

CHAPTER 9 - BASIC SOARING METEOROLOGY

The real art in becoming a soaring pilot lies in a good understanding of the weather. In Chapter 1 we covered the various types of weather conditions which enable a glider to stay in the air, gain height and maybe fly cross-country. Now we will cover in a little more detail the aspects of weather which a glider pilot needs to understand in order to use his glider to optimum effect.

ATMOSPHERIC STABILITY AND THE DRY ADIABATIC LAPSE RATE

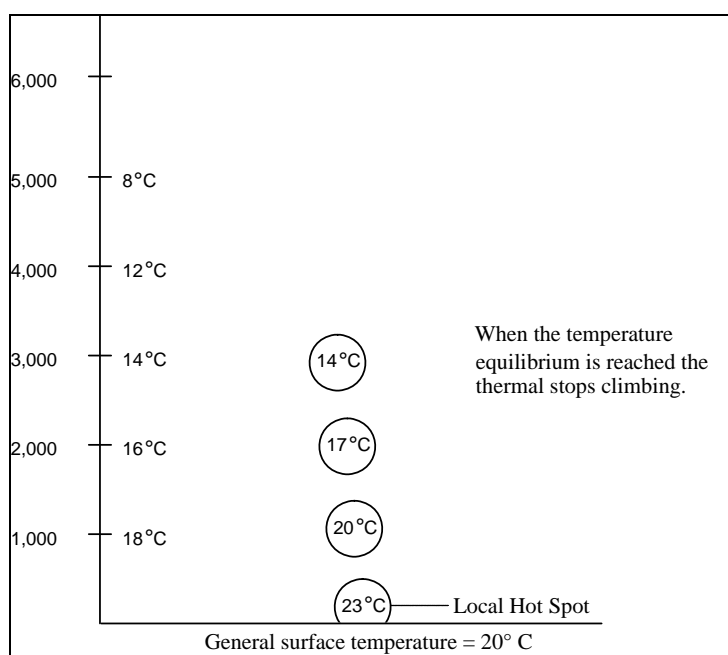
One of the factors which govern whether a glider is likely to be able to soar or not is the "stability" or "instability" of the atmosphere. The definition of these terms is essential knowledge for the soaring pilot. Briefly, the two terms can be described as follows:-

Stability

A thermal comes into existence because the sun heats a particular area of ground to a higher temperature than surrounding terrain. The heated ground in turn heats the air immediately above it. Eventually this air will rise because it is warmer than the air which surrounds it. It will continue to rise for as long as it remains warmer than the general atmosphere around it.

As a general rule, the temperature of air gets less as the height above the earth's surface is increased. This rule applies to thermals as well as to the atmosphere generally. Thermals always cool at a fixed rate, which is 3 degrees Celsius for every 1,000ft gain of height. The general atmosphere may or may not cool at this rate - sometimes it is more, sometimes less. It varies from day to day.

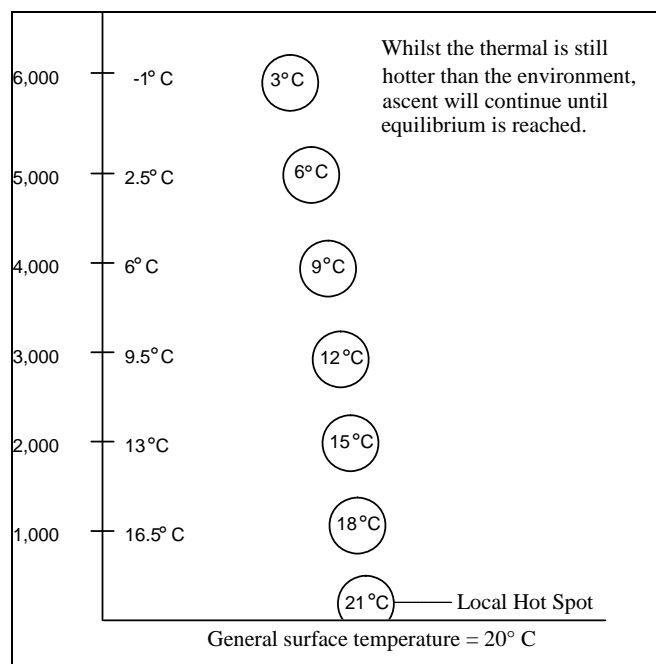
If a thermal (cooling at 3 degrees per 1,000ft) rises above a local hot-spot on the ground and the surrounding (or environmental) air is cooling at the rate of 2 degrees per 1,000ft, the thermal soon gets to the stage where it cools to the same temperature as its surroundings. At this point it stops ascending and such conditions are said to be stable. Stable conditions are not generally regarded as being very good for thermal soaring, but they can work quite well in the height of an Australian summer, when there is a lot of sunshine and local hot-spots become very hot indeed. Such stable days are very late starters, it being quite common to wait until 3pm before thermals are rising to usable levels. When they do get going, though, they are often strong and go to considerable heights. The following diagram illustrates the basic principle of atmospheric stability



