Thunderstorms

National Meteorological Library and Archive

Factsheet 2 — Thunderstorms

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Introduction

A thunderstorm can be described as one or more sudden electrical discharges, manifested by a flash of light (lightning) and a sharp or rumbling sound (thunder). Thunderstorms are associated with deep convective clouds, called cumulonimbus and are most often, but not necessarily, accompanied by precipitation at the ground. This factsheet describes how cumulonimbus clouds form, how they produce lightning, how it can be detected and finally how to stay safe during a thunderstorm.

Cumulonimbus clouds

(Latin: *cumulus* – heap; *nimbus* – rainy cloud)

Heavy and dense cloud, of considerable vertical extent, in the form of a mountain or huge towers. At least part of its upper portion is usually smooth, or fibrous or striated, and nearly always flattened; this part often spreads out in the shape of an anvil or vast plume. Under the base of this cloud, which is often very dark, there are frequently low ragged clouds either merged with it or not, and precipitation sometimes in the form of virga.

Figure 1: A mature cumulonimbus cloud (© M.J.O. Dutton).

Cumulonimbus clouds normally develop from large cumulus, but they can also do so from stratocumulus or altocumulus. When they cover a large expanse of sky the under surface can present the appearance of nimbostratus. The character of the precipitation may be of assistance in identifying the cloud. Cumulonimbus gives showers, very often quite heavy for comparatively short periods of time.

If hail, thunder or lightning are observed then, by convention, the cloud is cumulonimbus. The evolution of the cloud can also aid identification. The change from large cumulus with domed tops and a hard outline (produced by water drops) to a top with a softer fibrous outline (produced by ice crystals) marks the change from cumulus to cumulonimbus.

A cumulonimbus cloud can be described as a 'cloud factory'; it may produce extensive thick patches of cirrus, altocumulus, altostratus, cumulus or stratocumulus. The spreading of the highest part usually leads to the formation of an anvil; if the wind increases with height, the upper portion of the cloud is carried downwind in the shape of a half anvil or vast plume.

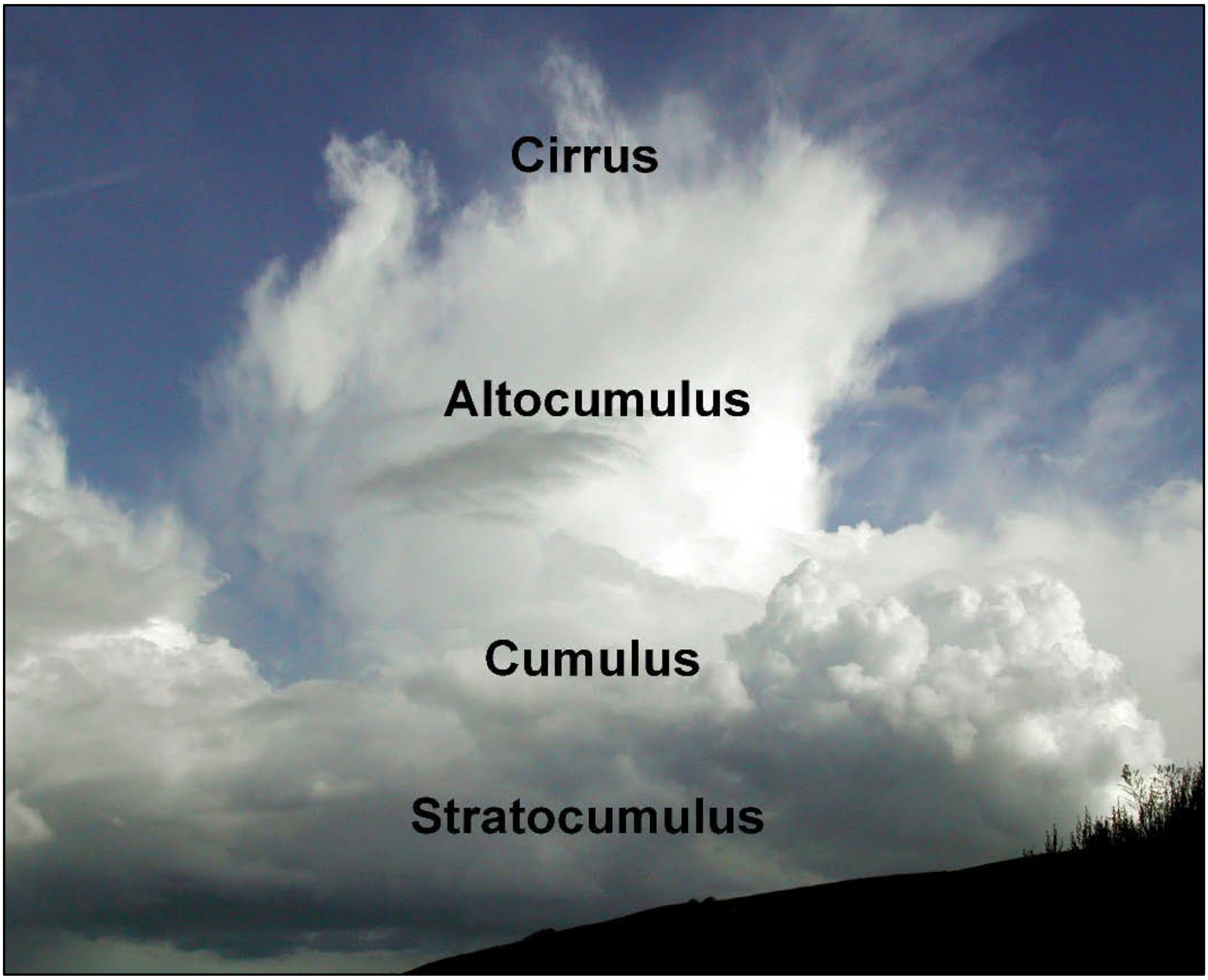

Figure 2: A cumulonimbus 'cloud factory' (© J. Corey).

Not all cumulonimbus clouds bring thunderstorms; some just bring heavy showers or hail. On average, an individual cumulonimbus cloud takes only one hour to take shape, grow and dissipate. It produces less than 30 minutes of thunder and lightning. If a thunderstorm lasts longer than this, it is probably because there is more than one cumulonimbus present.

Supercell thunderstorms

Supercell thunderstorms are cumulonimbus clouds which have a rotating updraft. The rotating updraft occurs due to normal cumulonimbus developing in a region of strong vertical wind shear. The high vertical wind shear introduces a region of vorticity which when convectively lifted causes a rotating updraft to form. The rotating storm is called a mesocyclone. Furthermore, the updraughts and downdraughts are tilted meaning they are separate. This means the updraught can continue to lift unstable buoyant air into the supercell without the more stable downdraught injecting stable air into the updraught causing the thunderstorm to weaken. This means a supercell can last for several hours, much longer than a conventional thunderstorm. Furthermore, they are more likely to produce large hail and tornadoes.

Tornadoes are narrow, rapidly rotating columns of air which extend down from the cloud to the ground. When these occur in associated with supercells they start near the centre of the mesocyclone, where the pressure is lowest and if several conditions are right near the base of the cloud a funnel of rotating air begins to descend towards the ground. Only once the circulation reaches the ground does it become a tornado.

Tornado size and intensity vary greatly. Typically in the UK a tornado is 10-215 metres wide at the surface, lasts for a few minutes and has a track length of 1.0-4.6 km. Wind speeds typically range from 25-51 m/s (56 to 114 mph, 90 to 184 km/h). (Kirk, P.J. (2014), An updated tornado climatology for the UK: 1981–2010. Weather, 69: 171-175. https://doi.org/10.1002/wea.2247)

The largest tornadoes are very rare occurrences and typically happen in places like the USA, although can also occur elsewhere in the world such as Continental Europe. They can be over 3.2 km (2.0 miles) wide, track for over 100 km (60 miles) and have wind speeds more than 480 km/h (300 mph).

Case study – Thunderstorms of 28th June 2012

Satellite imagery is very useful in locating cumulonimbus cloud development. Severe convective storms on 28th June 2012, including three supercells, led to some severe hail, lightning and tornadoes at a number of places across central England.

