DOCUMENT

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DOCUMENT TITLE

METEOROLOGY FOR AUSTRALIA

CHAPTER 20 – THUNDERSTORMS

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THUNDERSTORMS

THUNDERSTORM DEVELOPMENT

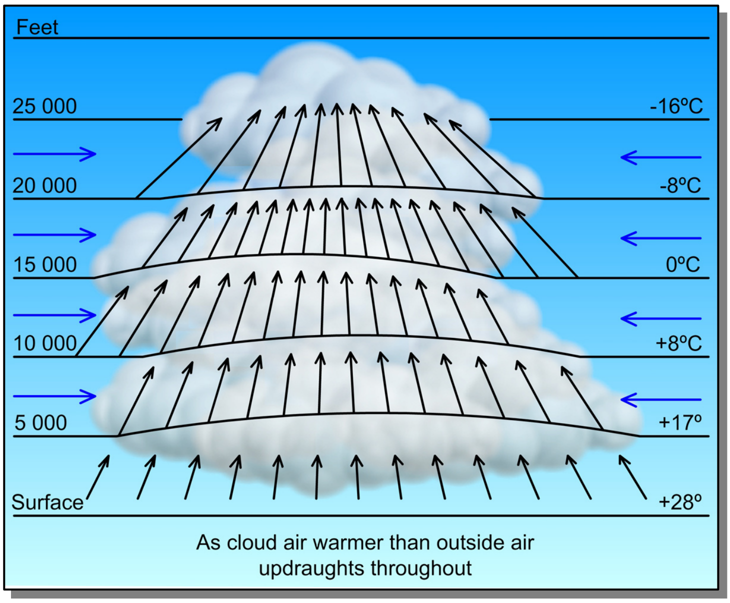
Before a thunderstorm will occur, there are three basic requirements:

- A vast amount of **water vapour**, especially in the lower atmosphere;
- **Instability** or conditional instability through a deep layer of the lower atmosphere; and
- A **trigger** mechanism to make the air rise.

Given these conditions a thunderstorm can now take place. It does so in three phases: the growing stage, the mature stage and the dissipating stage.

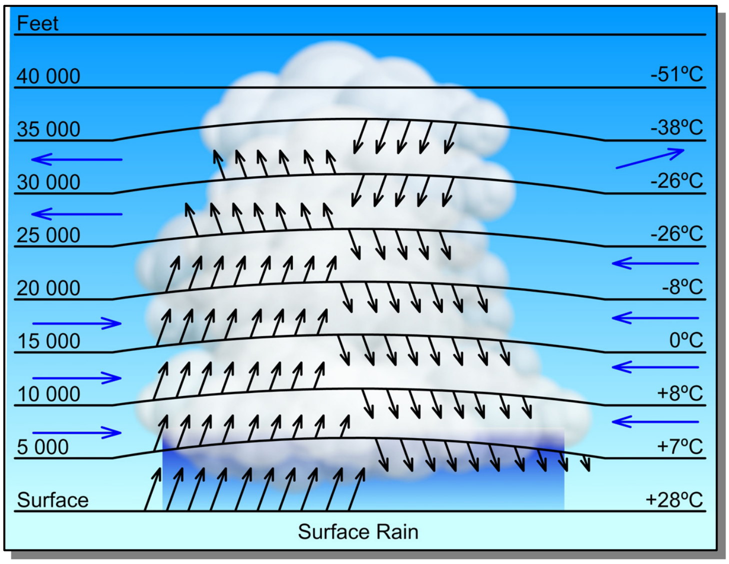
Growing (Cumulus) Stage (10–15 minutes)

Cumuliform cloud will appear, becoming visibly taller. The cloud consists mainly of water droplets with some ice crystals. There will be strong up currents, of the order 15–20 mps. There will be **no** precipitation.



