Natural Hazards PARTNERSHIP

Science Note
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Advice provided by:

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British Geological Survey

Cabinet Office

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Environment Agency

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Health & Safety Laboratory

National Oceanography Centre

NERC Science of the Environment

Ordnance Survey

The Scottish Government Riaghaltas na h-Alba

SEPA Scottish Environment Protection Agency

UK Space Agency

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Wind

This Science Note is one of a series of short guides covering a range of natural hazards. These guides aim to provide non-experts with a brief introduction to each hazard and to highlight key aspects that may need to be taken into account in decision-making during an emergency involving this hazard. They are not intended to be fully comprehensive, detailed analyses or to indicate what will happen on any particular occasion. Instead they will signpost issues that are likely to be important and provide links to sources of more detailed information.

What is Wind?

Wind consists of the bulk movement of air. Measurements show that it is continually varying, due to turbulence. In the UK, it is normally described by its average speed and direction over a 10-minute period. Shorter duration peaks of wind speed are referred to as gusts. Most wind hazards are associated with strong winds. Surface vegetation and obstacles reduce wind speed, so the strongest winds are found at sea and on high ground. Strong winds arise from three types of weather system in the UK: large scale weather systems such as winter depressions; local winds such as squalls and tornadoes, associated with thunderstorms; mountain winds, such as lee waves and down slope winds that sometimes affect areas downwind of mountains/hills. Wind speeds of 34knots (39mph) or more are termed gale force and are responsible for most infrastructure damage and health impacts on land.

How does Wind affect the UK?

Over land, the highest winds generally occur on high ground, in coastal areas exposed to the prevailing south-westerly wind (i.e. wind coming from the south-west) and in the north where deep depressions are more frequent. Very strong low level winds may be associated with very intense depressions. However, strong winds associated with the outflow from thunderstorms (downbursts) can occur anywhere, especially in the south-east, and mountain winds are prevalent on the east side of the Pennines and Cumbria.

At sea, wind generates waves, and it is this combination that generally causes difficulties for shipping.

Wind can be especially variable (gusty) near fronts and thunderstorms and downwind of hills, cliffs and large buildings. Such variability affects control of vehicles on land, sailing ships on the sea and, especially, aircraft manoeuvring close to the ground.

Wind is a critical issue for building resilience. The varying climatology of wind strength across the UK is reflected in building standards to ensure safety of property and life. Design standards are also required to avoid creation of road and building

configurations that may create local wind hazards caused by amplifying the natural wind. Bridges are particularly sensitive to wind, so must be designed accordingly, and may need to be closed in high winds.

In the UK, strong winds are often associated with heavy rain or snow, so the hazards of wind and rain or wind and snow may be difficult to separate. This is particularly an issue in interpreting hazard impact statistics, which tend to categorise storms as either wind or rainstorms, depending on how they are reported by insurers or the press.

Wind is a factor in agricultural productivity. In particular, trees grow stunted in locations exposed to strong winds, and strong winds at the surface may damage crops or forestry. Coastal locations with strong onshore winds are affected by salt transported by air currents. More generally, locations that are downwind of sources of toxic material or pathogens will be more at risk than other locations. Sources may include chemical and radioactive releases (including from explosions), animal and human disease outbreaks (e.g. foot & mouth disease or legionella), or toxins released from harmful algal blooms.

What are the Impacts of Wind?

Wind impacts in the UK may include:

- **Road transport**

  The most frequent cause of road traffic accidents and disruption from high winds is falling trees. Typically it is weak and diseased trees that fall, though in extreme storms, such as the October 1987 storm[1, 2], trees were felled more generally (even healthy ones) due to the force of the wind. Falling trees may also bring down power cables and masonry onto the road. In strong winds, control of vehicles becomes increasingly difficult, especially for high-sided vehicles and if the wind is gusty. High-sided vehicles may also be blown over in strong winds, typically on bridges, but also downwind of hills when strong down slope winds occur (e.g. on the A1, east of the Pennines). The resulting disruption can last for many hours.

- **Rail transport**

  The main issue for the railways in strong winds is movement of the electric power cables. In certain parts of the country, railway lines and embankments are also vulnerable to wind-induced ocean waves.