The satellite image (Figure 3) shows one of these supercells which had a track from the West Midlands to Lincolnshire. This produced ≥ 50mm diameter hail over a swathe of 110km, including hail with a diameter up to 90mm, causing extensive damage. In addition there was lightning damage and a tornado in Sleaford, Lincolnshire. (Clark, M.R. and Webb, J.D.C. (2013), A severe hailstorm across the English Midlands on 28 June 2012. Weather, 68: 284-291. https://doi.org/10.1002/wea.2162)

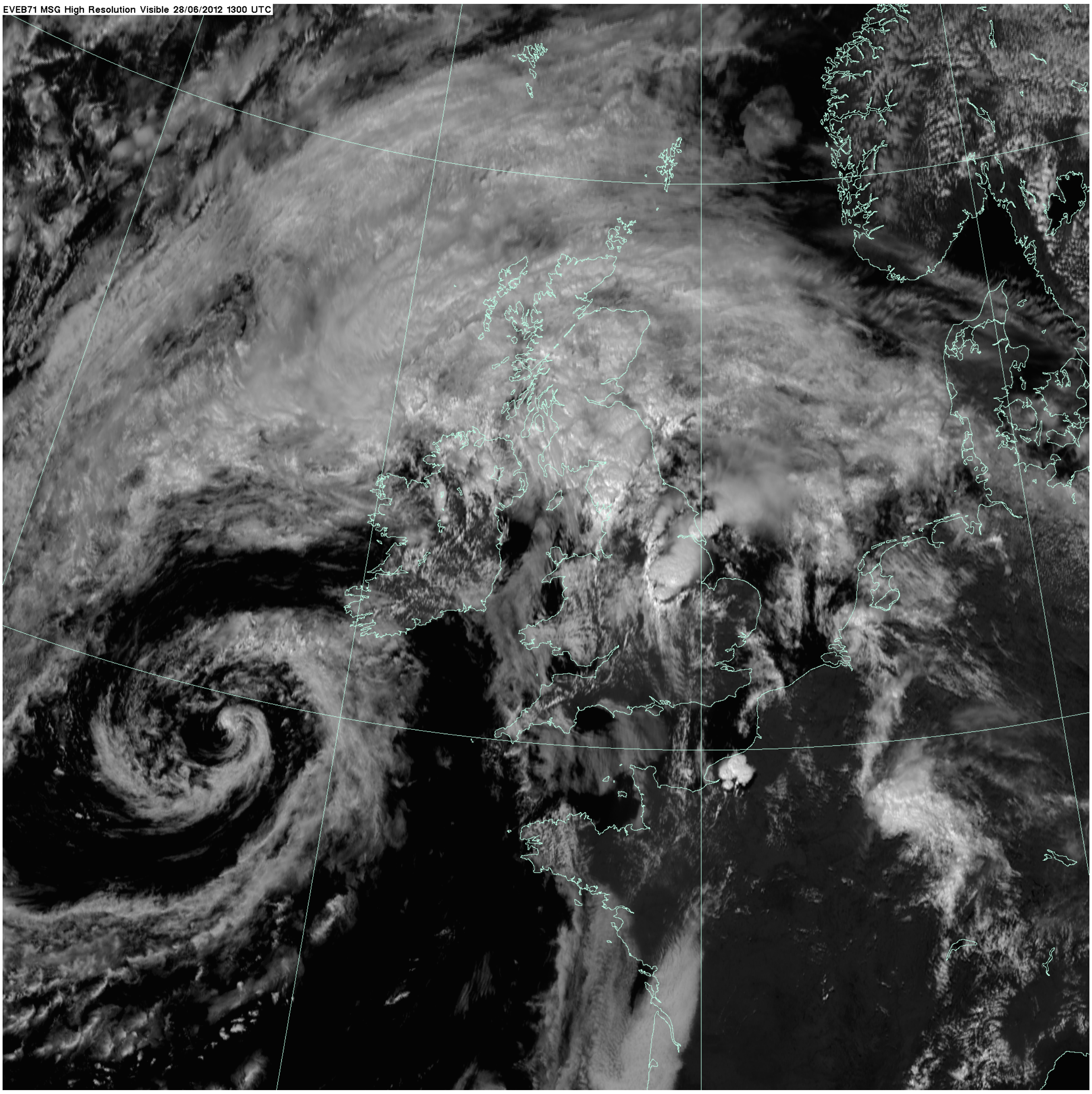

Figure 3: 1300Z 28th June 2012 MSG High Resolution Visible Satellite Image (© 2012 EUMETSAT/Met Office).

Lightning formation within a cumulonimbus cloud

Lightning is defined by the WMO as "A luminous manifestation accompanying a sudden electrical discharge that takes place from or inside a cloud or, less often, from high structures on the ground or from mountains."

An electrical discharge is a flow of electrons from a region of negative electrical charge to a region of positive electrical charge. Electrons are fundamental sub-atomic particles that carry a negative electric charge. Atoms also contain protons, which have a positive charge, and neutrons which have no charge. Unlike protons, electrons can be transferred from one atom to another through a process called charge separation which will produce atoms with positive and negatively charged atoms. Atoms which don't have a neutral charge are called ions.

To generate a lightning strike charge separation must occur to generate a region of negative ions, typically in the cloud base and positive ions near the ground and at the cloud top. Furthermore, the electrical resistance of air is incredibly high meaning the size of charge separation between the cloud and ground must become large to allow the air to break down to allow an electrical current to flow. When two regions carrying opposing electrical charge exist, separated by a gap an electric field form. The intensity of the electric field can be used to determine the level of charge separation.

Figure 3: Lightning seen over Iowa (© M. Clark).

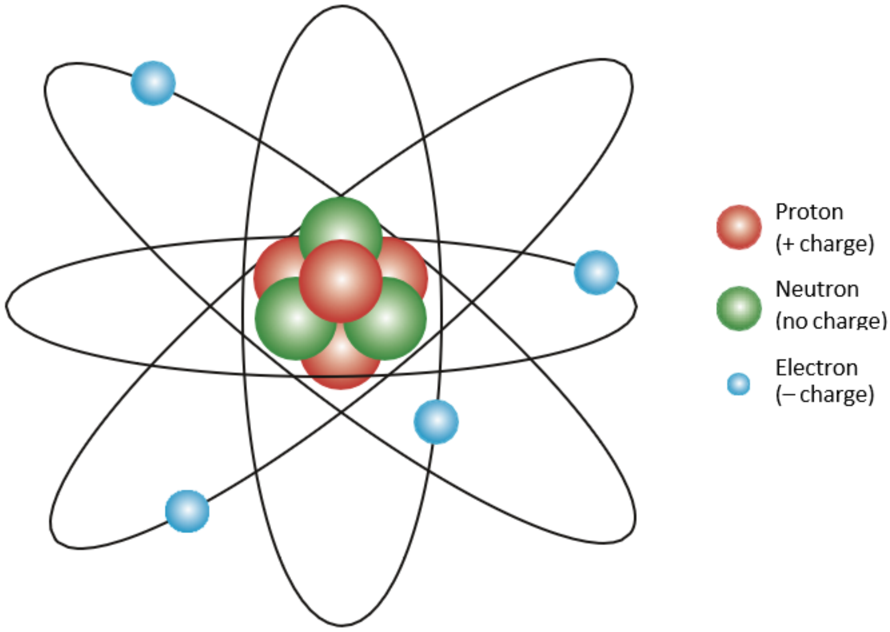

Figure 4: Diagram of atom

Water droplets form inside a storm cloud where they are propelled towards the top of the cloud by strong updraughts, where they turn to ice. Some of the pieces of ice grow large into hail, but others remain very small. As the pieces of hail get larger, they fall back through the cloud, bumping into smaller ice particles that are still being forced upwards. When the ice particles collide, some electrons are transferred to the hail. The electrons give the hail a negative charge, while the ice particles that have lost electrons gain a positive charge. The updraughts continue to carry the ice particles upwards, giving the top of the cloud a positive charge. Some of the hail has now grown so heavy that the updraughts can no longer propel them upwards and so collect in the lower part of the cloud, giving it a negative charge.

The negative[1] cloud base repels the electrons near the ground's surface. This leaves the ground and the objects on it with a positive charge, further increasing the strength of the electric field. When the electric field reaches sizes of several kV m^{-1} the air begins to break down into an ionised plasma and lightning initiation begins.

[1] Some Cumulonimbus clouds will exhibit a small positive region at the base of the cloud, the mechanism for which is still not fully explained. However the magnitude of this charge is small compared to the region of negative charge which dominates.

