 167ft Coast Redwood was toppled.

Farming:

- The National Farmers Union Scotland said the damage to farm buildings, walls, roofs and polytunnels will likely run into the millions of pounds.

Table 1. Observations at SYNOPTIC STATIONS

The following table contains wind speeds and rainfall observations at Met Éireann's SYNOPTIC stations over 3 days, between Thursday 25 November 2021 and Saturday 27 November 2021. Some observations have weather warning thresholds and these are highlighted. See the weather warnings page on www.met.ie.

Station location	Sustained (10-min mean) Wind Speed	Date highest mean	Wind Direction Highest sustained	Gust (3-sec mean) Wind Speed	Date Highest Gust	Wind Direction Highest Gust	Daily Rain (mm)	Total Rain (mm)
Malin Head* Co Donegal	96 km/h Storm Force (52 knots or 60)	Fri 26 Nov 2021 21UTC	0° (N)	130 km/h (70 knots or 81 mph)	Fri 26 Nov 2021 2205 UTC	0° (N)	3.7 Fri 26 Nov 2021	7.2
Mace Head** Co Galway	69 km/h Gale Force 8 (37 knots or 43)	Fri 26 Nov 2021 17UTC	340° (NNW)	107 km/h (58 knots or 67 mph)	Fri 26 Nov 2021 1710 UTC	340° (NNW)	4.0 Fri 26 Nov 2021	5.1
Finner Co Donegal	63 km/h Gale Force 8 (34 knots or 39)	Fri 26 Nov 2021 13UTC	330° (NNW)	94 km/h (51 knots or 59 mph)	Fri 26 Nov 2021 0653 UTC	320° (NW)	5.6 Fri 26 Nov 2021	10.3
Roches Point Co Cork	63 km/h Gale Force 8 (34 knots or 39)	Fri 26 Nov 2021 10UTC	310° (NW)	85 km/h (46 knots or 53 mph)	Fri 26 Nov 2021 1832 UTC	330° (NNW)	0.6 Fri 26 Nov 2021	0.6
Newport Co Mayo	59 km/h Near Gale (32 knots or 37)	Fri 26 Nov 2021 03UTC	290° (WNW)	93 km/h (50 knots or 58 mph)	Fri 26 Nov 2021 1935 UTC	340° (NNW)	13.2 Fri 26 Nov 2021	20.9
Belmullet Co Mayo	57 km/h Near Gale (31 knots or 36)	Fri 26 Nov 2021 18UTC	340° (NNW)	93 km/h (50 knots or 58 mph)	Sat 27 Nov 2021 0333 UTC	0° (N)	4.8 Fri 26 Nov 2021	10.4
Cork Airport Co Cork	56 km/h Near Gale (30 knots or 35)	Fri 26 Nov 2021 09UTC	320° (NW)	83 km/h (45 knots or 52 mph)	Fri 26 Nov 2021 2158 UTC	320° (NW)	1.5 Fri 26 Nov 2021	1.6
Valentia Observa- tory Co Kerry	52 km/h Near Gale (28 knots or 32)	Sat 27 Nov 2021 01UTC	10° (N)	85 km/h (46 knots or 53 mph)	Fri 26 Nov 2021 1838 UTC	340° (NNW)	4.3 Fri 26 Nov 2021	9.5
Sherkin Island Co Cork	52 km/h Near Gale (28 knots or 32 mph)	Sat 27 Nov 2021 12UTC and Fri 26 Nov 2021	330° (NNW) and 310° (NNW)	81 km/h (44 knots or 51 mph)	Fri 26 Nov 2021 2023 UTC	340° (NNW)	2.2 Fri 26 Nov 2021	2.4
Dublin Airport Co Dublin	52 km/h Near Gale (28 knots or 32)	Fri 26 Nov 2021 13UTC	320° (NW)	72 km/h (39 knots or 45 mph)	Sat 27 Nov 2021 0208 UTC	330° (NNW)	0.3 Fri 26 Nov 2021	0.3
Knock Airport Co Mayo	48 km/h Strong Breeze (26 knots or 30 mph)	Thu 25 Nov 2021 midnight and Fri 26 Nov 2021	290° (WNW) and 330° (WNW)	85 km/h (46 knots or 53 mph)	Fri 26 Nov 2021 1112 UTC	330° (NNW)	8.0 Fri 26 Nov 2021	12.1
Shannon Airport Co Clare	46 km/h Strong Breeze (25 knots or 29)	Fri 26 Nov 2021 21UTC	320° (NW)	80 km/h (43 knots or 49 mph)	Fri 26 Nov 2021 1722 UTC	350° (N)	3.4 Fri 26 Nov 2021	3.8
Claremorris Co Mayo	43 km/h Strong Breeze (23 knots or 26)	Fri 26 Nov 2021 23UTC	350° (N)	81 km/h (44 knots or 51 mph)	Fri 26 Nov 2021 1841 UTC	340° (NNW)	7.0 Fri 26 Nov 2021	10.7
Dunsany Co Meath	43 km/h Strong Breeze (23 knots or 26)	Fri 26 Nov 2021 15UTC	310° (NW)	69 km/h (37 knots or 43 mph)	Fri 26 Nov 2021 1509 UTC	320° (NW)	3.1 Fri 26 Nov 2021	3.1