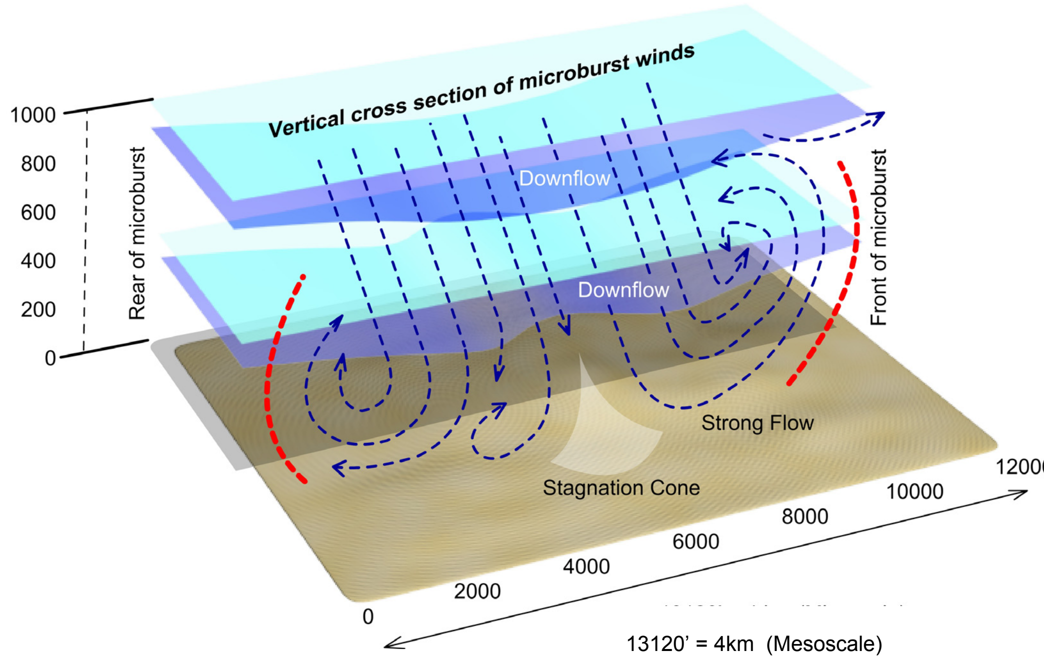
Mature Stage (15–30 minutes)

The onset of precipitation indicates the start of the mature stage. It is during this stage that low-level **windshear, turbulence and microburst** risk are the greatest. The air "falling" from the Cb is heavier and colder than the surrounding air. Precipitation is heavy rain, snow and hail. The hail and snow may melt below the FZL becoming heavy rain. An anvil top may begin to form.

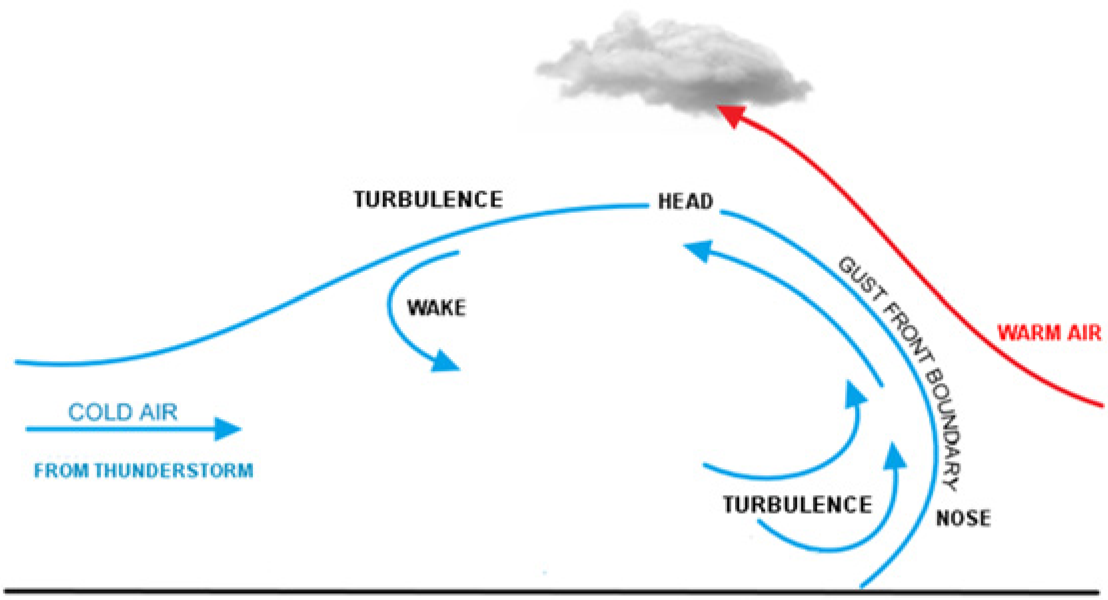


Air drawn in at the freezing level from outside the cloud is unsaturated (dry). It is taken upwards inside the cloud, mixing with the saturated air. The entrained air from outside the cloud modifies the lapse rate within the cloud, so that instead of changing temperature at the SALR, the mixture lapses at a slightly greater rate, between SALR and DALR. If the SALR at that level was (for convenience) 2°C/1,000 ft, then the actual lapse rate of air inside the cloud might be 2½°C/1,000 ft.