The change in temperature with an increase in height is known as the "Lapse Rate". The rate of 3 degrees per 1,000ft, at which a thermal always cools in clear air, is known as the Dry Adiabatic Lapse Rate (DALR, being dry air, cooling without mixing of air with its surrounds). The rate at which the surrounding air cools is known as the Environmental Lapse Rate (ELR).

Instability

As might be imagined, instability is the reverse of stability. Once again, a thermal cools at the DALR as it ascends. If the ELR in this example is 3.5 degrees per 1,000ft (a bit extreme, but it could happen), the thermal remains hotter than its surrounds as it climbs. This encourages the thermal to keep climbing until the environmental air changes its pattern and the two temperatures equalise. See diagram.



The above arguments apply to "dry air" thermals. A different set of rules apply if we introduce some moisture into the air.

DEW POINT

There is always some moisture in the atmosphere. Even the hottest Australian summer day will contain some moisture in the air, even though the actual amount may be very low. The unseen moisture which is present in the air is known as water vapour and the ability of the air to hold this water vapour in suspension depends on the air temperature. The hotter the air, the more water vapour can be present.

When the air is cooled, its ability to contain the water vapour is reduced. A point is reached where the air temperature is too low to keep the water vapour in suspension any longer and it condenses out into visible water droplets. These water droplets are what we call cloud.

The temperature at which the air transforms its water vapour into visible water droplets is called the DEW POINT.

THE SATURATED ADIABATIC LAPSE RATE

We know that a thermal cools at a fixed rate as it ascends in clear air. We also know that it probably contains a fair amount of invisible moisture. The thermal may keep ascending until a point is reached where it has become so cool that the moisture can no longer exist in suspension in the air and it condenses into visible droplets. The air has been cooled to its Dew Point and a cloud has been formed.

As soon as the cloud is formed, the air is said to be saturated. At this point, latent heat is released due to the change of state from water vapour to visible water droplets. This release of heat slows down the rate of cooling of the thermal. Thermals ascending inside clouds cool at a rate less than their lapse rate in clear air. They cool at about 1.5 degrees per 1,000ft in saturated air (it varies a bit, but this is reasonable guide). This new rate is known as the SATURATED ADIABATIC LAPSE RATE (SALR).

The combination of high moisture content of the air, a high degree of surface heating and an unstable ELR results in a tendency for large convection clouds to form. This is the breeding ground for thunderstorms. A weather forecast which contains warnings of these conditions being likely must be treated with great caution by the soaring pilot. The attraction of instability can turn into the destructive power of a convective storm in a very short time indeed.

PRESSURE PATTERNS

Most of us are familiar with the weather maps presented on television and in the newspapers. The patterns of high and low pressure follow a set of natural laws which we should try to understand if we are to predict the likelihood of soaring conditions.

The basic principles are very simple. Air decreases in pressure with an increase in height. It also decreases in temperature because the air expands as it ascends (air will always cool when expanded and heat up when compressed - remember the warming of a bicycle pump when you pump up a tyre). If large-scale heating of the air occurs at the surface of the earth (over a desert, for example), there will be similarly large-scale lifting of the air over that region. This results in pressure variations at high level. This in turn affects the pressure at the surface, because of the variation in the pressure exerted by the "columns of air" above the various points on the earth.

Variations in surface pressure around the world create a flow of air (wind) from high to low pressure. Winds are simply the result of nature trying to equalise the pressure over the earth's surface. They never quite succeed in doing this, which is why there is always some wind blowing somewhere in the world.

There is just one complication. Although the wind tries to blow in a straight line from high to low pressure, the rotation of the earth does not allow this to happen. The straight high-to-low flow is bent into a spiral pattern as the so-called "coriolis" force of the earth's rotation exerts its influence.

The result of this coriolis force is that winds in areas of high pressure tend to blow anti-clockwise around the centre and areas of low pressure develop a clockwise rotation. This is the situation in the Southern Hemisphere. In the Northern Hemisphere the rotation is the other way round.

Areas of low pressure are known as depressions, or in an extreme form, cyclones. Low pressure implies an unstable air mass, because the air is always trying to rise inside a depression. For this reason, depressions can become violent if heated by tropical temperatures and they may turn into cyclones (hurricanes or typhoons in the Northern Hemisphere). Even if they do not turn violent, depressions are generally fairly windy areas.