Athenry Co Galway	43 km/h Strong Breeze (23 knots or 26 mph)	Fri 26 Nov 2021 12UTC	320° (NW)	67 km/h (36 knots or 41 mph)	Fri 26 Nov 2021 1250 UTC	330° (NNW)	4.5 Fri 26 Nov 2021	6.0
Gurteen Co Tipperary	43 km/h Strong Breeze (23 knots or 26 mph)	Fri 26 Nov 2021 11UTC	290° (WNW)	67 km/h (36 knots or 41 mph)	Fri 26 Nov 2021 1607 UTC	340° (NNW)	2.0 Fri 26 Nov 2021	2.0
Mount Dillon Co Roscommon	41 km/h Strong Breeze (22 knots or 25 mph)	Fri 26 Nov 2021 09UTC	310° (NW)	74 km/h (40 knots or 46 mph)	Fri 26 Nov 2021 1505 UTC	340° (NNW)	4.1 Fri 26 Nov 2021	4.2
Johnstown Cas- tle Co Wexford	41 km/h Strong Breeze (22 knots or 25 mph)	Sat 27 Nov 2021 00UTC and Fri 26 Nov 2021 00UTC	330° (NNW) and 310° (NNW)	70 km/h (38 knots or 44 mph)	Fri 26 Nov 2021 2343 UTC and Sat 27 Nov 2021 0056 UTC	320° (NW) and 330° (NW)	0.3 Fri 26 Nov 2021	0.4
Casement Aero- drome Co Dublin	41 km/h Strong Breeze (22 knots or 25 mph)	Fri 26 Nov 2021 02UTC	250° (WSW)	61 km/h (33 knots or 38 mph)	Fri 26 Nov 2021 2135 UTC	310° (NW)	2.7 Fri 26 Nov 2021	2.7
Ballyhaise Co Cavan	39 km/h Fresh Breeze (21 knots or 24 mph)	Sat 27 Nov 2021 00UTC	330° (NNW)	69 km/h (37 knots or 43 mph)	Sat 27 Nov 2021 0024 UTC	340° (NNW)	4.6 Fri 26 Nov 2021	5.5
Oak Park Co Carlow	35 km/h Fresh Breeze (19 knots or 22 mph)	Fri 26 Nov 2021 11UTC and Sat 27 Nov 2021 1UTC	310° (NW) and 330° (NW)	61 km/h (33 knots or 38 mph)	Fri 26 Nov 2021 1123 UTC	320° (NW)	1.4 Fri 26 Nov 2021	1.4
Moore Park Co Cork	35 km/h Fresh Breeze (19 knots or 22 mph)	Fri 26 Nov 2021 13UTC	310° (NW)	61 km/h (33 knots or 38 mph)	Fri 26 Nov 2021 1349 UTC	300° (WNW)	0.8 Fri 26 Nov 2021	1.1
Mullingar Co Westmeath	31 km/h Fresh Breeze (17 knots or 20 mph)	Fri 26 Nov 2021 07UTC	290° (WNW)	56 km/h (30 knots or 35 mph)	Fri 26 Nov 2021 0706 UTC and Sat 27 Nov 2021 0020 UTC	290° (WNW) and 320° (WNW)	3.2 Fri 26 Nov 2021	3.2