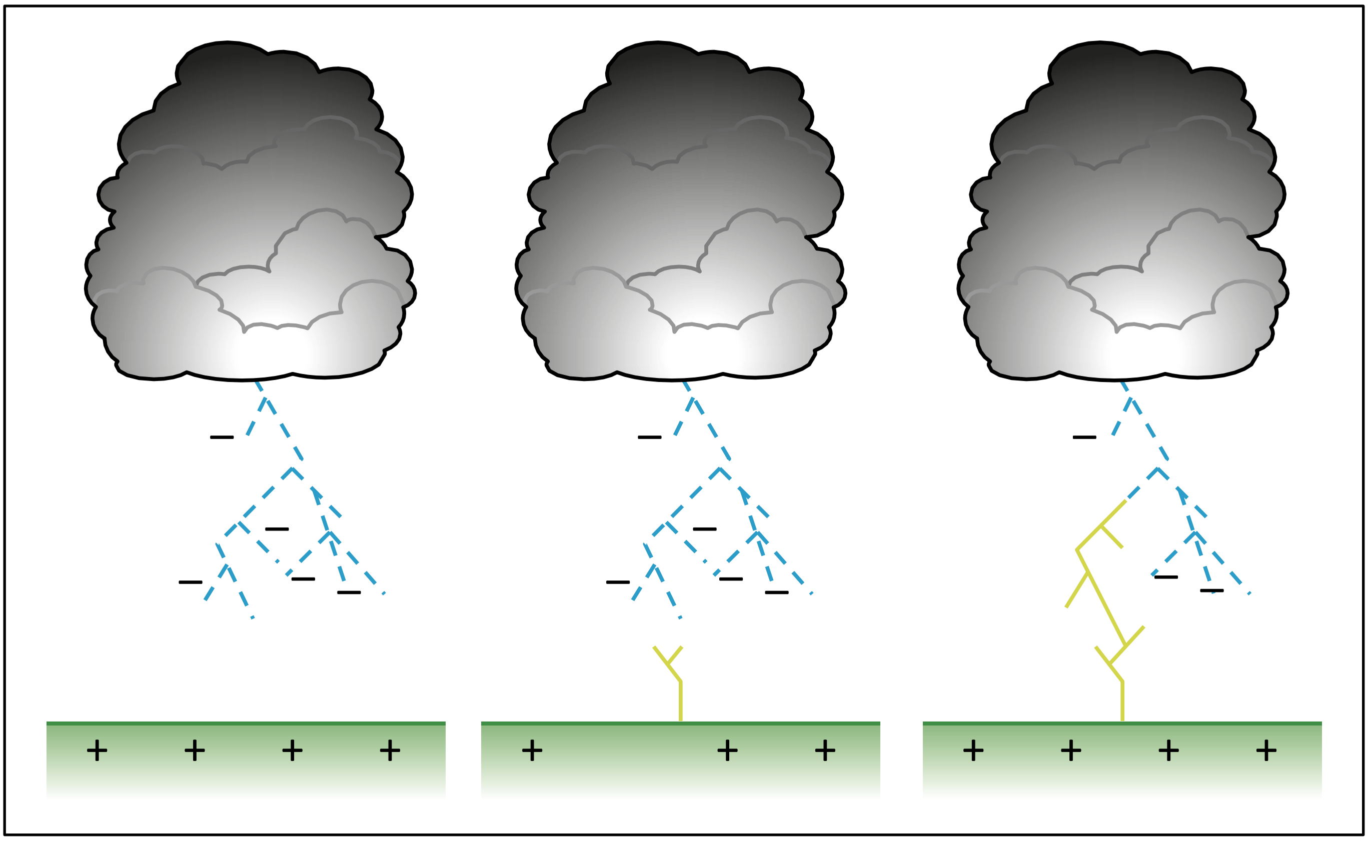

Figure 5: Stepped leader and upward streamers.

A negative stepped leader containing negatively charged electrons descends from the cloud base. A relatively positive streamer with positive ions begins heading upwards either from the ground or another cloud. When the two meet this closes the electrical circuit causing electrons to flow downwards at 430,000 km/h (270,000 mph).

This rapid transfer of electrons is called the return stroke. The electrical current transferred by a return stroke is of the order 10-100 kA. The strong current heats the lightning channel to temperatures of 30,000 °C and causes it to glow giving us the bright optical flash we see as lightning. Lightning often appears to propagate upwards as the electrons near the ground are the first to move. Lightning can also appear to have forks as the electrons from stepped leaders which didn't make contact also move into the main channel. The branches of the stepped leader are also lit up, but not as brightly as the main channel as there are fewer electrons present.

The heating of the lightning channel causes the surrounding air to expand releasing an audible shockwave which is heard as thunder. The return stroke lasts a few milliseconds, during this time a short burst broadband electromagnetic radio wave called an atmospheric (often shortened to sferic.) is also emitted by the return stroke.

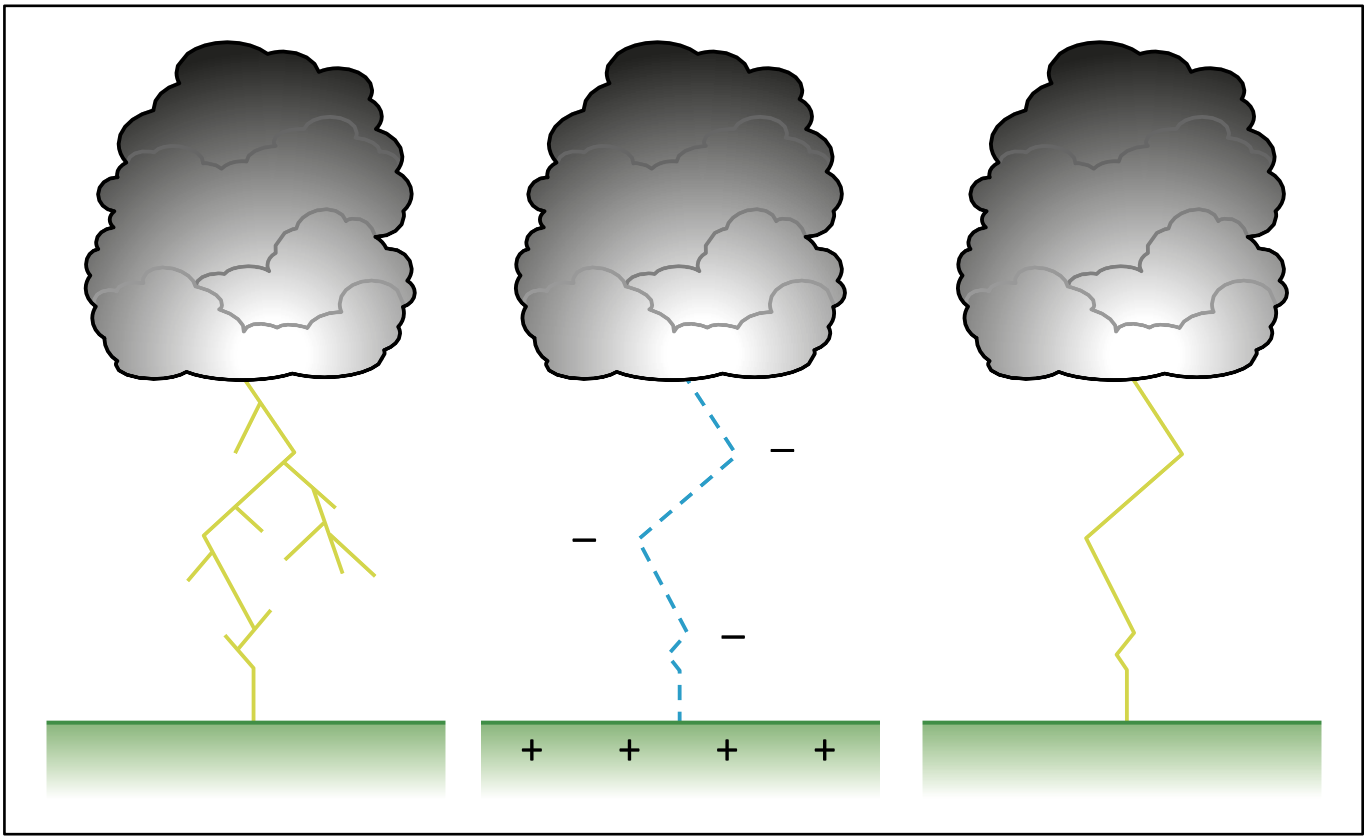

Figure 6: Return stroke and dart leaders.

After the return stroke the lightning channel remains highly ionised for up to a second. If the cloud still has appreciable negative charge, electrons begin forming a new leader down the residual lightning channel. This is called a dart leader. When the dart leader contacts the positive charged earth a subsequent return stroke occurs.

This is why lightning sometimes appears to flicker as there has been more than one return stroke in a fraction of a second down the same lightning channel. A lightning flash can contain one or more lightning strikes in close succession (< 1 second) and over the same area (<20 km). The mean amount of strikes in a flash in the UK is 1.7.

If the lightning channel degrades before a dart leader can establish another return stroke, the lightning flash stops.

