

MH0001 / METEOROLOGICAL AND HYDROLOGICAL / Convective-Related

# Downburst

## Definition

A downburst is a violent and damaging downdraught reaching the ground surface, associated with a severe thunderstorm (WMO, 1992).

## Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182, 2nd edition. World Meteorological Organization (WMO). [https://library.wmo.int/doc\\_num.php?explnum\\_id=4712](https://library.wmo.int/doc_num.php?explnum_id=4712) Accessed 13 October 2020.

## Annotations

### Synonyms

Microburst, Macroburst, Wind Sear.

### Additional scientific description

Downbursts are powerful winds that descend from a thunderstorm and spread out quickly once they hit the ground. These winds can easily cause damage similar to that of an EF0 (65–85 mph winds) or even EF1 (86–110 mph winds) tornado, and are sometimes misinterpreted as tornadoes. However, downbursts are a completely separate phenomenon (NOAA, 2019). The key differences between a downburst and a tornado are expressed by two words – IN and OUT (NOAA, 2019):

- *IN* - all wind flows INTO a tornado. Debris is often lying at angles due to the curving of the inflow winds.
- *OUT* - all wind flows OUT from a downburst. Debris is often lying in straight lines (hence the term ‘straight line winds’) parallel to the outward wind flow.

Downbursts are also far more frequent than tornadoes – in fact, for every one tornado there are approximately ten downburst damage reports. Tornadoes average about 800 per year in the United States, in contrast to an average of 100,000 thunderstorms (NOAA, 2019).

### Metrics and numeric limits

Comparison of a microburst and the larger macroburst (NOAA, 2019):

<u>Microburst</u>	<u>Macroburst</u>
Damaging winds extending up to 2.5 miles (4 km)	Damaging winds extending more than 2.5 miles (4 km)
Lasts 5 to 15 minutes	Lasts 5 to 30 minutes
Can cause damaging winds up to 168 mph (270 kph)	Damaging winds, causing widespread, tornado-like damage, up to 134 mph (216 kph)

### Key relevant UN convention / multilateral treaty

Not applicable.

**Examples of drivers, outcomes and risk management**

Downbursts are a particular hazard to aircraft at low level, especially on take-off or landing. An aircraft approaching a downburst will first encounter a strong headwind, which will lead to an increase in indicated airspeed. When trying to fly a set airspeed on approach, a pilot might therefore be tempted to reduce power. This would be very dangerous because, as the aircraft passes through the downburst, the wind becomes a tailwind and the indicated airspeed and lift drop. The significant downward force of air in the downburst may be enough to force the aircraft into the ground or at least cause it to lose a significant amount of height. The subsequent loss of performance, as the aircraft encounters tailwinds, may cause further loss of height and be enough to cause the aircraft to stall (SKYbrary, no date).

Many lives have been saved because of the reduction, if not elimination, of potential airline crashes caused by dangerous wind shear conditions on take-off and landing. These saved lives are the result of training pilots on the dangers of microbursts and the installation of Doppler radars at major airports across the United States to warn pilots when microbursts are present (Wilson and Wakimoto, 2001).

**References**

NOAA, 2019. How do downbursts form? National Oceanic and Atmospheric Administration (NOAA) National Weather Service. [www.weather.gov/lmk/downburst](http://www.weather.gov/lmk/downburst) Accessed 19 November 2019.

SKYbrary, no date. Microburst. [www.skybrary.aero/index.php/Microburst](http://www.skybrary.aero/index.php/Microburst) Accessed 19 November 2019.

Wilson J.W. and R.M. Wakimoto, 2001. The discovery of the downburst: T. T. Fujita's contribution. Bulletin of the American Meteorological Society, 82:49-62. <https://journals.ametsoc.org/doi/pdf/10.1175/1520-0477%282001%29082%3C0049%3ATDOTDT%3E2.3.CO%3B2>.

**Coordinating agency or organisation**

World Meteorological Organization (WMO).

# Lightning (Electrical Storm)

## Definition

Lightning is the luminous manifestation accompanying a sudden electrical discharge which takes place from or inside a cloud or, less often, from high structures on the ground or from mountains (WMO, 2017).