While descending in the rain, the air brought down would at all times be saturated through evaporation. Its descending lapse rate would therefore be the SALR of 2°/1,000 ft. During the descent back to the height of the 0°C level, it would warm at the SALR and be **colder** than the air elsewhere in the cloud at that level. Being colder it would be denser and heavier, and so accelerate downwards. Evaporation below the cloud would remove further latent heat, cooling the downdraught and producing a cold gust or squall below.



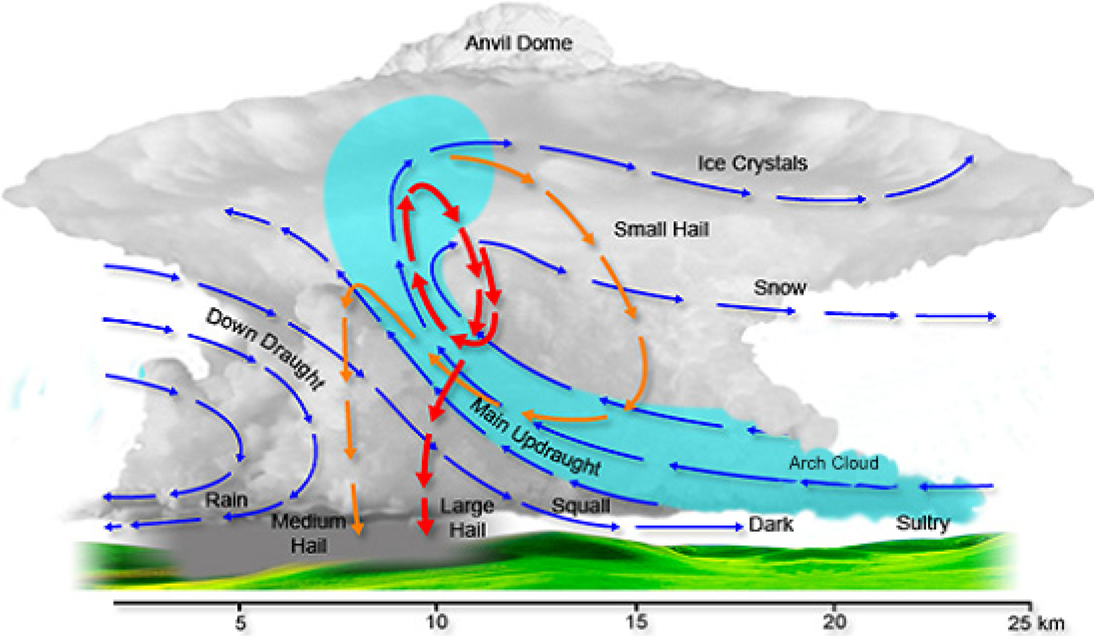
This is called a downburst or microburst.



Updraughts may be found upwind of the Cb. The cold air outflow causes severe low level windshear and the gust front. This is clearly shown above.

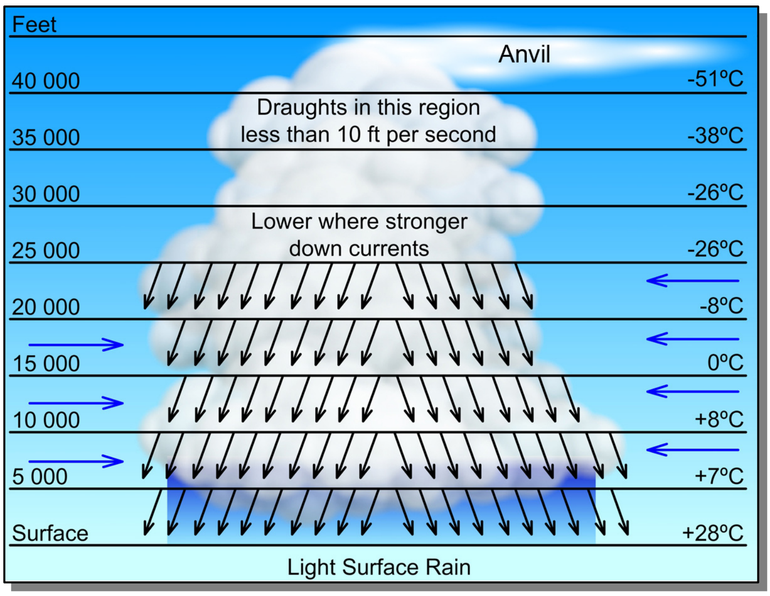
The diagram below shows the movement of air and hailstones within a thunderstorm. The largest hailstones fall from the main updraught (the more darkly shaded area), but then they are carried up on the updraught for a second time.