Types of lightning

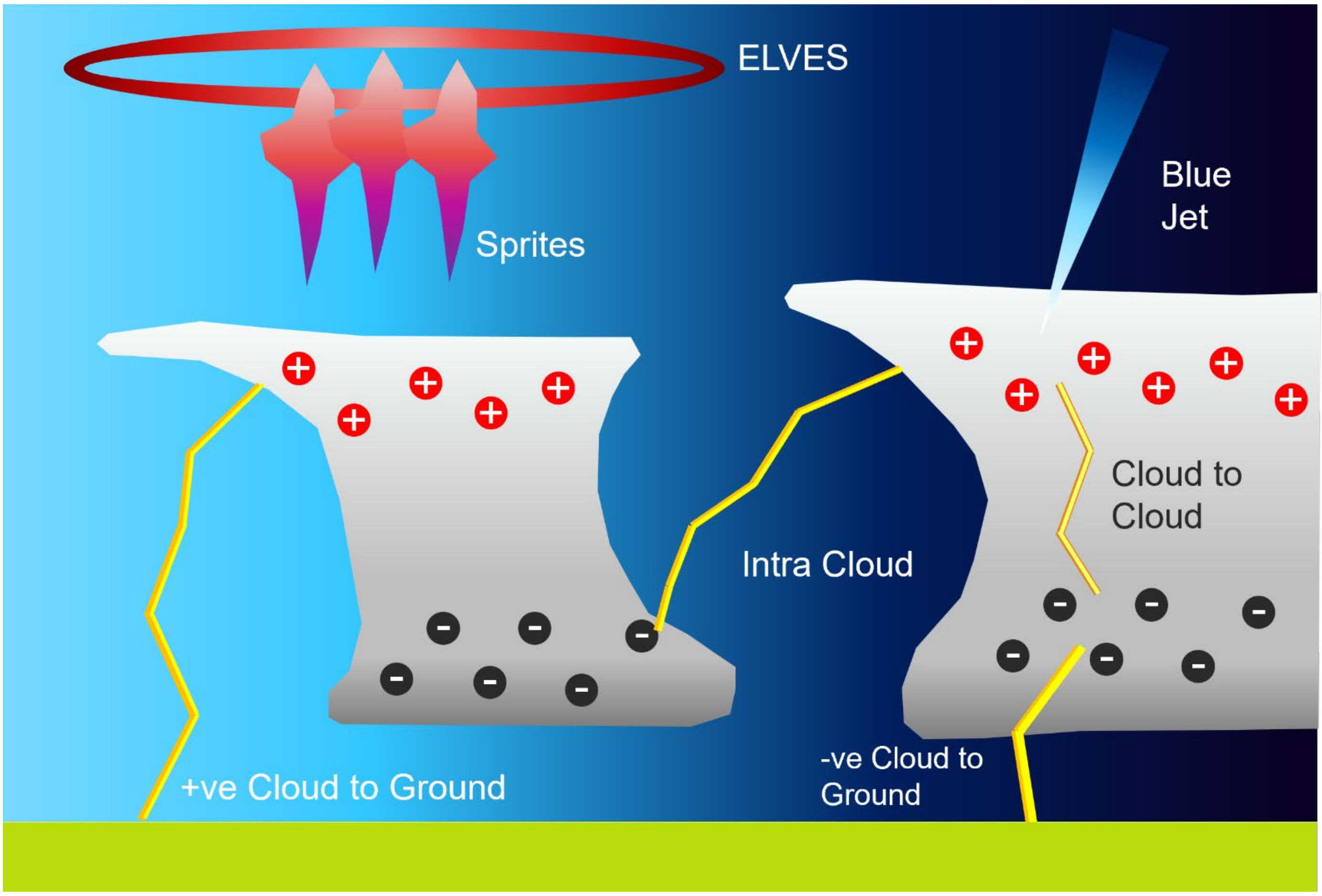

Figure 7: Diagram showing the main types of lightning strikes that occur in and below thunderstorms and three different type of trans luminous events which occur above thunderstorms

In the previous section the lightning initiation process was described for negative cloud to ground strike. However, the same process can happen between the charged regions of the cloud to give intra cloud or cloud to cloud lightning. Furthermore, the lightning can either be negative or positive. Positive lightning occurs in a similar method to that for negative lightning apart from the lightning strike either arcs between the ground and the positive part of the cloud or between a negatively charged region and a higher positively charge region. In these situations, the current flow upwards instead of downwards. Hence the change in polarity. Negative lightning strikes are more common. But positive lightning strikes tend to have stronger currents, can be more destructive and are less likely to have subsequent return strokes.

Due to the meteorological conditions surrounding the thunderstorms the types of lightning can have these visual manifestations:

- **Ball lightning** - an incredibly rare form of lightning in which a persistent and moving luminous white or coloured sphere is seen. There are various hypotheses, but the leading one is that the luminous sphere could be a bubble of vapourised soil which was formed when the lightning strike hit the ground.
- **Forked lightning** - lightning in which many luminous branches from the main discharge channel are visible.
- **Pearl-necklace lightning** - a rare form of lightning, also termed 'chain lightning' or 'beaded lightning', in which variations of brightness along the discharge path give rise to a momentary appearance similar to pearls on a string.
- **Rocket lightning** - a very rare and unexplained form of lightning in which the speed of propagation of the lightning stroke is slow enough to be perceptible to the eye. These are normally seen at the top of the Thunderclouds
- **Ribbon lightning** - ordinary cloud-to-ground lightning that appears to be spread horizontally into a ribbon of parallel luminous streaks when a very strong wind is blowing at right angles to the observer's line of sight.
- **Sheet lightning** - the popular name applied to a 'cloud discharge' form of lightning in which the emitted light appears diffuse and there is an apparent absence of a main channel because of the obscuring effect of the cloud.
- **Streak lightning** - a lightning discharge which has a distinct main channel, often tortuous and branching, the discharge may be from cloud to ground or from cloud to air.

Figure 8 Forked lightning (© M.J.O. Dutton).


Figure 9: Sheet lightning (© M. Clark).


Figure 10: Streak lightning © M Clark

Above thunderstorms trans luminous events (TLE) are observed. They form between the cloud top and the Ionosphere and are triggered by lightning strikes below.

- **Sprites** — are electrical discharges that occur high above the cumulonimbus cloud of an active thunderstorm. They appear as luminous reddish-orange, plasma-like flashes triggered by positive lightning between the cloud and the ground. Sprites usually occur in clusters of two or more simultaneous vertical discharges, typically extending from 65 to 75 km (40 to 47 miles) above the Earth. Depending on their shape they maybe called Jellyfish Sprites if tendrils are present
- **Blue Jets** — these differ from sprites in that they project directly from the top of the cumulonimbus above a thunderstorm, typically in a narrow cone, to heights of 40 to 50 km (25 to 30 miles) above the earth. They are also brighter than sprites and, as implied by their name, are blue in colour. They are triggered by intracloud lightning at the top of the cloud between the positively charge region at the top and the negatively charged cloud boundary.
- **Elves** – these often appear as a dim, flattened, expanding glow around 400 km (250 miles) in diameter that lasts for, typically, just one millisecond. They occur in the ionosphere 100 km (60 miles) above the ground over thunderstorms. They are believed to be triggered by accelerated electrons from the thunderstorms below interacting with the Ionosphere and exciting nitrogen molecules to release light.

St Elmo's Fire

During a thunderstorm a large electric field is present. If a pointed object protrudes into an electric field. The electric field intensifies round that point. This causes the air to break down and a small current to begin flowing. Under certain conditions visible steamers up to 10cm long which can be blue in colour can protrude off aerials, pine trees, ship masts, or flight wing tips. Compared to lightning the electrical current flowing through the point is about 10 μA (9 orders of magnitude smaller than a lightning strike current). St Elmo's Fires is also known as corona or a point discharge current.

Thunder

Thunder is the sharp or rumbling sound that accompanies lightning. The word thunder is derived from Thor the Norse god of thunder, lightning and storms. Thunder is caused by the intense heating and expansion of the air along the path of the lightning associated with a high current. The rumble of thunder is caused by the noise passing through layers of the atmosphere at different densities. Thunder lasts longer than lightning because of the time it takes for the sound to travel from different parts of the lightning channel.

How far away is a thunderstorm?

This can roughly be estimated by measuring the interval between the lightning flash and the start of the thunder. By counting the time in seconds and dividing by three, the approximate distance in kilometres can be calculated. Thunder is rarely heard at more than 20 km.

Thunderstorm occurrence

There are two metrics which are commonly used to describe thunderstorms frequency. Thunder days which are simply days where audible thunder was observed at least once at a given location. The second is flash density which looks at the amount of lightning flashes over a given area per year.

Thunder days are a useful metric for understanding how many days a year a particular location experienced thunderstorms, regardless of the amount of lightning produced. Flash density gives information about the amount of lightning produced by thunderstorms over a given area regardless of the number of thunderstorms present that year.

