

## Lightning Facts Seconds Count to Measure Distance

**Lightning can be heard up to about 10 miles away. To determine distance count seconds after the flash to hearing the thunder then divide by 5 to get the miles away it was.**

Thunder is always associated with lightning. Thunder is the shock wave created by superheated air in the lightning channel. For every five seconds from seeing the flash to hearing the bang, lightning is one mile away, which means for a count of 10, lightning is 2 miles away, for a count of 20, it is 4 miles away, etc.

For simplicity, there are two types of lightning produced by thunderstorms: lightning that strikes the earth and lightning that does not. Flashes of lightning between a thunderstorm and earth are called cloud-to-ground (CG). Flashes of lightning within a thunderstorm are called intra-cloud (IC). There is roughly five to 10 times more IC than CG flashes.

The life span of a thunderstorm can be as short as 45 minutes or as long as 12 hours. Lightning is initiated by the attraction of positive and negative charges, but air (gases) in our atmosphere acts as an insulator to inhibit the flow of electricity between electrical polarities. When the electrical potential builds up to overcome resistance of the air, lightning will occur.

Nearly 70% of all lightning occurs in the tropical latitude band between 35° north and south latitude. Globally, 85% to 90% of lightning occurs over land because solar radiation heats land faster, causing convection (thunderstorms) to be taller and stronger. Some intense thunderstorms over land have been known to tower over 70,000 feet (21,000 m). There are 50-75 flashes to ground occurring every second on earth. In the U.S., there are over 125 million flashes of lightning annually; an estimated 25 million strike ground.

The vertical extent of a CG lightning channel averages 3-4 miles (5-6.5 km) with a maximum height of about 6 miles (9.6 km). Most CG flashes originate in thunderstorms between 15,000-25,000 feet (4,500-7,600 m) above ground level in the mixed water and ice region.

During a cloud-to-ground flash, the first stroke of lightning is downward from the cloud along the channel. A flash consists of one or more return strokes. A CG flash may have only one return stroke, but usually has more (two to three). They are called returned strokes because the flash originates in the cloud, not at the ground. The flash and strokes lower charge to ground. Then objects on the ground send up streamers to meet the leader coming down. The electrical discharge travels upward at one-third the speed of light (62,000 miles per second or 94,000 km/second). It is routinely followed by two to three downward return strokes to ground. This is why you see lightning flicker during a CG flash.

The sounds produced by thunder have been categorized into recognizable terms. Claps are sudden loud sounds lasting 0.2 to 2 seconds. Peals are sounds changing frequency or amplitude. Rolls are irregular sound variances. Rumbles are of long duration but relatively low in frequency. Close-in lightning has been described first as a clicking or cloth-tearing sound, then a cannon shot sound or loud crack/snap, followed by continuous rumbling.

Lightning has a diameter of 1-2 inches (2-5 cm) and can heat air to 70,000° F (39,000° C) in a few milliseconds. Ninety percent of the electrical energy of lightning is released in the form of heat, which is quickly dissipated into the atmosphere. Less than 1% of lightning's energy is converted into sound and the rest released in the form of light. A sudden increase in pressure and

temperature causes surrounding air to expand violently at a rate faster than the speed of sound, similar to a sonic boom. The shock wave extends outward for the first 30 feet (10 m), after which it becomes an ordinary sound wave called thunder. The speed of sound through air at sea level is 758 mph (1,130 feet/second; 344 m/second) at 68° F (20° C). Thunder is exploding air occurring along the entire length of the lightning channel. An average thunderstorm produces thousands of mi/km of lightning channel during its lifetime.

Sound velocity is proportional to the square root of temperature. Temperature typically decreases with height, unless there is an inversion (warm air over cooler air). Thus, the sound of thunder will be deflected upward. Humidity, wind velocity, wind shear, temperature inversions, terrain features, and clouds, also influence thunder's audibility. The loudness of thunder can be expressed in decibels (dB). A clap of thunder typically registers at about 120 dB in close proximity to the ground stroke. This is 10 times louder than a garbage truck or pneumatic jackhammer drill. By comparison, sitting in front of speakers at a rock concert can expose you to a continuous 120+ dB level. Thunder in close proximity is capable of producing temporary deafness and may cause rupturing of the ear's tympanic membrane that can lead to hearing damage or deafness.

Thunder is seldom heard beyond 10 miles (16 km) under ideal conditions. The sound of distant thunder has a characteristic low-pitched rumbling sound. Pitch, the degree of highness or lowness of a sound, is due to strong absorption and scattering of high-frequency components of the original sound waves, while the rumbling results from the fact that sound waves are emitted from different locations along the lightning channel, which lie at varying distances from a person. The longer the lightning channels, the longer the sound of thunder. Humans hear frequencies of thunder between 20-120 Hertz (Hz). However, there is a small amount, less than 10%, that is inaudible to humans produced from lightning, called infrasonic. Special listening devices are required to record these inaudible sounds.

Lightning and its subsequent thunder can be used in lightning safety to protect yourself and others. The flash-to-bang method of protection considers the time between seeing lightning to hearing its thunder. Light from lightning travels at the speed of 186,000 miles per second (300,000 km/second), arriving at the observer in about 10 microseconds when the strike point is 1.85 miles (3 km) away. The sound wave, at an air temperature of 68° F (20° C) and atmospheric pressure of 29.92 in of mercury or 1,013.25 millibars, arrives more slowly in about 10 seconds. Figure 1 shows how a time interval from flash-to-bang of 5 seconds = 1 mile (1.6 km) can be approximated.

The Lightning Safety Group (LSG), an interdisciplinary group of the nation's lightning experts, met at the 1998 American Meteorological Society Annual Meeting. New lightning data showed that most CG flashes in a storm were within 5-6 miles (8-9.6 km) of the previous flash. The LSG recommended what has become known as the 30/30 Rule. Using the flash-to-bang method, lightning that has a 30-second count between the flash and the thunder is 6 miles (9.6 km) away. This translates into 5 seconds per mile (1.6 km). It is possible that the next flash of CG lightning may occur at your location.

The LSG also suggests waiting 30 minutes after hearing the last sound of thunder or seeing the last lightning in daytime before returning to any outside activity. This allows the thunderstorm to move out of the area, greatly reducing the lightning threat level. The average lightning flash

distance between two flashes averages about 2-3 miles (3-5 km), but 6 miles (9.6 km) accounts for about 80% of subsequent CGs.

A few short rhymes or slogans to remember for lightning safety are as follows:

"If you see it, flee it."

"If you hear it, clear it."

"When lightning roars, go indoors."

"Lightning kills; play it safe."