Because the hailstones are now much larger than the surrounding water droplets, they rise only slowly, building up a thicker layer of ice. Repeated passage through this process results in "layering" in the internal structure of the hailstone.



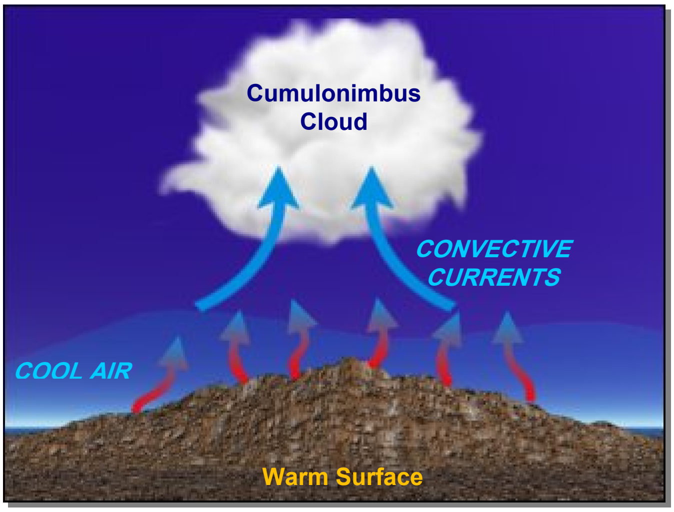
Dissipating Stage (30 minutes)

By now the thunderstorm air movement consists of only down-draughts. Rain, snow and ice will still be present in the cloud, but precipitation will be mainly rain. A large anvil is present with the top blowing downwind. The top becomes ragged and diffused, with a Ci appearance.



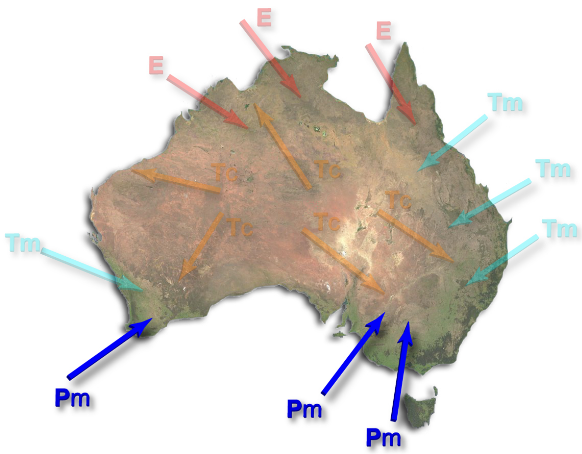
THUNDERSTORM CLASSIFICATION

Thunderstorms need a "trigger" action to provide the initial vertical motion. This trigger is used to describe the type of thunderstorm.



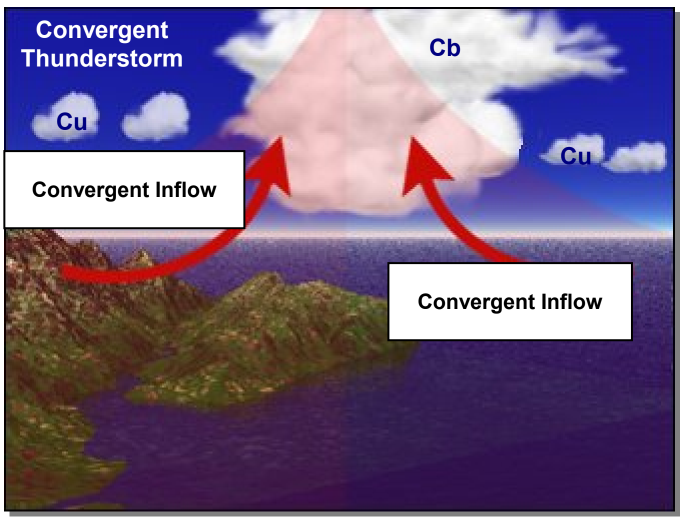
Heat Thunderstorms

Convective thunderstorms are common in tropical areas on most afternoons as strong surface heating creates an unstable atmosphere.