Anticyclones imply a subsidence of the entire air mass towards the surface. This creates a stable air mass, inhibiting thermal development. For this reason anticyclones are generally benign in terms of bad weather, except that they can encourage the development of fog under some conditions. They are generally areas of light winds, although quite strong winds may precede an impending change in the weather, especially in southern Australia.

Pressure systems move from west to east in Australia. Processions of anticyclones and depressions are in perpetual motion across the continent. They are accompanied by disturbances in the weather which directly result from their interaction with each other.

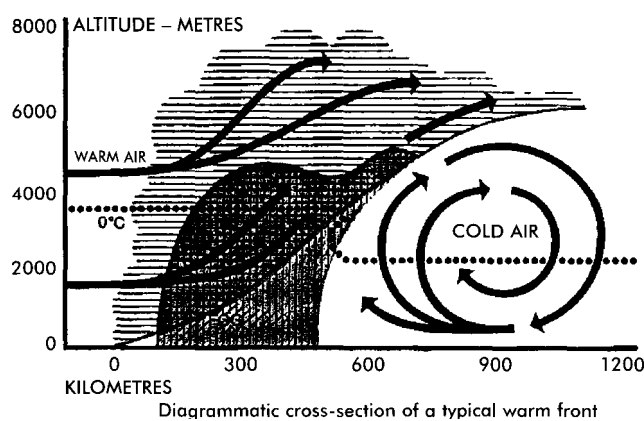
FRONTS

Air is not a good mixer. Air masses of two different temperatures can exist alongside each other for a long time without any sign of mixing, although eventually they will show signs of starting to mix.

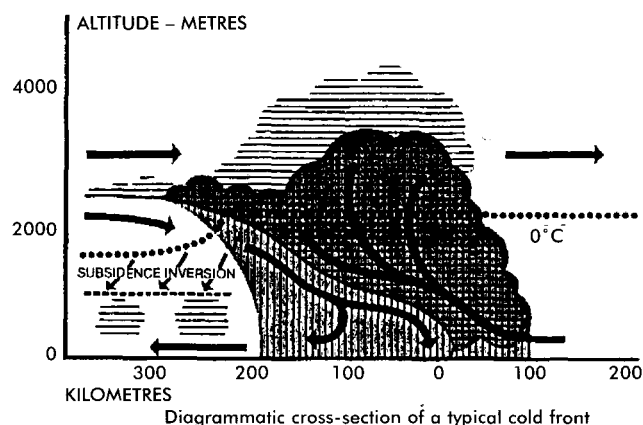
When air flows from high pressure to low pressure, the chances are that a temperature difference will occur due to the introduction of "new" air to "old" air. The two masses of air will not mix and a demarcation line is formed between the two. This line is known as a FRONT.

A front starts as a fairly straight line of demarcation between two different air masses. Very soon, though, our old friend coriolis gets to work and combines with the friction which inevitably exists between the two masses. The combination of these two forces twists the fronts into a characteristic pattern which is familiar to everyone who has seen a weather map. The main types of fronts are :-

Warm front, where warm air overtakes cold air. Warm air is less dense and therefore climbs up over the cold air when it meets it. The rate at which the warm air rises up the face of the cold air is very slow and for this reason the conditions found in the vicinity of a warm front are generally benign. They may be overcast and rainy, but they will not be violent. Warm fronts tend to take a long time to pass and they leave warm, moist air in their wake.



Cold front. This results from cold air overtaking warm air. The denser cold air undercuts the warm air, forcing it upwards very rapidly. The conditions in a cold front are generally blustery with quite heavy rain and often thunderstorms. Cold fronts tend to pass fairly quickly and they leave cold and showery conditions in their wake, which usually clear very quickly to good unstable soaring conditions.



Warm fronts are rare in mainland Australia. Maybe one or two will get to the southern coast of the mainland, although more than this may be experienced in Tasmania. The reason for this is that the fronts develop way to the south-west of Australia and the warm front (which is usually ahead of the cold front) has cleared to the south before the pressure pattern has moved close enough to influence our weather.

HAZARDOUS WEATHER

There are several kinds of hazardous weather which can affect gliding operations, viz:-

Strong winds.