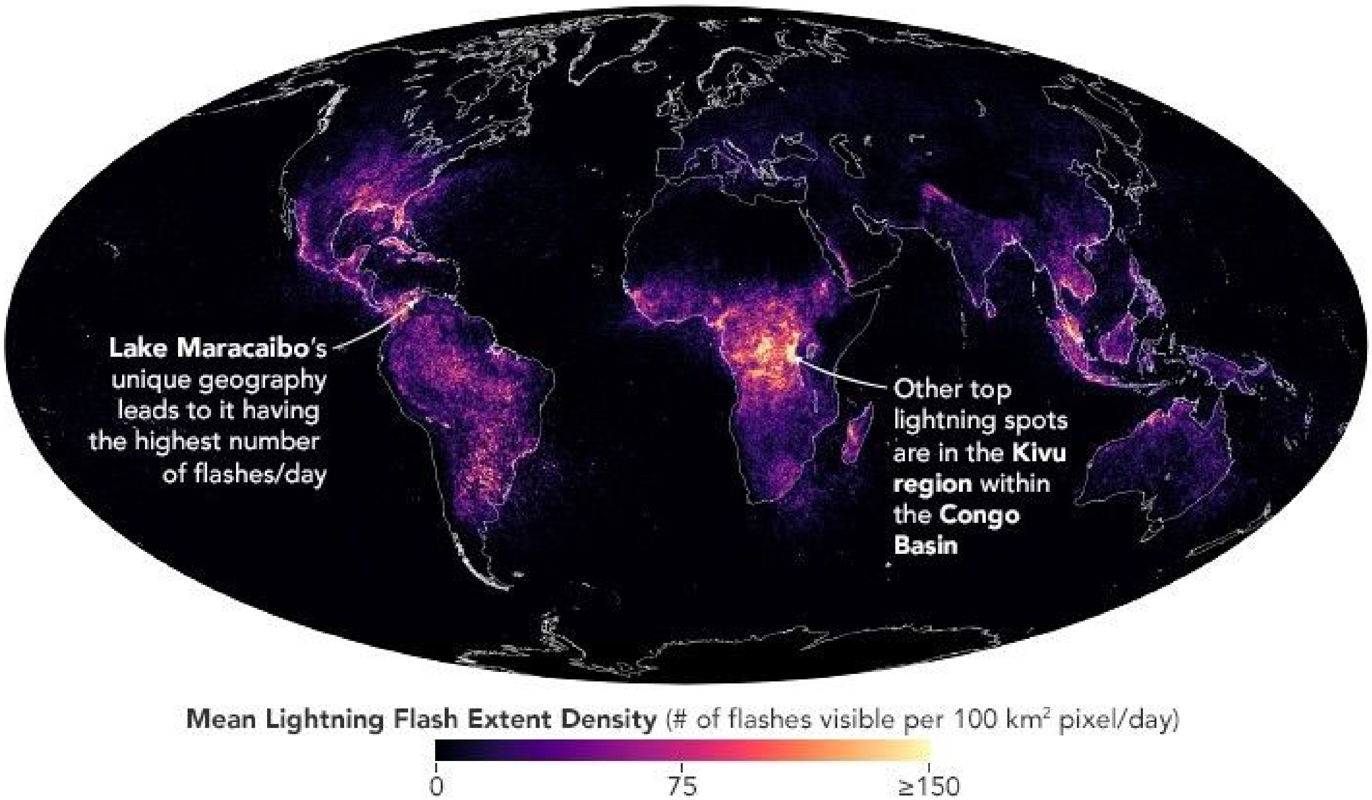

Figure 11: Mean flash density over the Globe (NASA) with hotspots labelled

The most thundery parts of the earth are Lake Maracaibo in Venezuela, South America and the Congo Basin in Africa, which observe a mean of more than 150 flashes per 100 km^2 a day. Over landmasses in the tropics thunderstorms occur almost daily. In temperate regions, they are most frequent in spring and summer, although they occur in regions of convergence at any time of year. Thunderstorms are rare in polar regions due to the cold climate and stable air masses that are generally in place, but they do occur from time to time, mainly in the summer months.

In the UK thunderstorm occurrence at a given location can vary from year to year due to the localised nature of thunderstorms. Typically locations will see between 5 to 20 days of thunder each year, with the majority of these days happening during the summer months. The 30 year mean annual amount of thunder days is less than 5 days in western coastal districts and over most of central and northern Scotland, and 10 to 15 days over East Midlands, East of England, London & parts of the South East.

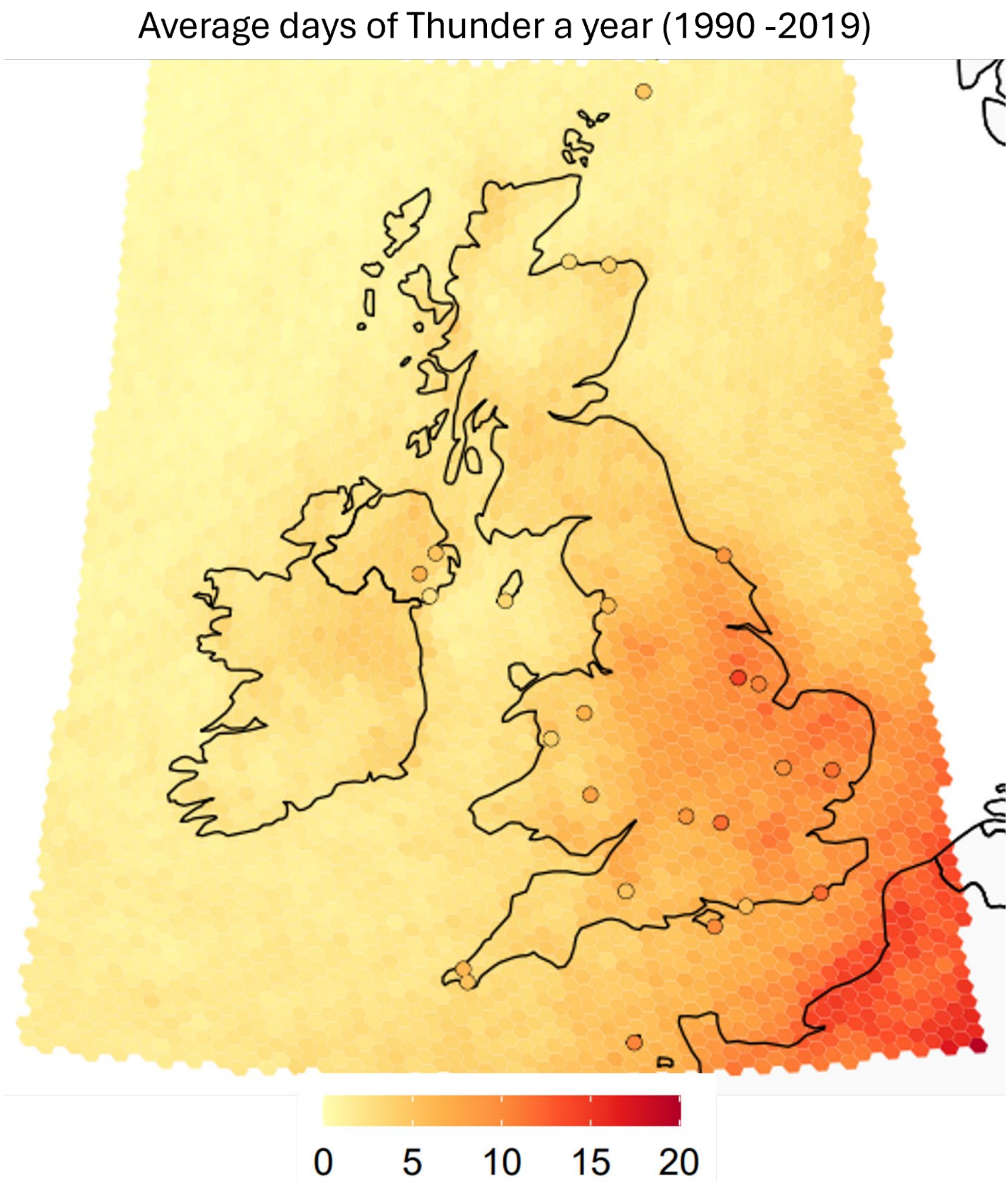

Figure 12: Mean number of days of thunder per year from 1990 to 2019 (Stone, E.K., Horseman,A., Odams, P. & Marlton, G. (2022) A gridded 30-year days of thunder climatology for the United Kingdom. Quarterly Journal of the Royal Meteorological Society, 148(747), 2784–2795.)

Staying safe during a thunderstorm

Thunderstorms bring heavy rainfall, hail, strong winds, lightning and in rare cases tornadoes. All of these present natural hazards.

Heavy rainfall can lead to localised flash flooding, resulting in travel disruption, damage to property and in severe cases loss of life.

Hail stones in the UK have typical diameter of 5 mm. However, in intense thunderstorms these can grow to 50 mm or more in diameter. In places such as the USA where supercells are more prevalent hail stones with diameters of 100 mm or more are not uncommon. Larger hailstones can damage property and cause injury to people and livestock.

Strong winds can sometimes be associated with thunderstorms especially if the thunderstorm has become a supercell. Strong winds can cause travel disruption, damage to property and risk of injury from flying debris. If the thunderstorms have become a supercell there is also a risk of a tornado which can cause significant structural damage to buildings.

Lightning strikes, due to the large currents involved and heat generated, can cause damage to property and a threat to life. In the UK between 1988 and 2012 there were two deaths per annum from being struck by lightning (Elsom, D.M. and Webb, J.D.C. (2014), Deaths and injuries from lightning in the UK, 1988–2012. Weather, 69: 221-226. https://doi.org/10.1002/wea.2254). The chances of getting struck by lightning are incredibly low. This is due to only 15% of lightning striking the ground. Furthermore, lightning is more likely to strike a nearby elevated object.

To help stay safe during a thunderstorm:

Prepare:

- Check weather forecasts for thunderstorms and be aware of any lightning or thunderstorm warnings that are in place and consider replanning any outdoor activities.
- Use the Met Office app and webpages to check for real time lightning location data and position of heavy rainfall
- Consider a lightning protection risk assessment for your business or organisation premises

If you know a thunderstorm is close, or see a lightning flash or hear thunder:

Don't...

- Venture outside, unless absolutely necessary.
- Use plug-in electrical equipment which you have to hold or touch like hair driers, electric razors, food processors and wired telephones during the storm. Lightning may strike the power or telephone lines outside.
- Take laundry off the clothes line.
- Work on telephone or power lines, pipelines, or structural steel fabrication.
- Use metal objects like golf clubs and fishing rods
- Handle flammable materials in open containers.
- Stay on hilltops, in open spaces, near wire fences, metal clotheslines, exposed sheds, isolated trees and any electrically conductive elevated objects.

Do...

- Stay indoors.
- Stay away from open doors and windows, radiators, metal pipes, and plug-in electrical appliances.
- Get out of the water and off small boats.
- Stay in your car if you are travelling. Cars offer excellent lightning protection.
- Seek shelter in a well-grounded building.
- When there is no shelter, avoid the highest object in the area. If only isolated trees are nearby, your best protection is to crouch in the open with your feet as close together as possible.
- When you feel the electrical charge — if your hair stands on end or your skin tingles — lightning may be about to strike you. Drop to the ground immediately.

Thunderstorm location

Why do we need to detect lightning?

The locations of thunderstorms are of great importance to public safety as it is not only the lightning strike that is dangerous, but many other factors linked to thunderstorms. These include intense rainfall, large hail, high straight-line winds and tornadoes. For example, the Boscastle flood in 2004, the Birmingham tornado in 2005 and the Coventry-Sleaford severe hailstorm in 2012 were all caused by thunderstorms.

How can lightning be detected?