Cold Stream Thunderstorms (latitudinal heating)

In southern Australia, as a cold Pm southerly stream moves northwards over a warmer surface, the ELR near the surface increases and becomes unstable.

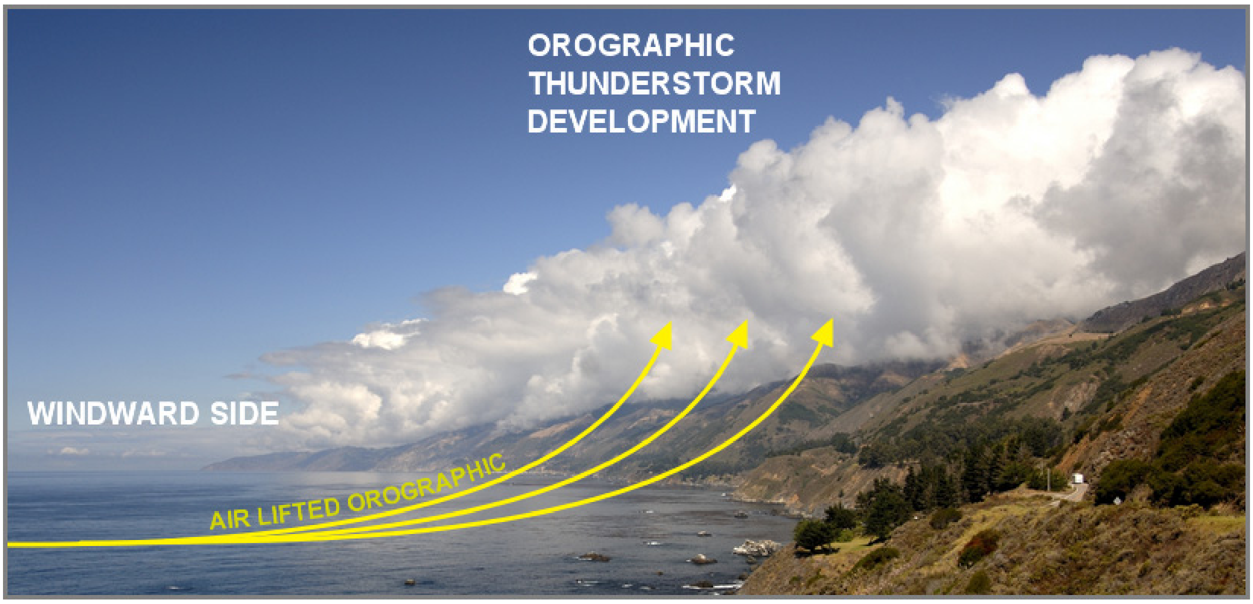


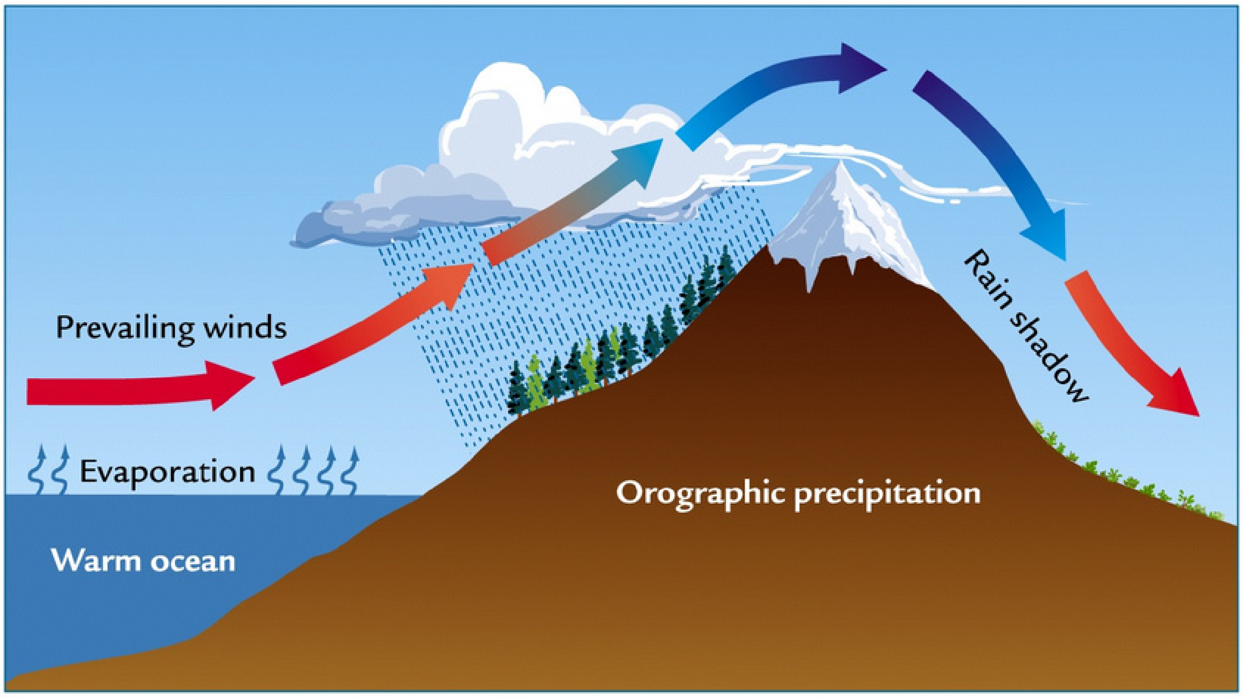
Convergence Thunderstorm

These are caused by surface convergence. Air above 2,000 ft. flows parallel to the isobars but the air below 2,000 ft. veers (Southern Hemisphere) or backs (Northern Hemisphere) by about 30°. Air in a low or a trough converges and is therefore forced to rise.

Orographic Thunderstorms