Table 2: Marine Impacts

The following table was provided by the Met Éireann Marine Unit (on 8-Feb-2022) for the days 25-27 November 2021.

buoy	Max Mean Winds	Max Gust	Max Sig. Wave	Max Individual
M2	74 km/h Gale Force 8	107 km/h 58 knots 67 mph	5.3 m	7.7 m
M3	74 km/h Gale Force 8	96 km/h 51 knots 60 mph	6.8 m	12. m
M4	59 km/h Near Gale	85 km/h 46 knots 53 mph	7.8 m	13.3 m
M5	57 km/h Near Gale	91 km/h 49 knots 56 mph	4.3 m	7.2 m
M6	61 km/h Near Gale	78 km/h 42 knots 48 mph	6.4 m	11.1 m

Wind warnings issued for Storm Arwen

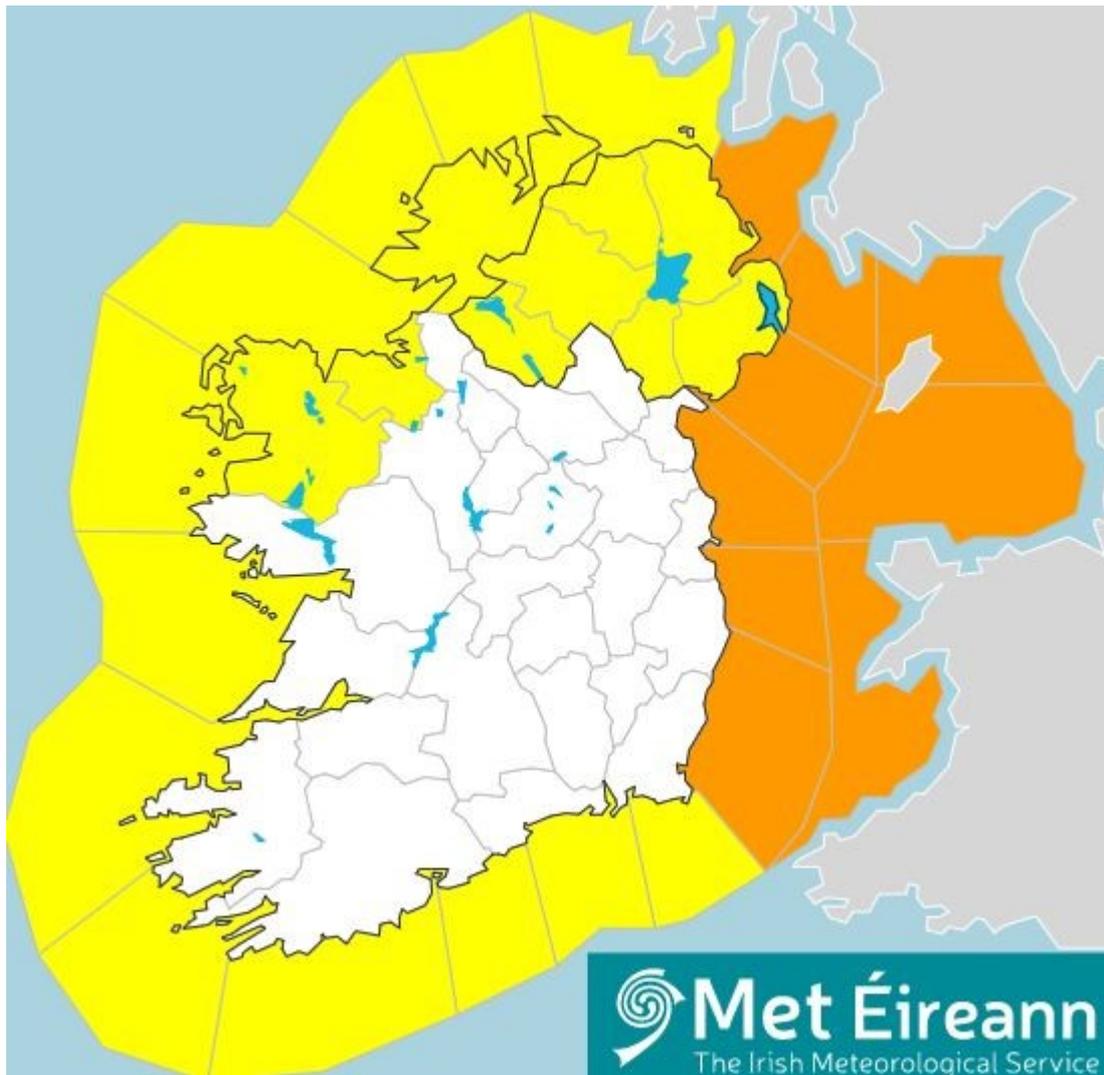


Figure 7: Wind warnings issued by Met Éireann and Met Office (United Kingdom) for Storm Arwen

Climate projections for Ireland

Due to its geographic location along the Western edge of Europe, Ireland is affected by mid-latitude wind storms. Latest future projections indicate an overall decrease of 10% in the number of less severe storms affecting Ireland by the middle of the 21st century (Nolan and Flanagan, 2020). These projections also show there will be an eastward extension of the more severe wind storms over Ireland.

As our planet warms, so does our atmosphere. Warmer air has the ability to hold more moisture. In Ireland, we have seen an increase in average annual rainfall by about 6% over the last 30 years (compared to the previous 30 years).

Latest future climate projections for Ireland indicate a decrease in mean rainfall by mid-century; a decrease in mean annual and spring and summer rainfall (Nolan and Flanagan, 2020) while heavy rainfall events are expected to become more frequent. Rainfall is expected to become more variable, with projected increases in frequency of both heavy rainfall events and dry periods also. These projections are in line with those carried out previously (e.g. Nolan 2015, Nolan 2017).