The return stroke from a lightning strike produces a broadband electromagnetic burst called an atmospheric or more commonly known as a sferic. The sferics from lightning strikes around the world could be heard on old analogue radios as crackles and the effect of nearby storms also produced interference on old analogue TVs. Each sferic has its own unique waveform, similar to a fingerprint, which can be used differentiate two lightning strikes that occur in close time and space. A sferic peaks in the Very Low Frequency (VLF) band of the radio spectrum. With a network of multiple radio receivers, the position of a lightning strike can be found.

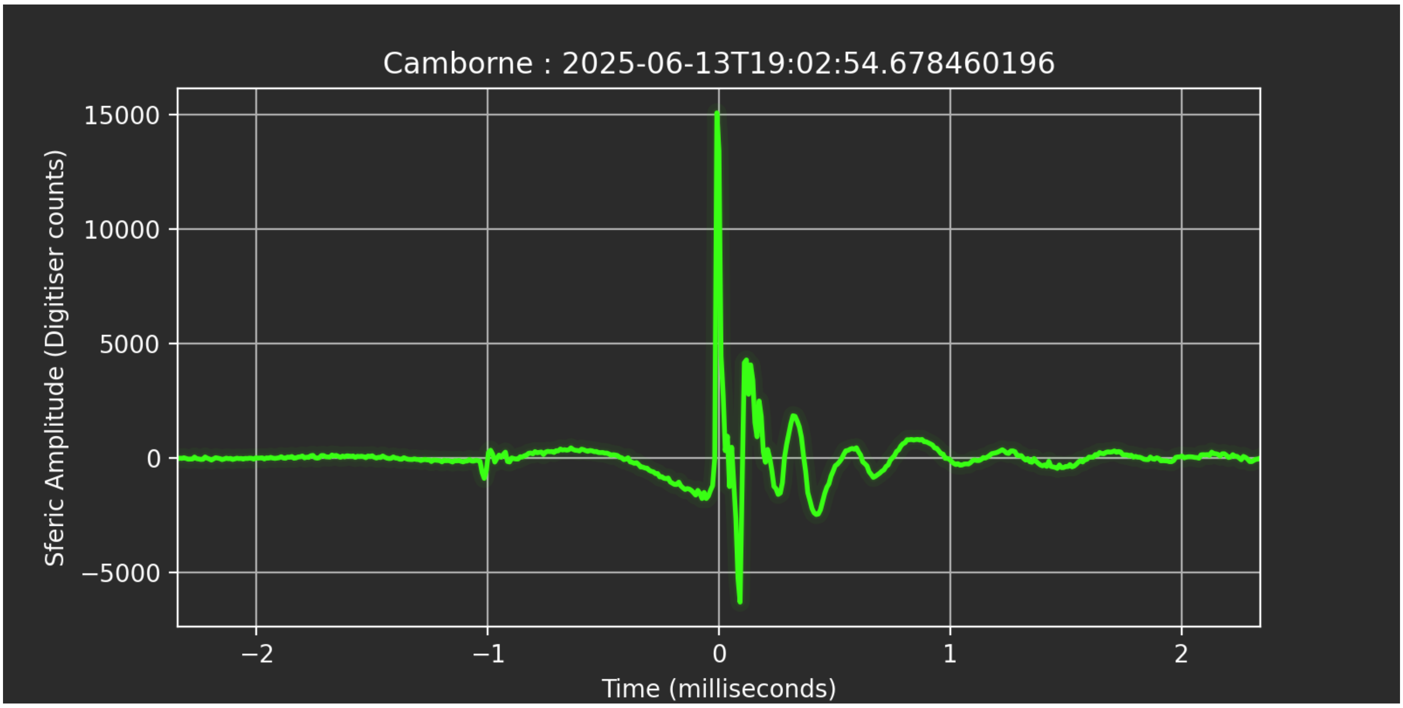

Figure 13: A Sferic generated by cloud to ground strike over the UK detected at Camborne Cornwall

The optical flash from a lightning strike can be detected by space borne lightning imagers operating in the near IR at 777 nm that orbit the earth such as that found on Meteosat-12 covering Africa and Europe.

Radio detection of lightning

The Met Office has operated a radio-based Lightning Location Systems (LLS) since 1915. The first system developed by Robert Watson Watt, who later went on to develop Radar, was a direction-finding system that used a network of receiving stations where each receiver had two antennas mounted at 90 degrees to observe the direction or bearing the sferic was observed from. By combining bearings from multiple sites, the position of a thunderstorm could be triangulated. In the 1980s the direction-finding method was replaced with the Arrival time difference (ATD) network.

The ATD network, and subsequent networks, have used multilateration and worked by calculating arrival time differences between pairs or receivers where a sferic was detected by multiple receivers across the network. Typically, one node is chosen as a reference, each of the other nodes will have an ATD relative to this.

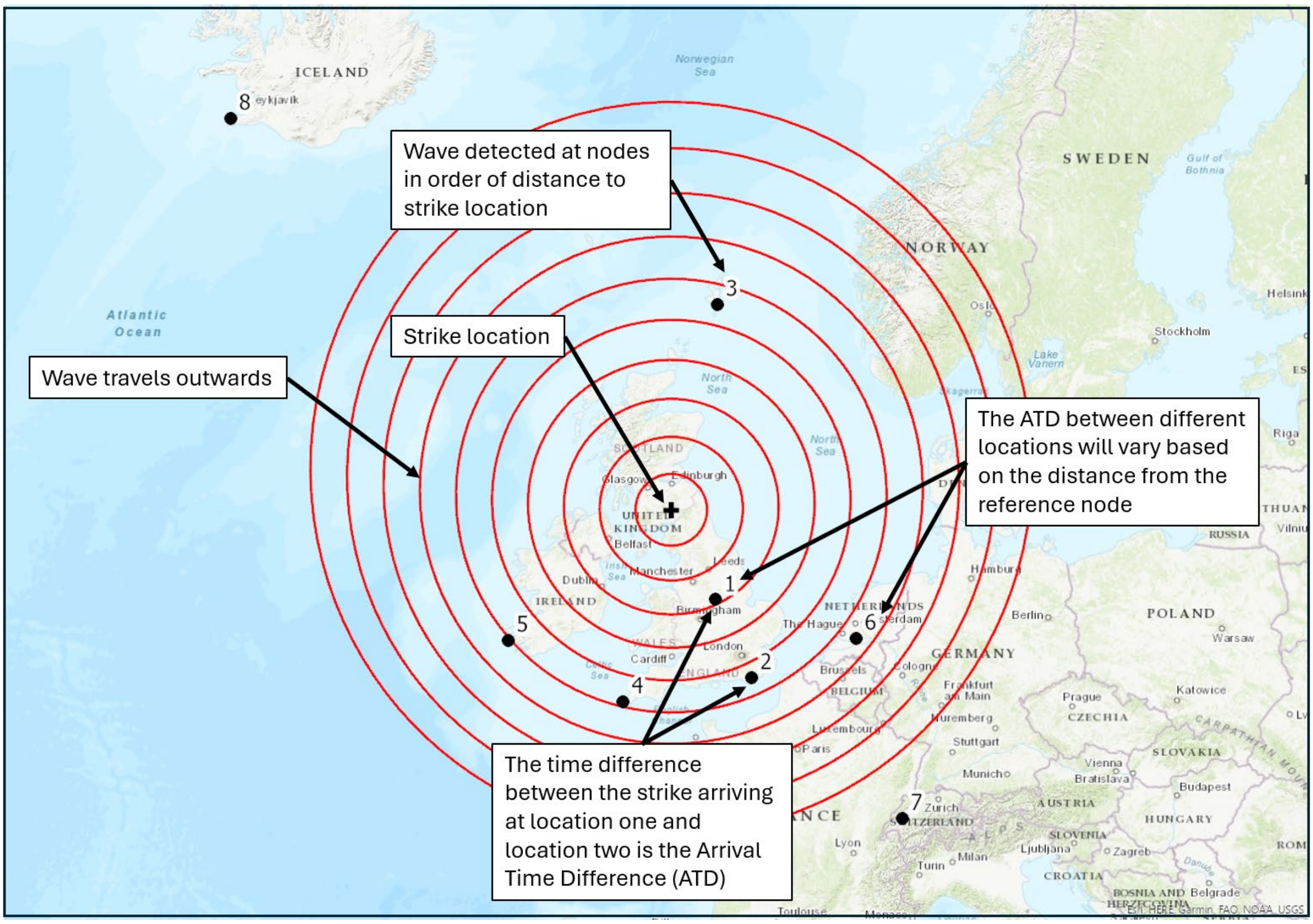

Figure 14: Detection of a strike by various sensors showing how the sferic arrives at each node at a different time. Background mapping ©ESRI 2025

The observed ATD for a given node pair have a specific value and accounting for the fact the sferic travels at the speed of light allow a line of constant ATD or to be drawn across the globe. This means that the lightning strike happened somewhere along this line. By plotting the lines of constant ATD for other node pairs on the same map, the place where all the curves cross is the location of the lightning strike (Figure 16). Thus, whilst a single sensor may be able to detect a sferic, but you need a minimum of four sensors to be able to calculate the location of the lightning strike.