Air is forced to rise on the windward side of a mountain or high ground. If the air is unstable, Cbs may form. These storms may remain stationary on the windward side.

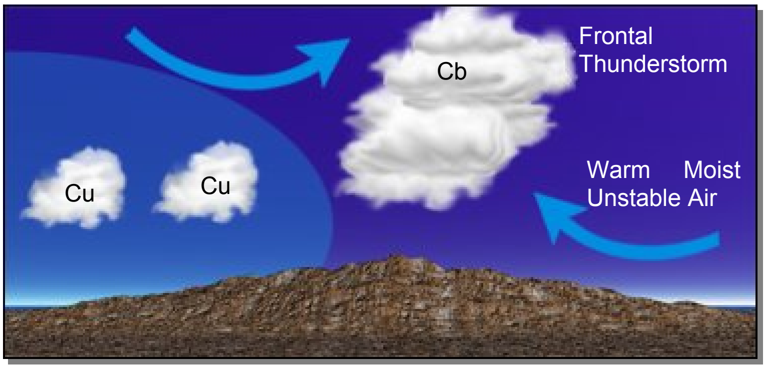




Frontal Thunderstorms

Fast moving Cold Fronts, produces thunderstorms by the warm air preceding the cold front being forced to rise. Frontal thunderstorms are more hazardous than air mass thunderstorms because:

- The cells are more numerous
- Cloud base are lower
- They move more rapidly
- A "wall" or a "line" of thunderstorms may form
- They produce or contain greater turbulence.



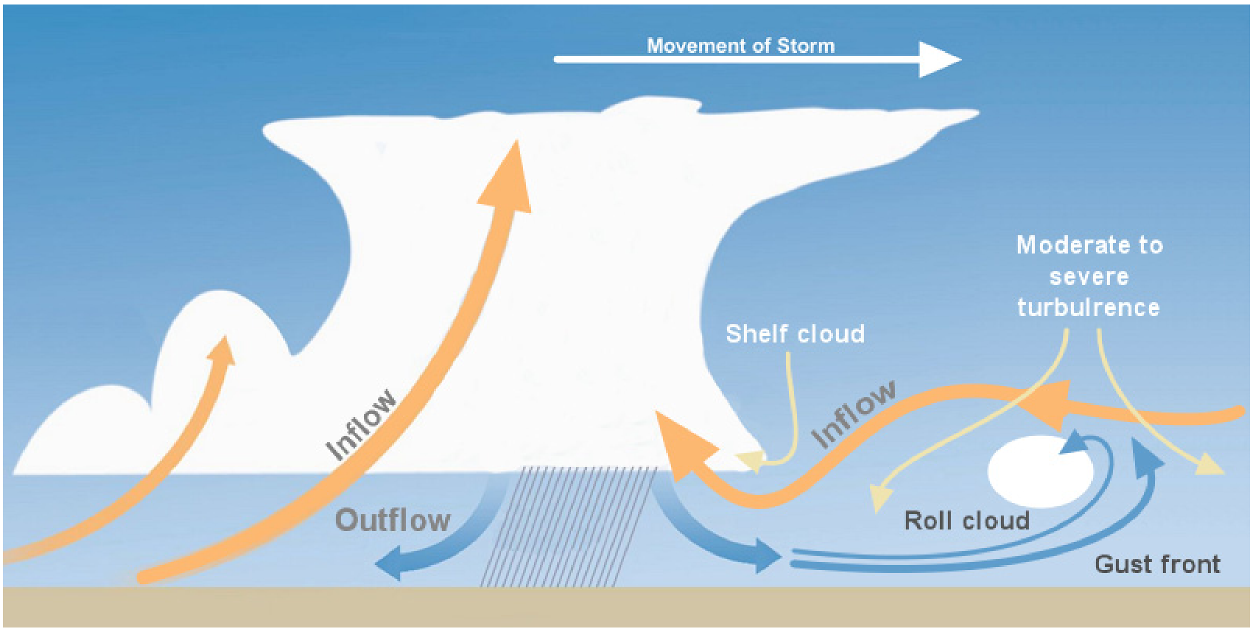
Nocturnal Equatorial Thunderstorms (Upper Cold Pool)