## Reference

WMO, 2017. International Cloud Atlas: Lightning. World Meteorological Organization (WMO). <https://cloudatlas.wmo.int/lightning.html> Accessed 26 November 2019.

## Annotations

### Synonyms

Bolt, Thunderbolt, Bolt-from-the-blue, Firebolt, Thunderstroke, Thunderball.

### Additional scientific description

Lightning is a transient, high-current electric discharge with pathlengths measured in kilometres. The most common source of lightning is the electric charge separated in ordinary thunderstorm clouds. Well over half of all lightning discharges occur within the thunderstorm cloud and are called intracloud discharges (AMS, 2012).

Lightning is a large electrical discharge caused by a thundercloud. It can occur within a cloud as intracloud lightning, between clouds as intercloud lightning, or between the cloud and the earth as cloud-to-ground lightning. A lightning discharge consists of pulses of electric current carried by electrons. The current is driven by a high voltage between the cloud's charge centres or between them and the earth. During the development of a thundercloud, negative charge is accumulated in the hail-forming region at the central part of the cloud, and positive charge in the top region which consists of ice crystals (Finnish Meteorological Institute, 2019).

Lightning strikes are classified into different types according to their own characteristics. The two most common types are cloud-to-ground lightning and cloud-to-cloud lightning (WMO, 2017).

- *Cloud-to-ground lightning* is lightning discharge between a cumulonimbus cloud and the ground. Of all types of lightning, cloud-to-ground lightning poses the greatest threat to people and facilities on the ground (WMO, 2017). The usual cloud-to-ground lightning has been studied more extensively than other lightning forms because of its practical interest (i.e., as a cause of injury and death, disturbances in power and communication systems, and ignition of forest fires) and because lightning channels below cloud level are more easily photographed and studied with optical instruments (AMS, 2012). Cloud-to-ground lightning can occur as either positively or negatively charged bolts. Positively charged bolts are considerably more rare, more powerful (e.g., by an order of magnitude or more) and often can strike miles beyond the parent anvil of the thunderstorm (e.g., these positive strikes are referred to as a 'bolt out of the blue') (NOAA, 2019).
- *Cloud-to-cloud lightning* and cloud-to-air discharges are less common than intracloud or cloud-to-ground lightning. All discharges other than cloud-to-ground are often lumped together and called cloud discharges (AMS, 2012; WMO, 2017). Cloud-to-cloud lightning is the discharge between areas of cloud without the discharge channel reaching the ground. For most of the time, it occurs between oppositely charged portions of the same cloud but sometimes it takes place between two separate clouds. Since the discharge channel of cloud-to-cloud lightning may be obscured by the cloud, it may or may not be visible to an observer on the ground. It may therefore be surprising to learn that cloud-to-cloud lightning is, in fact, the most frequently occurring type of lightning. It occurs around ten times more often than cloud-to-ground lightning. Cloud-to-cloud lightning does not pose a threat to life and property on the ground. However, this type of lightning takes place in the sky and sometimes passes through the clear air between clouds, it is therefore of great practical interest to those concerned with the safety of aircraft (WMO, 2017).

Ball lightning includes a fireball which sometimes appears after a lightning flash. Its diameter is usually between 10 and 20 cm and rarely attains 1 m. The fireball moves slowly through the air or along the ground, it may be distorted in passing through narrow places and usually vanishes suddenly with a violent explosion (WMO, 1992).

### **Metrics and numeric limits**

Not available.

### **Key relevant UN convention / multilateral treaty**

Not available.

### **Examples of drivers, outcomes and risk management**

Lightning strikes the earth more than 8 million times per day. The risk of being struck is low but the consequences of lightning strike injuries are serious. During 2003–2012, lightning caused an average of 35 deaths per year in the United States (CDC, no date). The Centres for Disease Control and Prevention also provides helpful fact sheets on lightning safety tips, first aid recommendations, lightning strike victim data, information for workers, information for outdoor recreation, information for organised sporting events, information for water activities, and information for pet owners (CDC, 2020).

