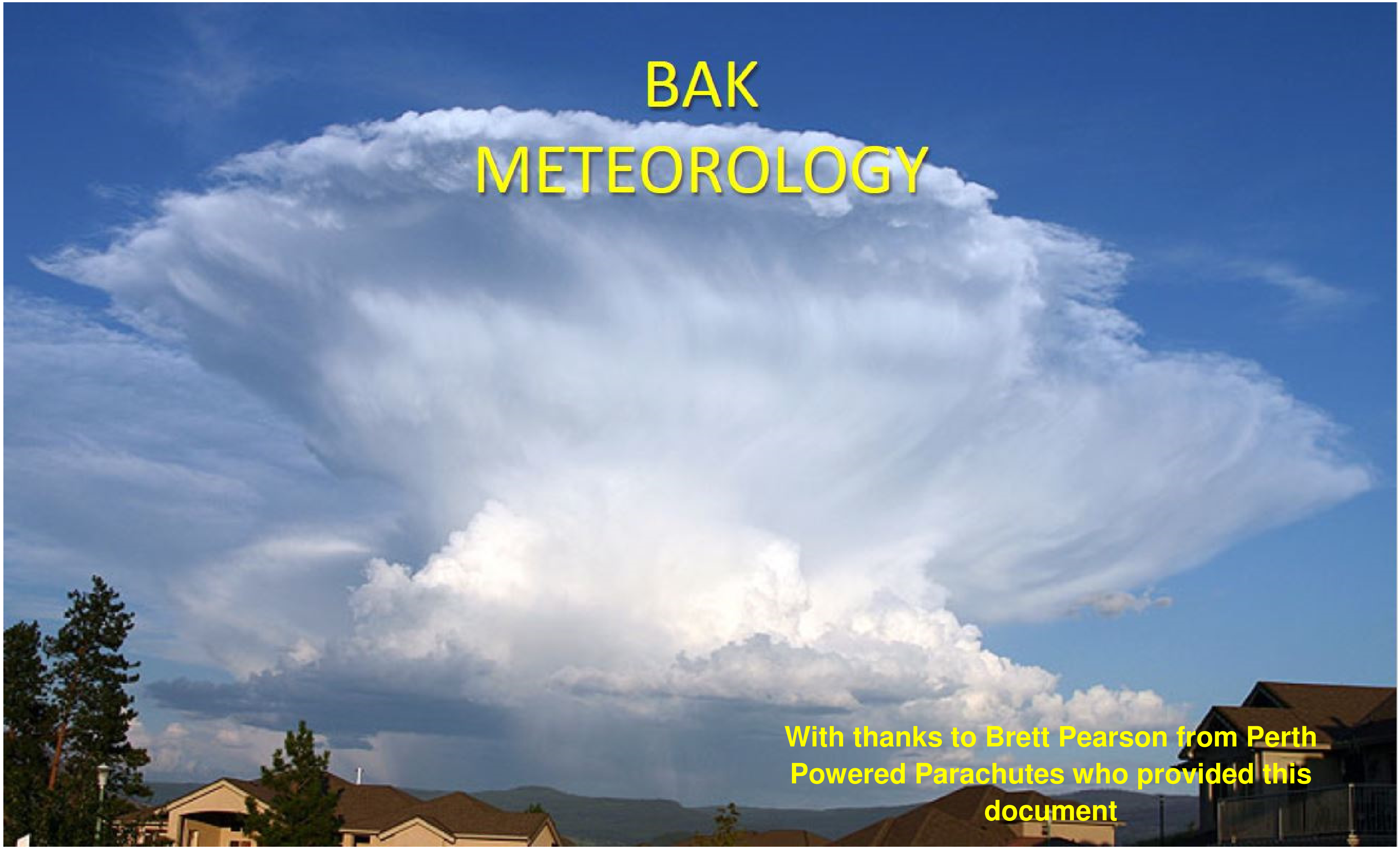


Aim: 1. To interpret the information contained on weather maps.