These occur at night over tropical oceans. A thick cover of cloud over the sea keeps the surface warm but radiation cooling of the cloud tops creates an upper air cold pool. The ELR increases and the air becomes unstable. They usually occur near dawn when the cooling of cloud tops is the greatest.

HAZARDS OF FLYING THROUGH A THUNDERSTORM

The following hazards exist when flying in the vicinity of thunderstorms:

- Down draughts near ground level
- Hail
- Severe turbulence
- Severe icing
- Poor visibility and a low cloud base
- Lightning
- Water Ingestion (in Turbine engines)



DO'S AND DON'TS OF THUNDERSTORM FLYING

Normally, all aircraft will avoid thunderstorms. In the unlikely event that the flying through a storm is unavoidable, it must be remembered to never regard any thunderstorm lightly even when radar observers report the echoes are of light intensity. Avoiding thunderstorms is the best policy. Following are some do's and don'ts of thunderstorm avoidance:

- **Do** plan an alternative route, before take off, if thunderstorms are forecast. Planning will be far more rational in the calm of the briefing office than in flight when confronted by the problem. Be prepared to divert before the thunderstorms become unavoidable.
- **Don't** land or take-off in the face of an approaching thunderstorm. A sudden gust front of low level turbulence could cause loss of control.
- **Don't** attempt to fly under a thunderstorm even if you can see through to the other side. Turbulence and windshear under the storm could be disastrous.
- **Don't** fly without airborne radar into a cloud mass containing scattered embedded thunderstorms. Scattered thunderstorms which are not embedded can usually be visually circumnavigated.
- **Don't** trust the apparent size as a reliable indicator of turbulence inside a thunderstorm.
- **Do avoid by at least 20 nm any thunderstorm**.
- **Do** circumnavigate the entire area if the area has five oktas or more thunderstorm coverage.
- **Do** remember that vivid and frequent lightning indicates the probability of a severe thunderstorm.
- **Do** regard as extremely hazardous any thunderstorm with tops of 35,000 ft. or higher whether the top is visually sighted or determined by radar.

If you **cannot avoid** penetrating a thunderstorm, following are some do's **before** entering the storm:

- Tighten your seat belt, put on your shoulder harness if you have one, and secure all loose objects.
- Plan and hold your heading to take you through the storm in a minimum time.
- To avoid the most critical icing, establish a penetration altitude below the freezing level or above the level of -15°C.
- Verify that pitot heat is on and select carburettor heat or turbine-engine anti-ice. Icing can be rapid at any altitude and cause almost instantaneous power failure and/or loss of airspeed indication.
- Configure your aircraft for turbulence penetration using power settings and airspeed recommended in your aircraft manual.
- Turn up cockpit lights to highest intensity to lessen temporary blindness from lightning.
- If using automatic pilot, disengage altitude-hold mode and speed-hold mode. The automatic altitude and speed controls will increase manoeuvres of the aircraft, thus increasing the likelihood of structural stress.
- If using airborne radar, tilt the antenna up and down occasionally. This will permit you to detect other thunderstorm activity at altitudes other than the one being flown.