- **Aircraft**

  Aircraft are primarily vulnerable to variations in wind. Turbulence from strong winds precludes aircraft operation in such conditions. Localised wind gradients, such as those found in the vicinity of thunderstorms or downwind of hills when turbulent rotors associated with lee waves are present, are particularly dangerous to aircraft on approach to landing. Leisure aircraft can be vulnerable to even modest wind changes at take-off and landing and the vertical winds associated with lee waves can pose a threat to leisure aircraft, particularly when flying at low altitudes. Generally, civil aircraft are able to avoid dangerous wind gradients by using weather forecasts and radar. However, extreme localised wind variations near thunderstorms, including those associated with tornadoes, are difficult to forecast or detect and are capable of causing a crash during the approach to landing. Aircraft also create their own turbulence, which can be dangerous to following aircraft, unless dispersed by the natural wind.

- **Ships and marine craft**

  While damage to large sea-going ships is now rare in UK waters, the risk to coastal and leisure craft from wind is rising. An extreme storm (Beaufort force 10 averaging 60mph or above) may result in wave damage to large cargo or passenger ships, leading to the need to evacuate the ship, with potential major environmental consequences. Ferries are more vulnerable, but services are usually suspended during strong wind events, restricting impact to trading losses and travel delays. A modest wind (of Beaufort force 5, averaging 22mph, or more) especially if associated with poor visibility can also cause death as leisure craft can be blown offshore,

- **Buildings**

  Old, poorly maintained buildings are most at risk of damage from strong winds – damage often consisting of fallen chimneys, dislodged roof tiles and fallen garden walls. Temporary buildings and roofs are particularly vulnerable. Flying debris is often the cause of additional damage, especially to windows. Extreme winds, such as those associated with the strongest UK tornadoes, may destroy whole buildings, with mobile homes a considerable risk.

- **Reservoirs**

  Overtopping caused by strong winds may result in damage to capping stones on the tops of some dams. In extreme situations this could lead to failure of earth core dams, although this is a rare occurrence.

- **Energy and telecommunications**

  Electricity and telegraph wires are frequently brought down in strong winds, most often by falling trees. The resulting power and communications outages are the dominant economic impact of wind, sometimes extending to a week or more in remote areas. Electricity failures may also be caused by sparking between cables.

- **Health**

  Health impacts may be divided into two categories[3]:

  - **Direct impacts** caused by the physical effect of the wind: injury from being physically blown over, flying debris or falling trees, or building collapse causing injury to persons alongside or underneath the structure. Road traffic collisions due to vehicles overturned by wind or debris from the wind obstructing travelling vehicles causing injury and death.

  - **Indirect impacts** – Injuries, infections and insect bites incurred during storm preparations or clean-up post-storm such as falls, chainsaw injuries, lacerations etc. Injuries/infections resulting from loss of power supplies during and after a storm as people utilise alternative energy sources such as candles or generators, leading to electrocutions, burns and carbon monoxide poisoning.

How can I Assess the Severity of the Impact of Wind?

For coastal seas, the shipping forecasts and gale warnings issued by the Met Office[4] provide warnings when hazardous winds are expected. For inshore waters, strong wind warnings accompany the inshore waters forecasts for leisure users[5]. Both of these are expressed in terms of Beaufort force[6], which is related to impact.

For aviation, Met Office provides terminal area wind forecasts for pilots and air traffic control. The Met Office also provides strong wind warnings for landing and take-off at specific airports.

Over land, the strong wind warnings of the National Severe Weather Warning Service[7] indicate risk as a function of probability and expected wind impact. Specific forecasts for strong winds on bridges are provided to road operators. Forecasts of enhanced wind speeds on mountain tops are included in Met Office mountain area forecasts[8].

Timeline of a Major Frontal Windstorm

An example of a typical major windstorm event is as follows, with day numbers relative to the arrival of the windstorm. These events are associated with large (synoptic) scale weather systems which can be reliably predicted several days ahead and with increasing confidence closer to the event.

5 days before: First reliable indications of major windstorm. Yellow warning is likely to be issued.

2-3 days before: Yellow warning in place and may be raised to Amber where confidence allows.

1 day before: Amber or Red warning of areas at high risk of disruption.

Day 0: Winds increase to storm force with gusts in excess of 100mph. Bands of heavy rain affect many areas, especially in the west. Wind damage is concentrated in swathes, bringing down large numbers of trees together with chimneys, unsupported walls, and a few roofs. There is widespread damage to windows and vehicles from unsecured debris. Many roads and railways are blocked by trees. Major bridges are either closed or blocked by accidents. Multiple motorway accidents are caused by the combination of wind and rain. Power and telecommunications links are broken in multiple locations, but most major urban centres suffer only short breaks. There are multiple fatalities and injuries on the roads, and a large number of injuries from blowing debris.