2. To understand how the weather in your area is affected by local and regional conditions.

Scope of Meteorology Section

The Meteorology Section is divided into 4 main sub topics:

1. The Atmosphere - covers the temperature, pressure and density aspects of the atmosphere.

2. Pressure Systems and Wind – covers the 'large scale' pressure systems and how to read synoptic weather charts.

3. Local effects – covers the effects caused by local terrain and objects one the atmosphere.

4. Meteorological Forecasts and Reports

Section 1 – The Atmosphere

Understanding the structure of the atmosphere helps us understand many of the meteorological events that we see as pilots.

• The atmosphere is made up mainly of Nitrogen Gas (78%), Oxygen (21%), water vapour and other trace gasses.

• The atmosphere varies both vertically and horizontally in:

Pressure - Temperature - Density - Humidity

• Because the atmosphere varies at all locations around the world it is necessary to establish what the average atmosphere properties are. This 'average' atmosphere is called the **International Standard Atmosphere (ISA).** Some of the features of the ISA are described below.

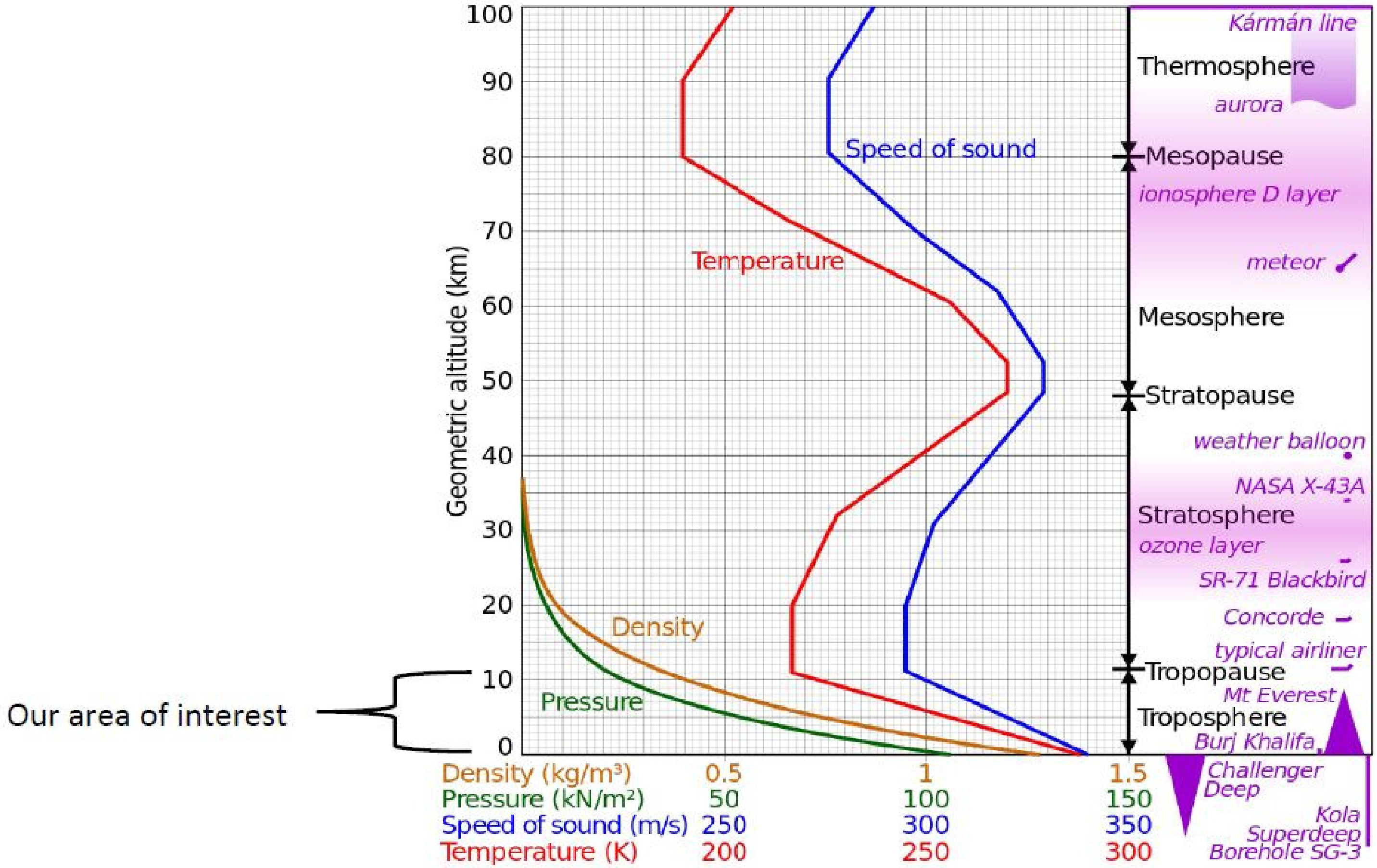
The International Standard atmosphere

- Mean Sea Level temperature of 15°C
- Temperature decreases by 1.98°C/1000 feet (called the temperature lapse rate)
- Mean Sea Level Pressure of 1013.25 millibars. Pressure decreases by about 1mb /30 feet.
- Mean Sea Level Density of 1225 grams per cubic metre. The density decreases with height.