Following are some do's and do not's during the thunderstorm penetration:

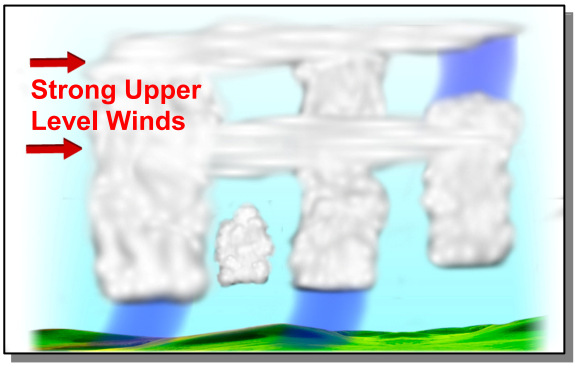
- **Don't** turn back once you are in a thunderstorm. A straight course through the storm will most likely get you out of it in the shortest time. In addition, turning manoeuvres increase stresses on the aircraft.
- **Don't** change power settings; maintain settings for the recommended turbulence penetration airspeed.
- **Do** maintain a constant attitude; let the aircraft 'ride the waves'. Manoeuvres to maintain constant altitude increase stresses on the aircraft.
- **Do** keep your eyes on your instruments. Looking outside the cockpit can increase danger of temporary blindness from lightning.

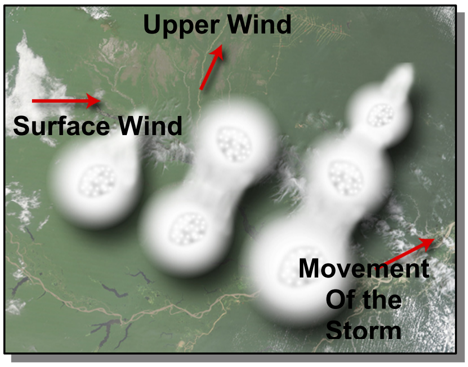
FORMATION OF ADDITIONAL CELLS

From the previous discussion, it would appear the life span varies on average from about 1 to 1½ hours. However, observation reveals that thunderstorms can last many hours. Therefore, it can be assumed that during the period of a thunderstorm, cells are continually growing and dissipating. New cells tend to grow in close proximity to existing cells and there are two processes that account for this.

Wind Shear Effect

When a wind shear exists near the top of a cumulonimbus cloud containing a thunderstorm (whether the wind shear be a change in the wind direction or speed does not matter), the top of the cloud is carried downwind from the main cloud "chimney". This causes the ice crystals in this upper part of the cloud to precipitate outside the lower part of the cloud giving two results. The first is that it prevents cooling of the rising currents in the main cloud, so that these currents are likely to be stronger and the cloud likely to give a longer lift.



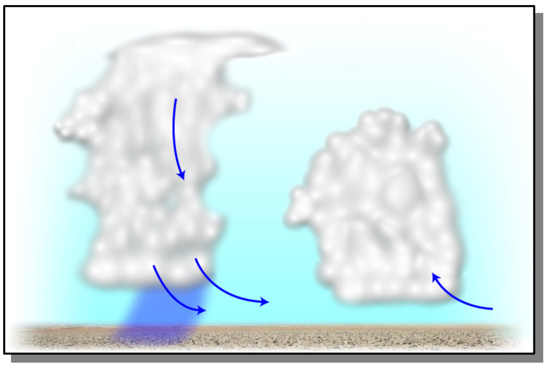


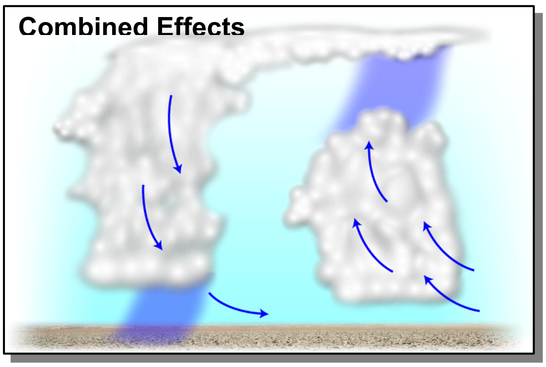
Windshear Effect

The second result is that if the ice crystals fall onto other cloud around the cumulonimbus, they tend to "seed" that cloud. This has the effect of causing supercooled water drops in the lower cloud to freeze, thus releasing latent heat of fusion. The release of the latent heat may then cause the air in that cloud to become unstable or more unstable, and so trigger further thunderstorm cells.

Pseudo Cold Front Effect

During the mature stage of the storm cell, the cold down currents associated with areas of precipitation, emerge from the base of the cloud and spread out underneath it in all directions. As this air may be some degrees cooler than the environment near the surface, it forces environmental air in its path, aloft. This may be sufficient trigger action to produce further thunderstorm cells in the same way that they are produced by a fast moving cold front.





Pseudo Cold Front Effect