As an example of a National Alerting Parameters, the China Meteorological Administration (2012) has three alerting thresholds and related preventative measures, including:

- Yellow: "In 6 hours, there will be thunder & lightning and likely to cause disasters."
- Orange: "In 2 hours, the thunder & lightning is either occurring or will occur with a high likelihood, and it's quite possible to cause disasters or accidents."
- Red: "In 2 hours, the thunder & lightning is either occurring or will occur with a highest likelihood; it's extreme possible to cause disasters or accidents."

### **References**

AMS, 2012. Lightning. American Meteorological Society (AMS), Glossary of Meteorology. <http://glossary.ametsoc.org/wiki/Lightning> Accessed 25 November 2019.

CDC, no date. Lightning. Centres for Disease Control and Prevention (CDC). [www.cdc.gov/disasters/lightning/index.html](http://www.cdc.gov/disasters/lightning/index.html) Accessed 8 October 2020.

CDC, 2020. Lightning: Lightning Safety Tips. Centres for Disease Control (CDC). [www.cdc.gov/disasters/lightning/safetytips.html](http://www.cdc.gov/disasters/lightning/safetytips.html) Accessed 23 March 2021.

China Meteorological Administration, 2012. Weather Warnings: Lightning. [www.cma.gov.cn/en/WeatherWarnings/WarningSignals/201203/t20120320\\_166767.html](http://www.cma.gov.cn/en/WeatherWarnings/WarningSignals/201203/t20120320_166767.html) Accessed 25 November 2019.

Finnish Meteorological Institute, 2019. Lightning and thunderstorm. <https://en.ilmatieteenlaitos.fi/lightning-and-thunderstorm> Accessed 25 November 2019.

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WMO, 1992. International Meteorological Vocabulary. 2nd Edition. World Meteorological Organization (WMO). [https://library.wmo.int/doc\\_num.php?explnum\\_id=4712](https://library.wmo.int/doc_num.php?explnum_id=4712) Accessed 19 November 2020.

WMO, 2017. Lightning: Cloud Discharge. World Meteorological Organization (WMO). <https://cloudatlas.wmo.int/en/lightning-cloud-discharges.html> Accessed 23 March 2021.

### **Coordinating agency or organisation**

World Meteorological Organization (WMO).

# Thunderstorm

## Definition

A thunderstorm is defined as one or more sudden electrical discharges, manifested by a flash of light (lightning) and a sharp or rumbling sound (thunder) (WMO, no date).

## Reference

WMO, no date. International Cloud Atlas. World Meteorological Organization (WMO). [cloudatlas.wmo.int/thunderstorm.html](https://cloudatlas.wmo.int/thunderstorm.html) Accessed 5 December 2019.

## Annotations

### Synonyms

None identified.

### Additional scientific description

Thunderstorms are associated with cumulonimbus clouds (WMO, 2017) and are most often accompanied by precipitation that, when it reaches the ground, is in the form of a shower of rain, snow, snow pellets, small hail or hail. Thunderstorms can cause tornadoes, strong winds, and flash flooding (Habitat for Humanity, 2021).

### Metrics and numeric limits

Example types of thunderstorms (NOAA, no date a,b; Australian Government, no date):

<b><u>Single-cell</u></b>	Single-cell thunderstorms are small, brief, weak storms that grow and die within an hour or so. They are typically driven by heating on a summer afternoon. Single-cell storms may produce brief heavy rain and lightning.
<b><u>Multi-cell</u></b>	A multi-cell storm is a thunderstorm in which new updrafts form along the leading edge of rain-cooled air (the gust front). Individual cells usually last 30 to 60 minutes, while the system as a whole may last for many hours. Multicell storms may produce hail, strong winds, brief tornadoes, and/or flooding.
<b><u>Squall line</u></b>	A squall line is a group of storms arranged in a line, often accompanied by 'squalls' of high wind and heavy rain. Squall lines tend to pass quickly and are less prone to produce tornadoes than are super-cells. They can be hundreds of miles long but are typically only 10 or 20 miles wide.
<b><u>Supercell</u></b>	A supercell is a long-lived (greater than 1 hour) and highly organised storm feeding off an updraft (a rising current of air) that is tilted and rotating. This rotating updraft – as large as 16 kilometres (10 miles) in diameter and up to ~15,000 meters (50,000 feet) tall – can be present as much as 20 to 60 minutes before a tornado forms. Scientists call this rotation a mesocyclone when it is detected by Doppler radar. The tornado is a very small extension of this larger rotation. Most large and violent tornadoes come from supercells.
<b><u>Mesoscale convective system</u></b>	A mesoscale convective system (MCS) is a collection of thunderstorms that act as a system. An MCS can spread across large areas and last more than 12 hours. On radar one of these might appear as a solid line, a broken line, or a cluster of cells.
<b><u>Mesoscale convective complex</u></b>	A mesoscale convective complex (MCC) – a particular type of MCS – is a large, circular, long-lived cluster of showers and thunderstorms identified by satellite. It often emerges out of other storm types during the late-night and early-morning hours.