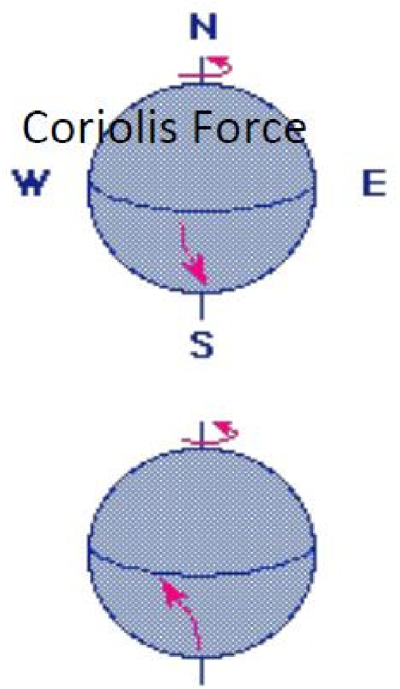
Aircraft performance figures or corrections to aircraft instruments are usually made when comparing the actual atmosphere to the ISA. There are known as **"ISA Deviations".** For example, if the sea level temperature is +20°C then the atmosphere is 5°C warmer than the ISA, hence the deviation is +5.

As pilots, the important points to note are that the temperature, pressure and density all decrease with height. The temperature decrease is critical in the formation of clouds, inversion layers etc, which will be covered later. The pressure and temperature changes dictate the density of the atmosphere which effects the performance of the aircraft as we climb or descend.

ISA variation of temperature, pressure and density



Section 2 – Pressure Systems and Wind



Deflection to the left in the Southern Hemisphere

Coriolis Force. The Earths rotation creates an apparent force that deflects all moving objects to the **left in the southern hemisphere** (and to the right in the northern hemisphere). This force is called the **Coriolis Force**. Coriolis is partially responsible for the direction that the wind blows from.

Note that:

Coriolis is zero at the equator.

Coriolis is strongest at the poles

The Synoptic Chart

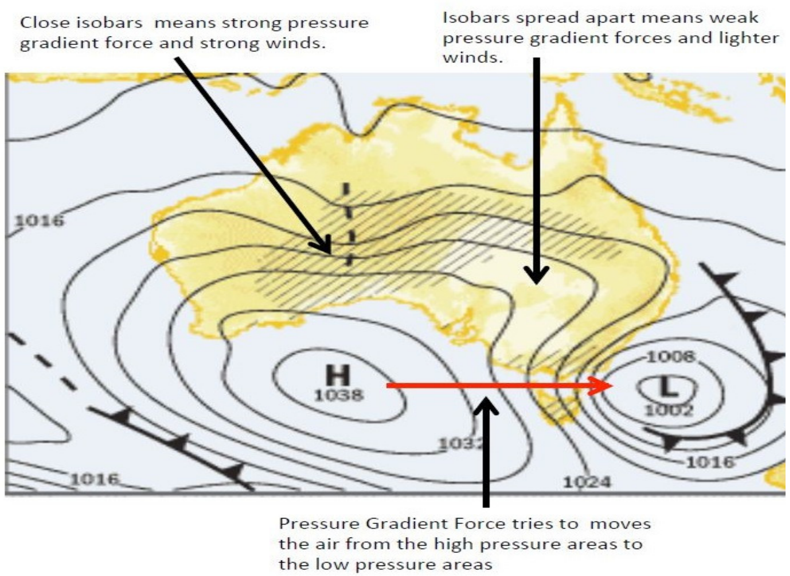
A synoptic chart shows the state of the atmosphere over a large area. The most commonly used synoptic chart shows the surface air pressure, as shown in the diagram. The air pressure is measured in Hectopascal (hPa), basically the same as Millibar.