Day 1: The strong winds have cleared away into NW Europe, replaced by blustery showers. Trees are cleared from roads and railways. Recovery of power and telecommunications links gets underway. Damaged buildings are given temporary repairs.

Day 2-5: Remaining power and telecommunications links are repaired.

Timeline of a Damaging Tornado

A severe tornado damage event in the UK might evolve as follows, with day numbers relative to the arrival of the windstorm. Note that tornadoes themselves cannot be forecast directly due to the current limitations with observing and forecasting technology. Only the conditions in which there is a risk of tornadoes can be predicted.

2 days before: First reliable indications of conditions that might produce a severe convective storm, with the possibility of tornadoes and possibly issue of a yellow warning for heavy rain.

Day 0: Warning of conditions likely to produce a tornado about 6 hours ahead, and possibly issue of an amber warning – again most likely for the associated rain. Thunderstorms develop about 2 hours before the first tornado. First observation of a tornado is about 10 minutes before first damage is reported. The tornado touches down in several locations causing severe damage to a small number of buildings and resulting in

one or more fatalities and several injuries. Later the same day further tornadoes occur causing similar levels of damage, including almost total destruction of a caravan park. Local infrastructure is severely damaged at each touchdown site.

Day 1-3: The thunderstorms have cleared away. Damaged buildings are given temporary repairs and loose rubble is cleared from roads and pavements. Emergency repairs are carried out to local infrastructure.

Historic Examples: Major Frontal Windstorms

- **South-East England, 16 October 1987**: The "Great Storm" was one of the most significant UK windstorms in recent decades. There were 13 deaths and significant property damage. As it was during the autumn, many trees were still in leaf making them more susceptible to wind, and a very large number were blown down (estimated at 15 million).
- **South-East England, 25 January 1990**: The "Burns Day Storm" was another significant UK windstorm. Less tree damage occurred as it was mid-winter and trees were not in leaf. Unlike the 16 October 1987 case, this event occurred during daylight hours and resulted in 47 deaths.
- **18 January 2007**: Strong winds across many parts of the UK, with gusts at Heathrow up to 67mph. This event caused 9 deaths, widespread damage to trees and buildings as well as power disruption.
- **Northern Scotland, 8 December 2011**: A deep Atlantic low pressure system brought winds gusting to 81 mph across northern Scotland. The event caused widespread disruption, power cuts affecting 150,000 homes and school closures.
- **3-5 January 2012**: a winter storm brought gusts in excess of 81 mph across the Central Belt of Scotland on 3 January. Very strong winds also occurred across England, Wales, and Northern Ireland. A further windstorm followed during 4-5 January with damaging winds across northern and eastern England. This case caused widespread travel disruption (including a several hour-long closure of the QEII Bridge on the M25) and power cuts affected more than 100,000 Scottish properties. There were two deaths.
- **28 October 2013**: The "St Jude" windstorm was one of the worst autumn storms to affect the UK in the last forty years. It evolved from a low pressure system bringing gusts exceeding 80mph across south east and south west England. Due to the timing of the storm early on Monday, widespread travel disruption to rail, port and aviation services occurred as well as surface water flooding and extensive power outages. Four deaths were recorded.

References **(web references accessed on 15th August 2016)**

(1) Prichard, B. (2012). The Great Storm of 16 October 1987. *Weather*, 67(10).

(2) Fox, A., Sherwin, R. and Ralston, F. (2012). Lessons learnt at the Met Office from the Great Storm of 1987 – a comparison with recent strong wind events. *Weather*, 67(10).

(3) Goldman, A., Eggen, B., Golding, B. and Murray, V. (2014). The health impacts of windstorms: a systematic literature review. *Public Health*, 128(1), p3-28. http://www.publichealthjrnl.com/article/S0033-3506(13)00337-5/fulltext

(4) Met Office Shipping Forecast & Gale Warnings:
http://www.metoffice.gov.uk/weather/marine/shipping_forecast.html

(5) Met Office Inshore Waters Forecasts & Strong Wind Warnings:
http://www.metoffice.gov.uk/weather/marine/inshore_forecast.html

(6) Beaufort wind scale: http://www.metoffice.gov.uk/weather/marine/guide/beaufortscale.html

(7) Met Office National Severe Weather Warning Service: http://www.metoffice.gov.uk/public/weather/warnings/

(8) Met Office mountain area forecasts: http://www.metoffice.gov.uk/loutdoor/mountainsafety/