Furthermore, to achieve high location accuracy the timing across the network must be synchronised and precise to at least 1 microsecond (1/1,000,000 of a second). This is due to the sferic propagating very close to the speed of light and that two equidistance stations, for example stations 4 and 5 in Figure 14 could have an ATD < 10 microseconds. Without very accurate timing, the calculations done to locate the strikes would be impossible. Thus, timing is done at each sensor using a precise oscillator all of which are synchronised with each other by satellite time signals from Global Navigation Satellite Systems.

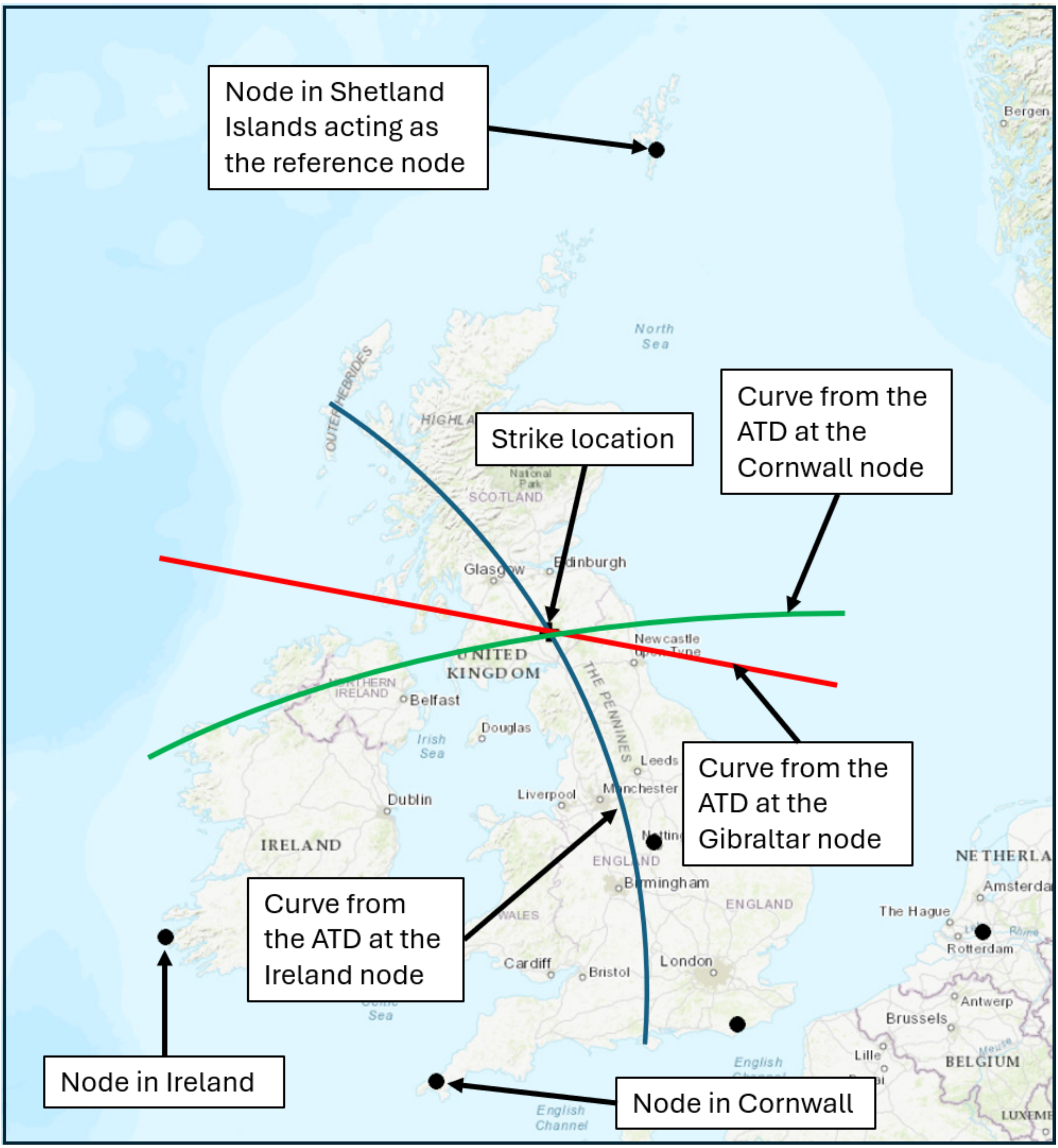

Figure 15: ATD lines plotted on a map showing the location of a strike in Ireland. The reference node on this occasion is in the Shetland Islands. Background mapping ©ESRI 2025

As sferics peak in the VLF they can travel great distances because they are reflected between the surface of the Earth and an electrically charged layer of the upper atmosphere called the ionosphere — in a similar way to light travelling within a fibre optic cable (Figure 17).

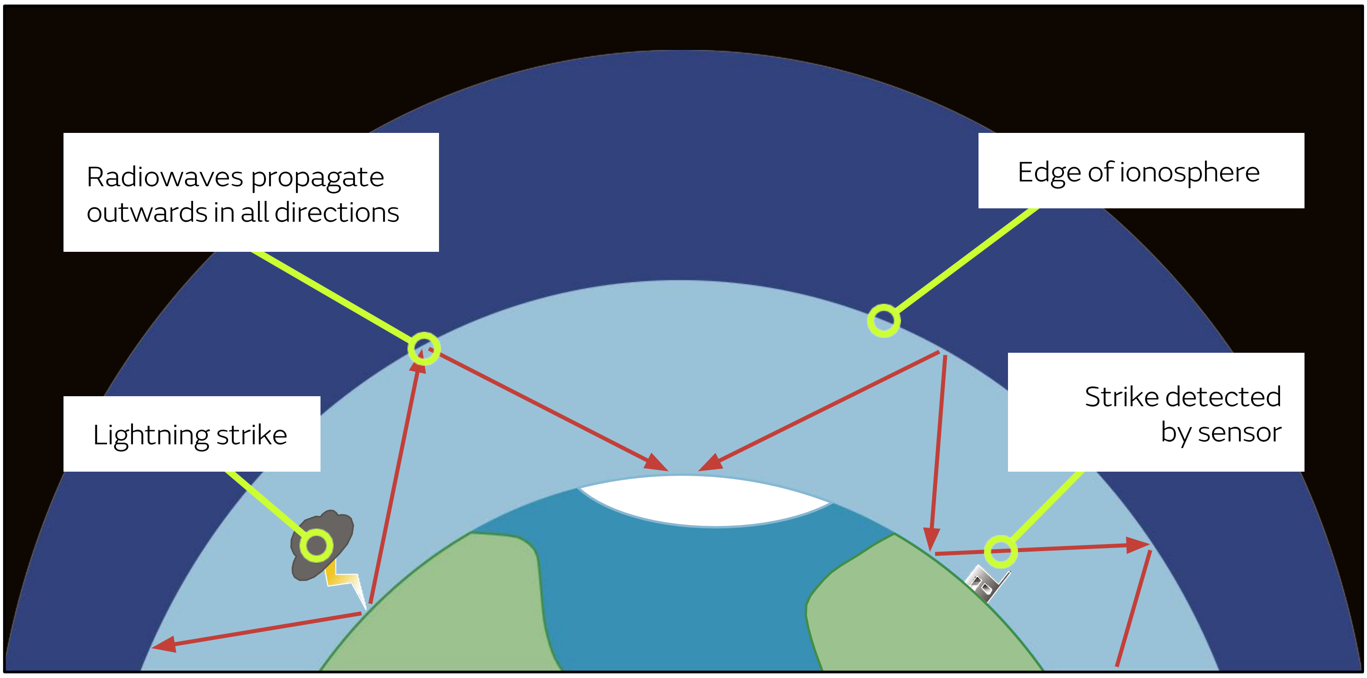

Figure 16: The propagation path of a sferic between the earth and Ionosphere.

ATD was replaced with ATDnet in 2008 which offered a boost in performance and allowed even more sferics to be detected and process.

Our current VLF LLS, Lightning Electromagnetic Emission Location using Arriva time differencing (LEELA) is optimised to locate thunderstorms across Europe. The LEELA system consists of a network of 11 nodes positioned around Europe (Figure 18), tuned to pick up these sferics and feed their reports back to a cloud computing service which works out the origin of the sferic.

Figure 17: LEELA node locations. Background mapping ©ESRI 2025

LEELA is capable of detecting lightning at distances more than 10,000 km as shown in Figure 19. The areas where lightning can be detected further afield are dependent on the propagation path of the VLF sferic signal and so it does not detect lightning in all parts of the world. The location accuracy and detection efficiency also drops with increasing distance outside of Europe. LEELA superseded ATDnet as the operational LLS in June 2023 and operates 24 hours a day, 7 days a week.