- Lines on the pressure chart show places of equal pressure and are called **"Isobars".** Looking at the synoptic chart shown below, air from the HIGH PRESSURE area will always try to flow to the LOW PRESSURE area, as shown by the red arrow. The force causing this is simply due to the pressure difference between the two locations and is called the PRESSURE GRADIENT FORCE. The result of this that the air (wind) will try to move from the high to low pressure.

• The chart has areas of high pressure and low pressure.

• Most Synoptic charts you see show the sea level pressures however, charts are produced showing the pressure at various heights.

• It is important to note that **the closer together the isobars are the greater the pressure difference between two points on the ground.**



• The chart has areas of high pressure and low pressure.

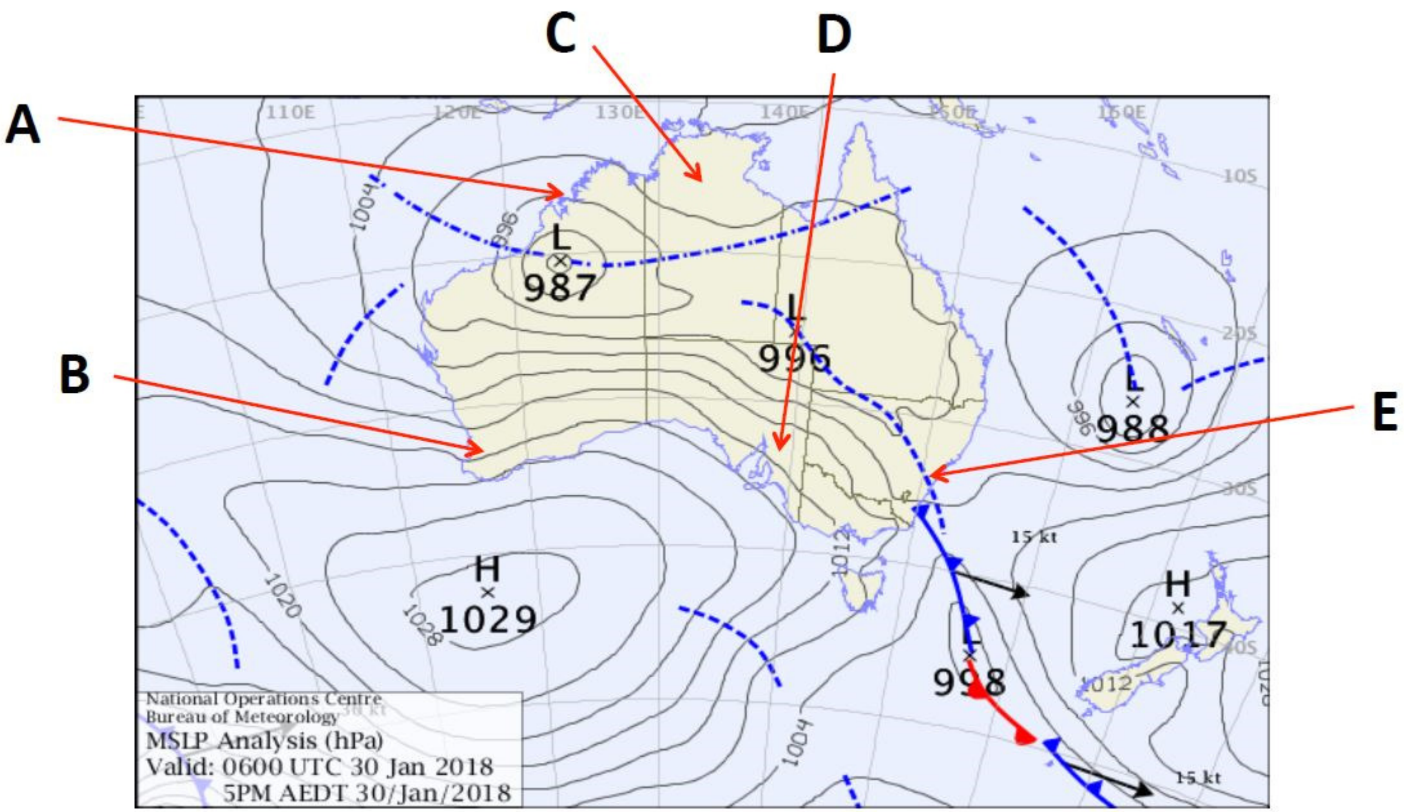
• Most Synoptic charts you see show the sea level pressures.