These projections were downscaled from CMIP5 output of the EC-Earth global climate model (Hazeleger 2012).

References

- Hazeleger, W, X Wang, C Severijns, S Stefanescu, R Bintanja, A Sterl, K Wyser, T Semmler, S Yang, B van den Hurk, T van Noije, E van der Linden, and K van den Wiel (2012), EC-Earth V2: description and validation of a new seamless Earth system prediction model. *Climate Dynamics*, 39, 2611-2629
- Nolan P, 2015. Ensemble of Regional Climate Model Projections for Ireland. Environmental Protection Agency, Johnstown Castle, Ireland. Nolan P and McKinstry A
- Nolan P, Flanagan J (2020). Research 339: High-resolution Climate Projections for Ireland. A Multi-model Ensemble Approach. EPA report 339
- Nolan P, O'Sullivan J, and McGrath R (2017). Impacts of climate change on mid-twenty-first-century rainfall in Ireland: a high-resolution regional climate model ensemble approach. *International Journal of Climatology*

Definitions

Gust wind speeds are an average of 3-second wind speeds.

Sustained wind speeds are an average of 10-minute wind speeds. For observations of sustained wind speeds:

- Storm Force 10 \geq 89 km/h (48 knots)
- Violent Storm Force 11 \geq 103 km/h (56 knots)
- Hurricane Force 12 \geq 117 km/h (64 knots)

This report is based on the data observed at Met Éireann's weather stations and available on this date.

All times are UTC unless stated they are local Irish time.

Synoptic station data is midnight to midnight UTC.

Long-Term Averages (LTAs) and 'normal' refer to the observations being averaged over the period 1981-2010.

*Sunshine data is from the Autosol Network. LTAs for these sites are currently not used for comparison purposes.

For more information, contact Met Éireann at e-mail: enquiries@met.ie