<b><u>Mesoscale convective vortex</u></b>	A mesoscale convective vortex (MCV) is a low-pressure centre within an MCS that pulls winds into a circling pattern, or vortex. With a core only 30 to 60 miles wide and 1 to 3 miles deep, an MCV is often overlooked in standard weather analyses. But an MCV can take on a life of its own, persisting for up to 12 hours after its parent MCS has dissipated. This orphaned MCV will sometimes then become the seed of the next thunderstorm outbreak. An MCV that moves into tropical waters, such as the Gulf of Mexico, can serve as the nucleus for a tropical storm or hurricane.
<b><u>Derecho</u></b>	A derecho (pronounced similar to 'deh-REY-cho' in English) is a widespread, long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction similar to that of tornadoes, the damage typically is directed in one direction along a relatively straight swath. As a result, the term 'straight-line wind damage' sometimes is used to describe derecho damage. By definition, if the wind damage swath extends more than 400 kilometres (~250 miles) and includes wind gusts of at least 93 km/h (58 mph) or more along most of its length, then the event may be classified as a derecho.
<b><u>Virga</u></b>	Thunderstorms can be considered dry if they do not produce any rain at the surface. However, for the fire weather community, a 'dry thunderstorm' may be used to describe a storm producing very little rainfall, such that it is not effective in checking fire spread after lightning ignition. The second scenario is more common, although there are rare instances when thunderstorms produce no sensible rainfall. In the purest sense, 'dry' thunderstorms produce rain just below the cloud base but due to a very dry atmosphere below the cloud base, the rain evaporates at some point between the cloud base and the ground. Meteorologically speaking, this is called a virga.

### **Key relevant UN convention / multilateral treaty**

Not applicable.

### **Examples of drivers, outcomes and risk management**

As an example of National Alerting Parameters, the United States Weather Service defines a thunderstorm as a severe thunderstorm when it produces hail one inch (2.54 cm) or larger in diameter and/or winds equal or exceed 58 mph (93 kmh) (NOAA, no date c).

### **References**

Australian Government, no date. Severe thunderstorms. Australian Government, Bureau of Meteorology. [www.bom.gov.au/weather-services/severe-weather-knowledge-centre/severethunder.shtml](http://www.bom.gov.au/weather-services/severe-weather-knowledge-centre/severethunder.shtml) Accessed 5 December 2019.

Habitat for Humanity, 2021. Thunderstorms. [www.habitat.org/impact/our-work/disaster-response/disaster-preparedness-homeowners/thunderstorms#:~:text=Thunderstorms%20last%20an%20average%20of%2030%20minutes%20and,to%20learn%20the%20danger%20signs%20and%20plan%20ahead](http://www.habitat.org/impact/our-work/disaster-response/disaster-preparedness-homeowners/thunderstorms#:~:text=Thunderstorms%20last%20an%20average%20of%2030%20minutes%20and,to%20learn%20the%20danger%20signs%20and%20plan%20ahead) Accessed 23 March 2021.

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WMO, 2017. Cumulonimbus (Cb) (Weillbach 1880). World Meteorological Organization (WMO). <https://cloudatlas.wmo.int/en/clouds-genera-cumulonimbus.html> Accessed 23 March 2021.

### **Coordinating agency or organisation**

World Meteorological Organization (WMO).