• It is important to note that **the closer together the isoba**
difference between two points on the ground.

The Synoptic Chart and wind direction

We have seen that the wind will try to flow directly from the higher pressure to the lower pressure and the strength depends on the pressure difference, or isobar spacing. However we have seen that the Coriolis Force deflects all moving objects to the left in the southern hemisphere. The **result is that the wind is deflected to the left and follows the isobar lines**. As shown by the blue lines on the synoptic chart.

On the synoptic chart shown below estimate the wind direction and state if the winds are weak, medium or strong at the points A,B,C,D and E



WIND CHANGES WITH HEIGHT

The wind strength generally increases with height. The first 2000ft – 3000ft above ground level is called the **friction layer**. In this layer the frictional forces of the surface slow the wind to around 1/2 to 1/3 of its strength above the layer. Because the wind in the friction layer is slowed, the effect of the Coriolis Force is reduced and the wind changes direction toward the LOW pressure system.

Wind generally is weaker near the ground and generally turns 25°-30° across the isobars toward the low pressure system.

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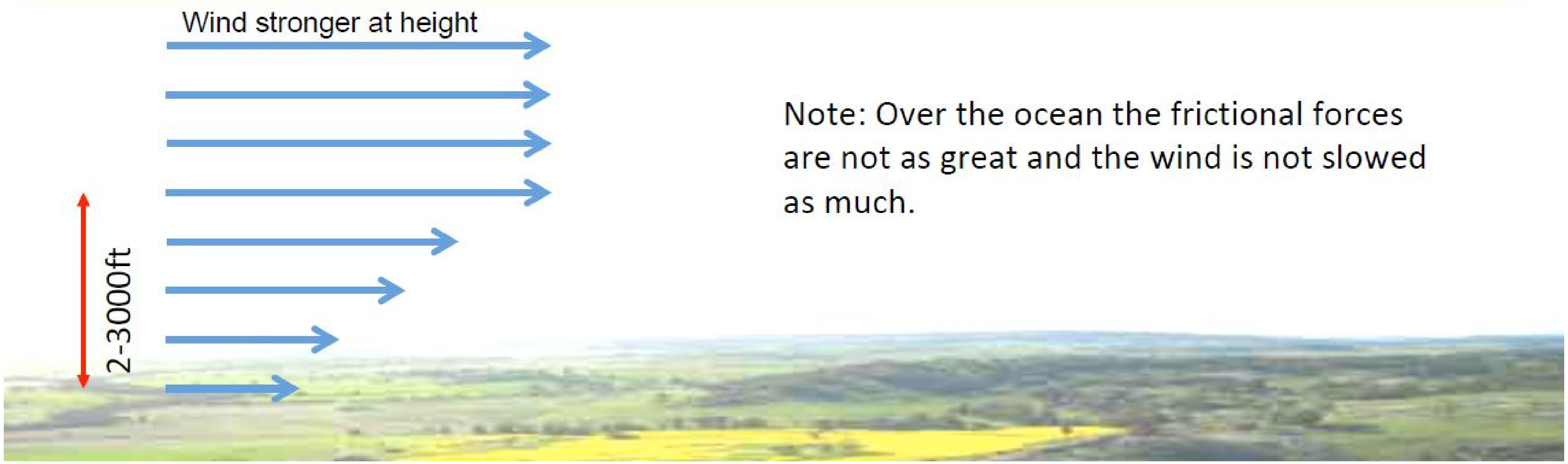


Note: Over the ocean the frictional forces are not as great and the wind is not slowed as much.

