Thunderstorms

On November 20th 1953, test pilot Scott Crossfield, a contemporary of Chuck Yeager, became the first man to fly at Mach 2. On April 19, 2006, at the age of 84, he died in a Cessna 210. Even a possessor of what Tom Wolfe, in his superb book, called The Right Stuff was no match for one of the great hazards to aviation – a thunderstorm.

How to make a thunderstorm

Three requirements. Firstly, the atmosphere needs to be unstable, or at least conditionally stable, for a considerable depth, meaning the environmental lapse rate (ELR – the fall in temperature with height, which is typically about 2° per 1000 ft, but it varies) is greater than the saturated adiabatic lapse rate (SALR – the rate at which the rising air in a cloud cools as it rises – a fixed 1.5° per 1000 ft). Since most readers have no doubt auto-dumped that part of their Meteorology theory after passing the relevant exam, let's put all that in plain English. What that means is that with the right ELR, once warm air starts to rise and cool and form cloud, it will keep rising because it's only cooling at 1.5° per 1000 ft, and the surrounding atmosphere is getting colder at a faster rate with height, so the parcel of air that's forming a cloud is staying warmer than the air around it.

The next thing you need is lots of moisture through a considerable depth, so as the rising air cools, it continues to form cloud to a great height. The reason tropical thunderstorms are the biggest is because the air in colder latitudes is not warm enough to hold the megaquantities of moisture needed to form a good cumulonimbus (CB) cloud.

The other requirement is a trigger to get the air rising in the first place. The descriptions of thunderstorms by type are based on the trigger. Some triggers are:

- A cold front, with colder heavier air sliding in under warmer, less dense air and pushing it up;
- A mountain range causing air to rise (orographic thunderstorms);
- Strong heating of the air in contact with the ground, causing convection – the typical summer afternoon storms in the Wheatbelt are this type;
- Cooling of the tops of big cumulus clouds at night as their heat is radiated to space, causing the lower warmer air to rise and turning the big CU cloud into a CB. Tropical thunderstorms at night are often this type.

The life cycle

Cumulus stage

The cumulus, or building, stage of a thunderstorm involves only updraughts, as the trigger causes the air to rise, the air rises and cools and moisture condenses, and a big cloud forms. CB's at this stage can grow faster than an aeroplane's ability to outclimb them.

Mature stage

Eventually the updraughts near the top of the cloud get weaker, and the water droplets and hail get too big to be supported by the updraughts, and they start to fall. As the precipitation falls, it drags air down with it, which causes strong downdraughts. Rain and lightning start at this stage.

In the mature stage there are still strong updraughts. If an 4000 ft per minute updraught is right next to a 4000 ft per minute downdraught, that kind of turbulence and windshear can rip an aeroplane apart, as it did to Scott Crossfield's 210.

As the cold downdraughts flow out of the base of the cloud and hit the ground, they can spread out and flow horizontally, leading to very strong windshear. That's caused the demise of quite a few aircraft, big and small, and that's why you don't try to land under a thunderstorm.

The mature stage typically lasts between 20 and 40 minutes, which is why thunderstorms generally appear on TAFs under the heading of an INTER or TEMPO.

Dissipating stage

The cold downdraughts eventually cause the warm updraughts to weaken, which means the cloud will stop growing and will eventually collapse into something smaller and less life-threatening.

The hazards

The dangers to aviation can be present not just in the cloud and under it, but also for some distance around it, particularly downwind. The hazards include:

- Severe windshear, which can lead to loss of airspeed, stalling, and structural damage;
- Severe turbulence (Note here that according to the AIP, one of the criteria for rating turbulence as Moderate is "Difficulty in walking." It's hard to walk in PGL, Dave Mac's Archer or Nathan Gudgeon's Cirrus at the best of times, which suggests the criteria are based on airliners. If turbulence is "Severe" for a big jet, how will it feel in your 4-seater?)
- Hail damage;
    - Hailstones can grow in the clouds as they fall and collect more and more water;
    - Big hail is not common (on the ground at least) in the tropics because it melts before it reaches the ground. That's why the reports of massive hail damage are more likely to be from Sydney than from Darwin.
- Severe icing;
- Lightning damage;
- Reduced visibility.

Downbursts and microbursts

A microburst can form under a big CB, and typically is no bigger than about 4 km, with a lifespan of about 10 minutes, and horizontal wind shear of up to 50 kt.

Virga (rain that doesn't reach the ground) is a good indicator of a microburst. If the rain is evaporating, it's absorbing latent heat from the air to do so, which creates a very cold heavy parcel of air that can plummet towards the ground at a rate that you will not outclimb. You won't overcome the associated windshear either, so avoid at all costs.

Tornadoes and waterspouts

In the growing (cumulus) stage, if the updraughts start close enough to the surface, they may suck up objects. Over the water that means waterspouts, and over land it means tornadoes which, if you take any notice of most media, only happen in the US, such as to Dorothy in Kansas, and not in Australia. We do get them once in a while in WA.

Avoiding them

As well as the forecasts, the anvil at the top of a good CB gives you a good indication of which was is downwind, and you should avoid the storm by even more in that direction than upwind.

Here's an easy one: don't fly anywhere near virga.

As an IFR pilot, if you saw "Embedded CB" on a forecast, you'd hope that if you flew into cloud, your weather radar would tell you if there's a CB embedded in the nice comfy stratus layer you're cruising. In. But as a VFR pilot, that's just one more reason to avoid the clouds, but also to avoid flying under them. Who knows what's coming out of the bottom of that CB that you can't see?

A multicell thunderstorm – a group of ordinary, short-lived cells that combine, with cells at different stages of their life cycles – can mean a cluster or a long line of thunderstorms with a relatively long life. A squall line is one example. This is a long line of continuous thunderstorm activity, developing due to a lifting mechanism along a line, such as a cold front, and they may present a wall of severe weather that's too high, wide and long to get around. If that's what's ahead of you, it's the big 180 degree turn. Or better still, don't take off in the first place.

On forecasts

On a TAF, most cloud types are not given. You only see, for example, *FEW030*, and you need to look out the window to see what type of cloud it is. But if it's CB or towering cumulus (TCU), the type will be included, as will any associated weather eg. *SCT030CB.* TSRA for thunderstorms with rain, or TSGR for thunderstorms with hail (GR is either the French word for hail – grele – or God-rocks, depending on your viewpoint.)

On a GAF, which generally includes only cloud with bases below 10,000 ft, CB or TCU will be included, even if the base is above 10,000 ft. For these cloud types, the amount is not given as FEW, SCT, BKN or OVC. It's ISOL, OCNL, FRQ or EMBD (I reckon you can make sense of those abbreviations without help!)

SIGMET are also issued for thunderstorms if they are obscured by smoke or haze, if they're a squall line, or if they're FRQ or EMBD.

For more information on thunderstorms and the ways they're included in forecasts, see the excellent information at Knowledge Centre (bom.gov.au).