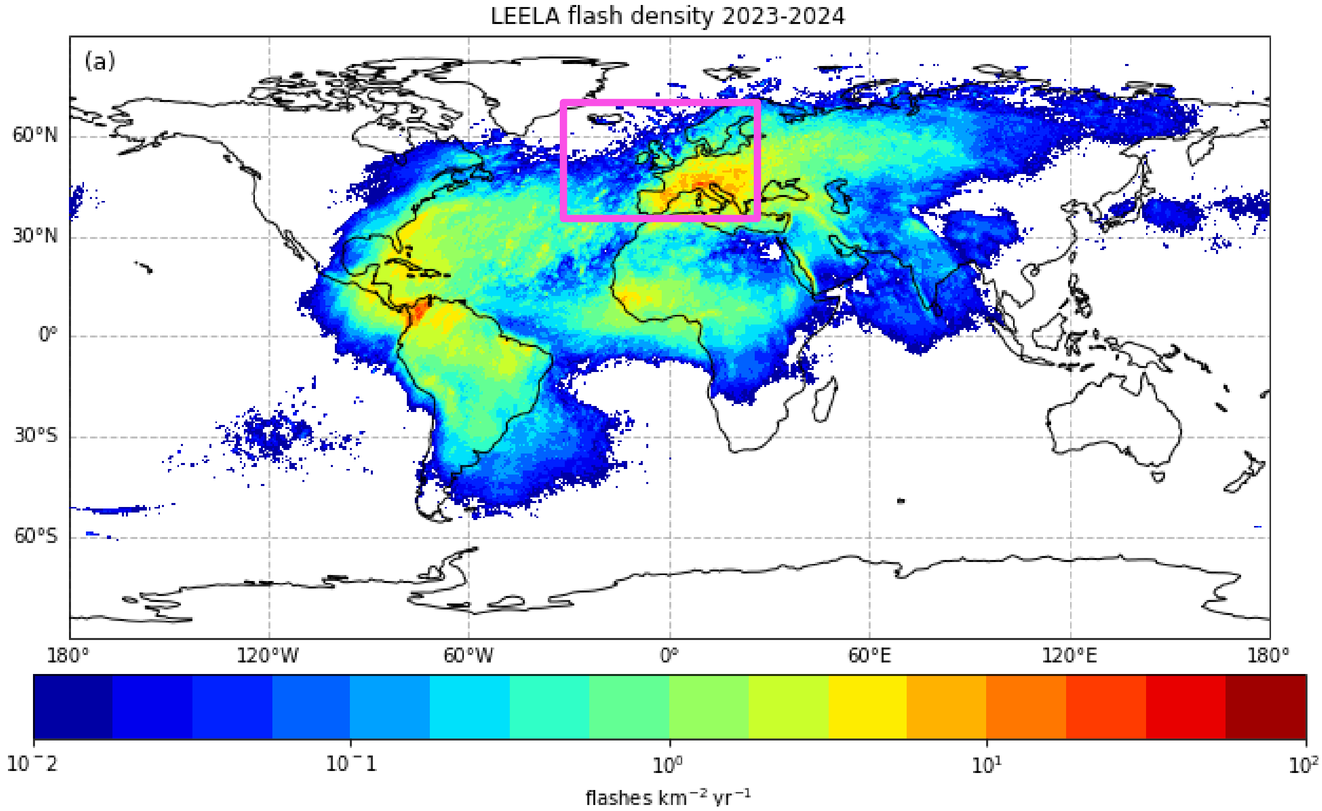

Figure 18: Lightning flash density plot for LEELA between 2023-2024 inclusive

How accurate is LEELA

The system is designed with several quality control systems in place to stop incorrectly located strike locations from being displayed in products sent out to our customers. The false strike location rate must be kept low for our customers to maintain confidence in the system. Furthermore, given the reduction in detection efficiency and location accuracy outside of Europe to ensure quality only lightning strike data within the magenta box in Figure 18 are offered to customers.

LEELA has been compared to other remote sensing lightning detection methods. However, comparisons between other remote sensing systems are difficult due to the following: For radio-based LLS different frequency bands are utilised which means they can have a different sensitivity to different parts of the lightning channel and associated processes. This means that a large proportion of strikes detected by both the test system and reference cannot be matched up. However, for the strikes that were matched the relative location accuracy of LEELA over the UK was 3 km, a factor of two better than ATDnet. The term relative is used as it is only as good as the accuracy of the other LLS. Satellite based optical methods tend to detect the whole flash as opposed to individual strikes. In addition to this parallax errors can also occur meaning it can be difficult to co locate flashes especially at higher latitudes.

An alternative is to use ground truths documented in media reports. Using these ground truths, it was found that during thunderstorms LEELA could detect a cloud to ground strike to within 5km of a ground truth 100% of the time. 93% of the time LEELA could detect the lightning strike to within 2 km of the ground truth. Figure 11 shows a cloud to ground strike which has a significant horizontal component. The accuracy of LEELA is comparable to the horizontal component of lightning strikes which can be as much as 10 times longer in the horizontal than in the vertical.

Optical detection of lightning from Space

Lightning Imaging sensors are high speed cameras which operate in excess of 500 fps and operate in the near infra-red at 777 nm. When a flash of lightning occurs in its field of view, it causes one or more of the cameras pixels to trigger. As the satellites position is known each pixel in the sensor corresponds to a longitude and latitude point on earth.

Typically, during a lightning strike multiple pixels or events will illuminate in a cluster that may last several camera frames, which is often referred to as a group. Groups close in time and space are then clustered into flashes.

The advantage of space borne Lightning Imaging sensors such as Meteosat Third Generation Lightning Imager (MTG LI) and the Geostationary Lightning Mappers on the GOES-East & GOES-West satellites is the ability to observe lightning flashes over large parts of the globe with good detection efficiency. However, these methods rely on the optical flash being observed through the top of the thundercloud so have less precision in terms of location accuracy and cannot infer information about the type of lightning.

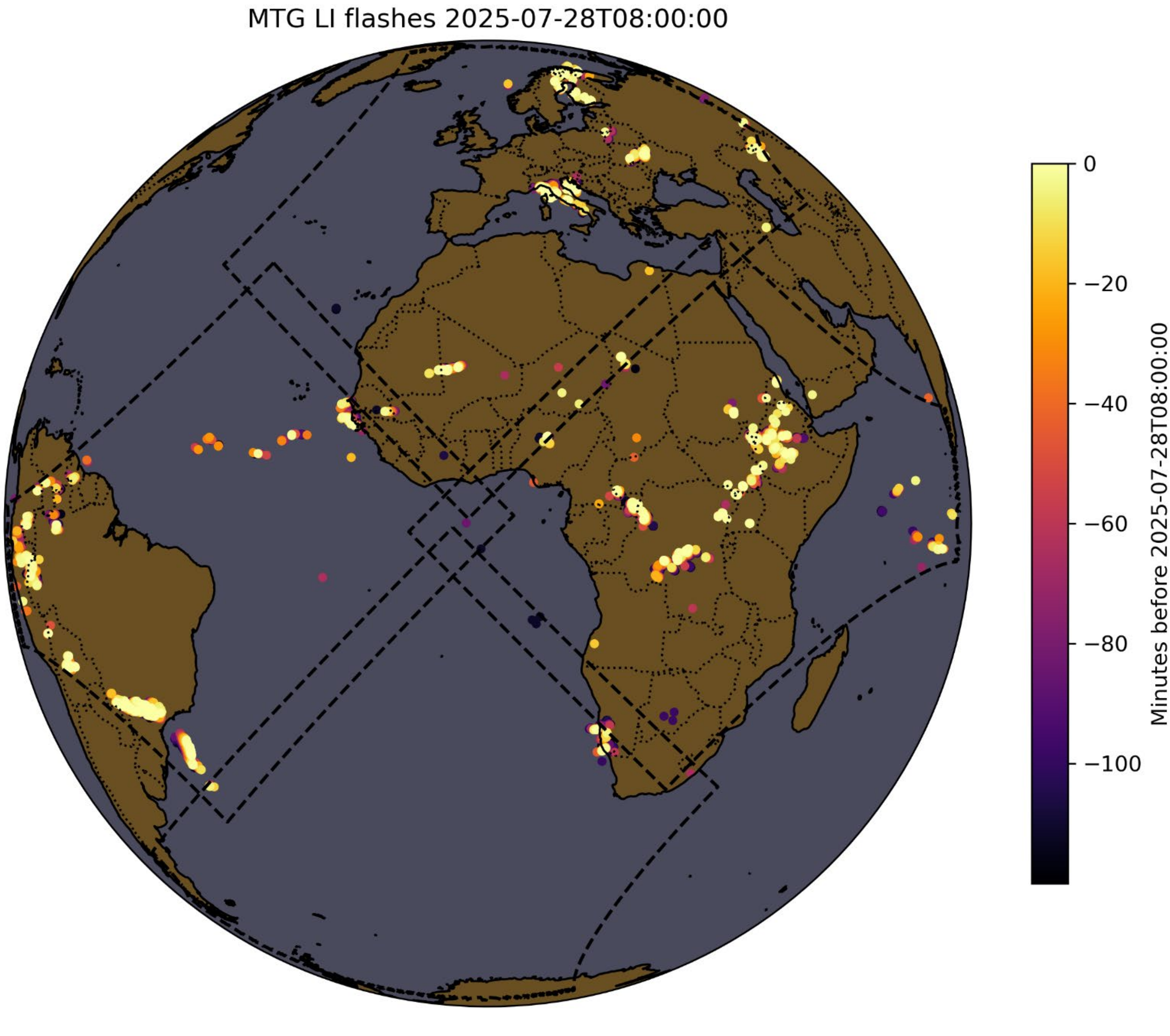

Figure 19: Lightning flash data from MTG-LI (EUMETSAT) for the two hours proceeding 08 UTC on 28th July 2025. Black dashed lines show MTG LI's field of view

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Met Office FitzRoy Road, Exeter, Devon, EX1 3PB, United Kingdom.
enquiries@metoffice.gov.uk
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