Section 3 – Local Effects

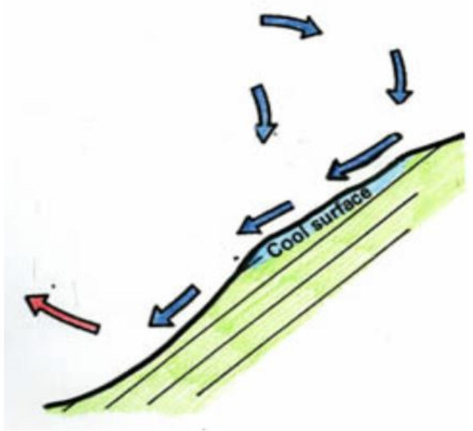
LOCAL WINDS

The surrounding terrain and weather conditions can result in local winds found only in the immediate vicinity.

These winds will be different to the large area winds as shown on the synoptic chart. Some of the more common local winds are described BELOW.

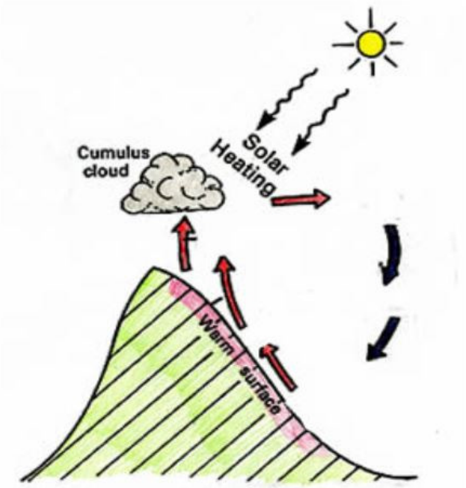
Katabatic Wind:

At night radiation cooling of the ground also cools the air in the lower layer near the ground. If this happens on the side of a large hill or mountain range the cooler and now heavier air, will "slide" down hill. Over a large distance this can cause a moderate night wind known as a **Katabatic Wind.**



Anabatic Wind:

This is the opposite effect to the Katabatic wind and occurs during the day due to the sun heating the ground and the lower layers of air near the ground. If the hill is sufficiently large the warmer lighter air moves up the slope creating an upslope wind called an **Anabatic Wind**. Note that this wind is usually light and not as strong as the Katabatic Wind.

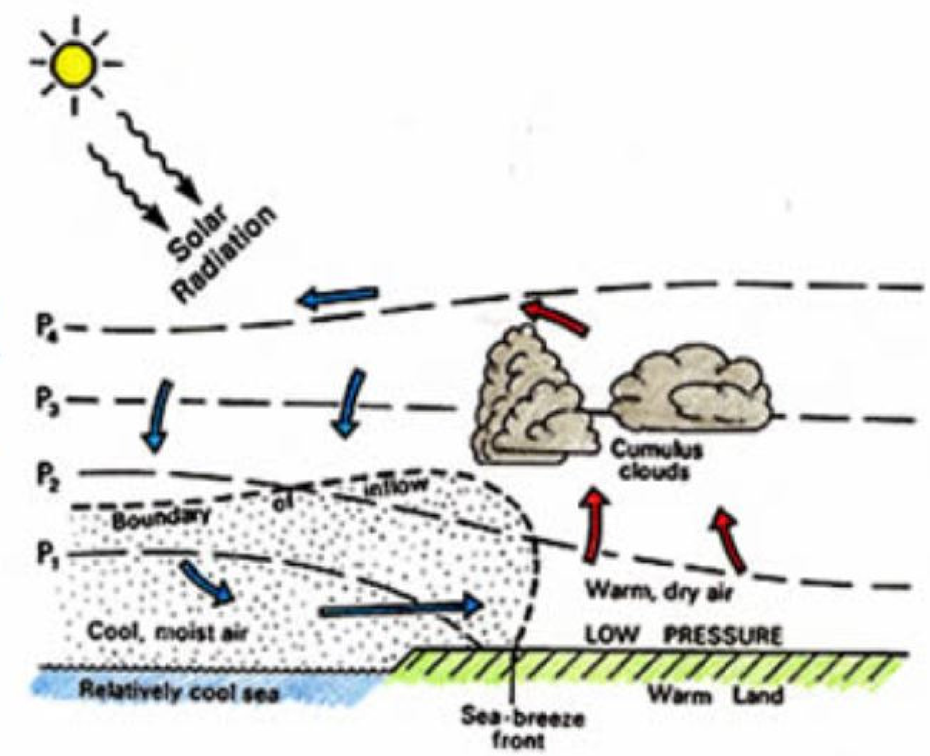


The Sea Breeze.