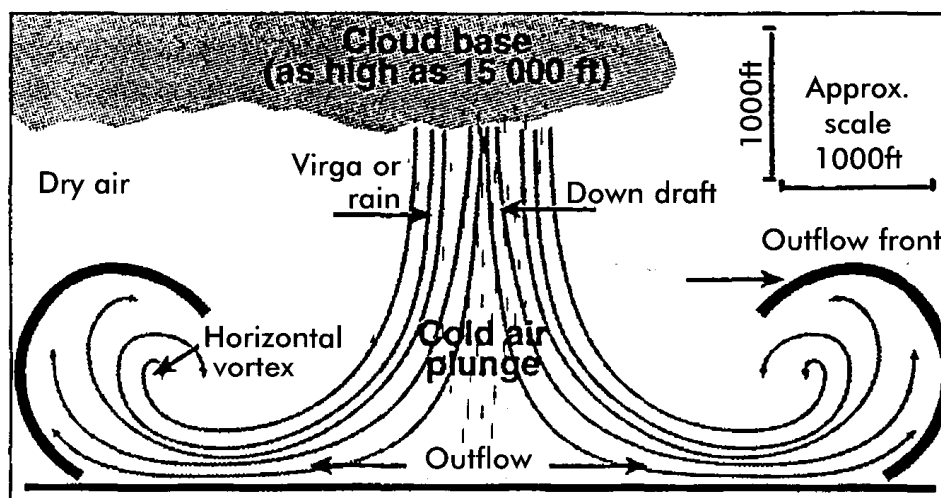
Although these are not usually hazardous to an airborne glider, they may be to a glider on the ground. Even an airborne glider is not completely immune to the effects of strong winds, as wind shear and wind gradient near the ground are known problem areas for glider pilots.

A glider on the ground is very vulnerable to the effects of strong winds. A typical training two-seater stalls at about 34 knots fully laden. At 35 knots it is flying quite well. Take away the weight of the two occupants (which constitute about 40% of the total weight of the glider) and its stall speed will be reduced to somewhere in the low 20s. With 25 knots of wind blowing over its wings, it will fly. An unattended glider in a strong wind is a firm candidate for being blown over unless it is properly secured. See Chapter 5.

Thunderstorms.

These are obviously hazardous. Severe turbulence, extreme up and downdrafts, hail and lightning can all be deadly to a glider which gets caught under or near the edge of a thunderstorm. This is especially true in the tropics, where the vertical extent of such storms gives them a violence which can easily tear a glider apart.

There is one hazard associated with thunderstorms which may not be obvious. This is the "downburst" phenomenon (sometimes referred to as "microburst"), a rapidly descending tongue of cold air emanating from the edge of a fully-developed storm. Apart from the extreme rates of descent which exist in such downbursts, they have a dramatic effect on surface winds when they arrive on the ground. They can make their presence felt up to 8km from the edge of a large storm, in a position where a glider pilot could believe himself to be safe from serious effects of the storm. A glider trying to outrun the storm and make a precautionary outlanding would be seriously hazarded by the downburst and may find it impossible to control the glider in the extremely strong and turbulent wind near the ground.



Microburst.

The motto is - avoid large storms, not by a small margin of 2 km or so - give them a very wide berth indeed. There are forces at work well outside the immediate vicinity of these storms and those forces are invisible to the eye.

Line squalls.

These can be described as miniature cold fronts of an extreme kind. Some of them give plenty of warning of their arrival, with cloud and rain heralding their approach. Others occur in clear air and the first hint of trouble is severe gusting of the wind, enough to overturn gliders and even tear them from their tie-down points.

Clear-air line squalls are fairly common in southern Australia and several gliders have been lost by being left out in the open instead of being hangared for the night. They seem to be exclusively a summer occurrence, related to instability and high temperatures. All that can be said about them is - expect the possibility of line squalls on very hot summer days if there has been very good lift around or you know (because of the forecast) that the air is very unstable.

Hail.

This is usually associated with thunderstorms or at least with very large vertical development of clouds. Gliders or tugs left out in hail storms will definitely get damaged, perhaps beyond repair. If a hail storm or heavy shower is seen approaching, get the gliders and tugs under cover without delay. Light hail, up to about 5mm in diameter, usually appears as white streaks hanging down from the approaching clouds. Heavy hail, where the ice is glazed and the diameter can be up to golf-ball size, appear as green streaks from the clouds. On no account should any flying machine be left out in the path of such a storm. An airborne glider must obviously avoid such areas like the plague.



A severe thunderstorm approaching Woomera, South Australia. The ragged grey-white pieces of cloud are known as a "roll cloud", as they rotate in a horizontal plane and indicate the presence of severe turbulence. The dark base of the storm can be seen and the haziness on the horizon indicates rising dust from the "storm front" striking the ground. This storm lasted for about two hours and produced much lightning, medium to heavy hail and wind gusts up to 60 knots.