The Sea Breeze usually occurs in the mid to late afternoon and is a result of the heating effect of the sun.

When the sun shines the ground heats up more than the sea. As a result of the heating, the air over the land heats up, expands, the pressure decreases and the air rises. The cooler, denser air over the water moves in to replace the rising less dense air over the land. A circulation pattern is set up and remains until the temperatures equalise, usually by the sun setting or cloud cover cooling the earth.

If the gradient wind opposes the sea breeze, the breeze may be delayed until later in the day or stopped completely.



At night the effect is reversed with the water being cooler than the land. The result is a land breeze blowing from the land to the water.

1. Normal Atmosphere:

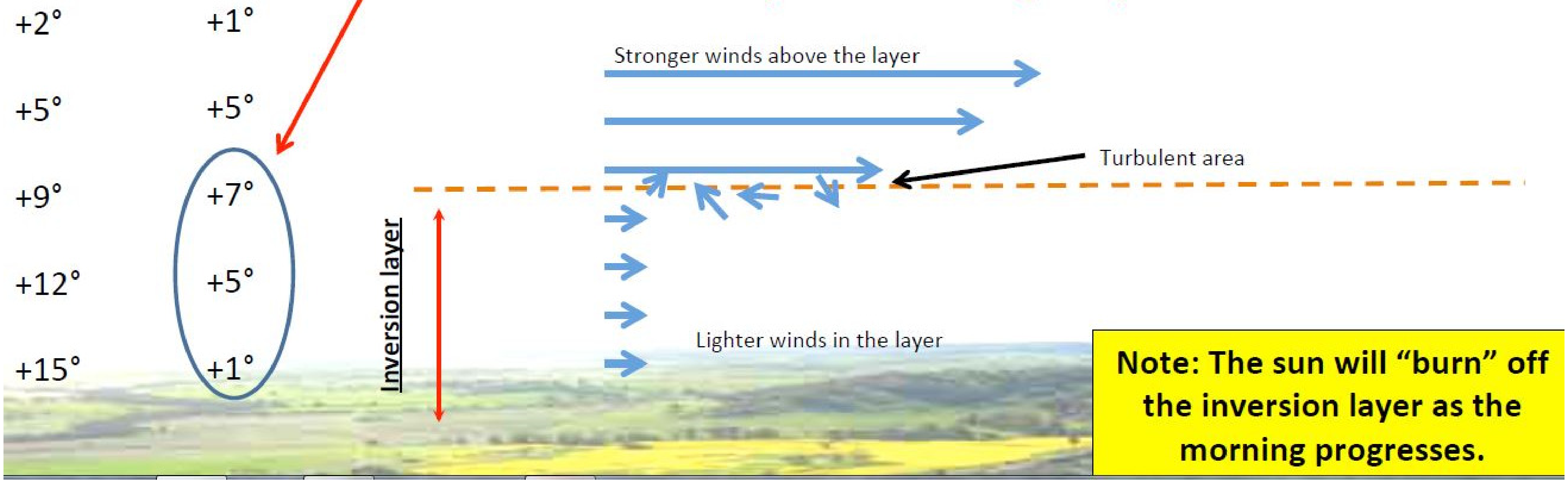
In the atmosphere the temperature generally decreases with height. This temperature drop is approximately 2° each 1000ft of height increase.

2. Inversion:

Often due to a cold still night, radiation can cool the layer of air near the ground resulting in the temperature initially increasing with height.
This creates a stable layer of air called an **INVERSION LAYER.** This stable Inversion Layer has light winds and traps pollutants.

When flying in the inversion:

- **The temperature will be colder near the ground.**
- **The winds are usually lighter than at height.**
- **There may be a turbulent layer near the top of the inversion.**
- **Winds above the inversion will be stronger.**
- **Visibility in the inversion layer may be reduced.**



TURBULENCE

Turbulence is the unstable flow of air in the atmosphere and occurs when wind direction and strengths fluctuate rapidly over a short distance.

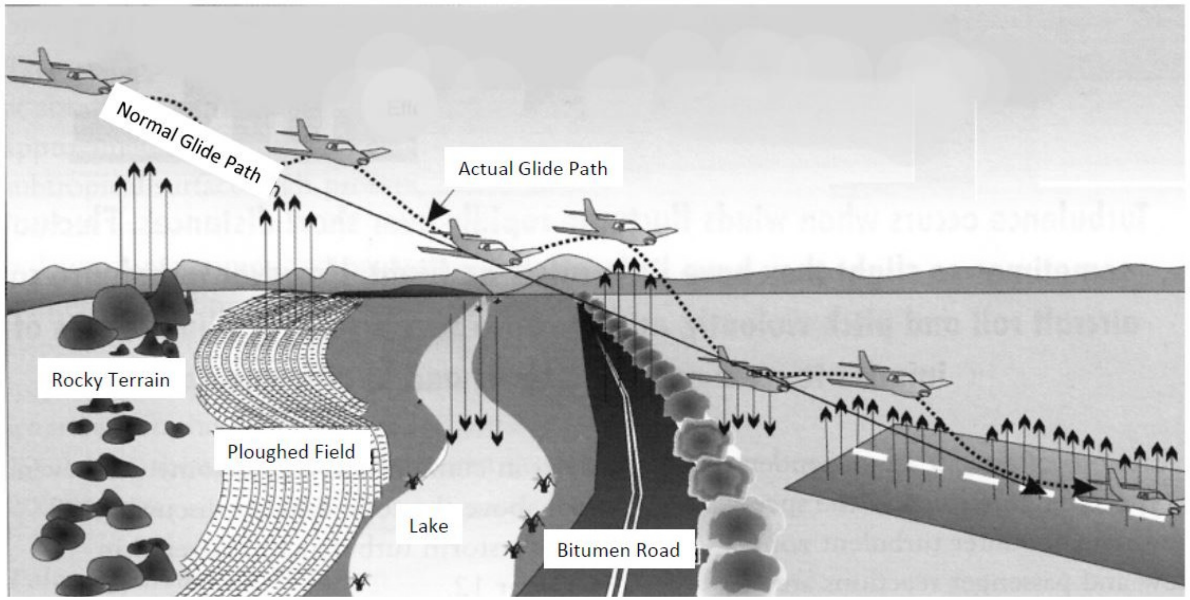
The main causes of turbulence that affect us whilst flying are:
Convection (heating) - Topography (mountains etc) -Aircraft wake - Weather fronts

Understanding the causes of turbulence can help us to avoid areas that strong turbulence may be encountered.

TURBULENCE - CONVECTION

Convective turbulence is due to the transfer of heat caused by the sun heating the earth.

Thermals:
On a warm day the sun heats up the ground and warms the air in the lower layers. This causes the air to rise and is felt as “bumps” as the Aerochute fly's thru the air. Some surfaces heat up more than others so the turbulence above these areas will be greater, for instance, over a ploughed field the air is heated more and rises more than compared to a grassed area.



TURBULENCE - CONVECTION

Dust Devils:

On a hot day when the winds are light we may get “Dust Devils” forming over a hot surface. These areas of rapidly rotating high speed winds contain severe turbulence **and must be avoided**.

TURBULENCE - CONVECTION

If there is enough moisture in the air, the rising air can cause clouds to form. These clouds can range from small ”fair weather” convective clouds to large thunder storms. Flying into clouds is not allowed in recreational aviation (we must maintain VMC) however, even close to these clouds we may encounter turbulence.

In general, the more vertical development a cloud has, the more turbulence is associated with the cloud. These clouds that have vertical development are called “Cumuliform” or “Cumulus” clouds and should be avoided.

”Strataform” or “Stratus” clouds are the clouds with a “layered” appearance and are not associated with strong turbulence.

Cumulus

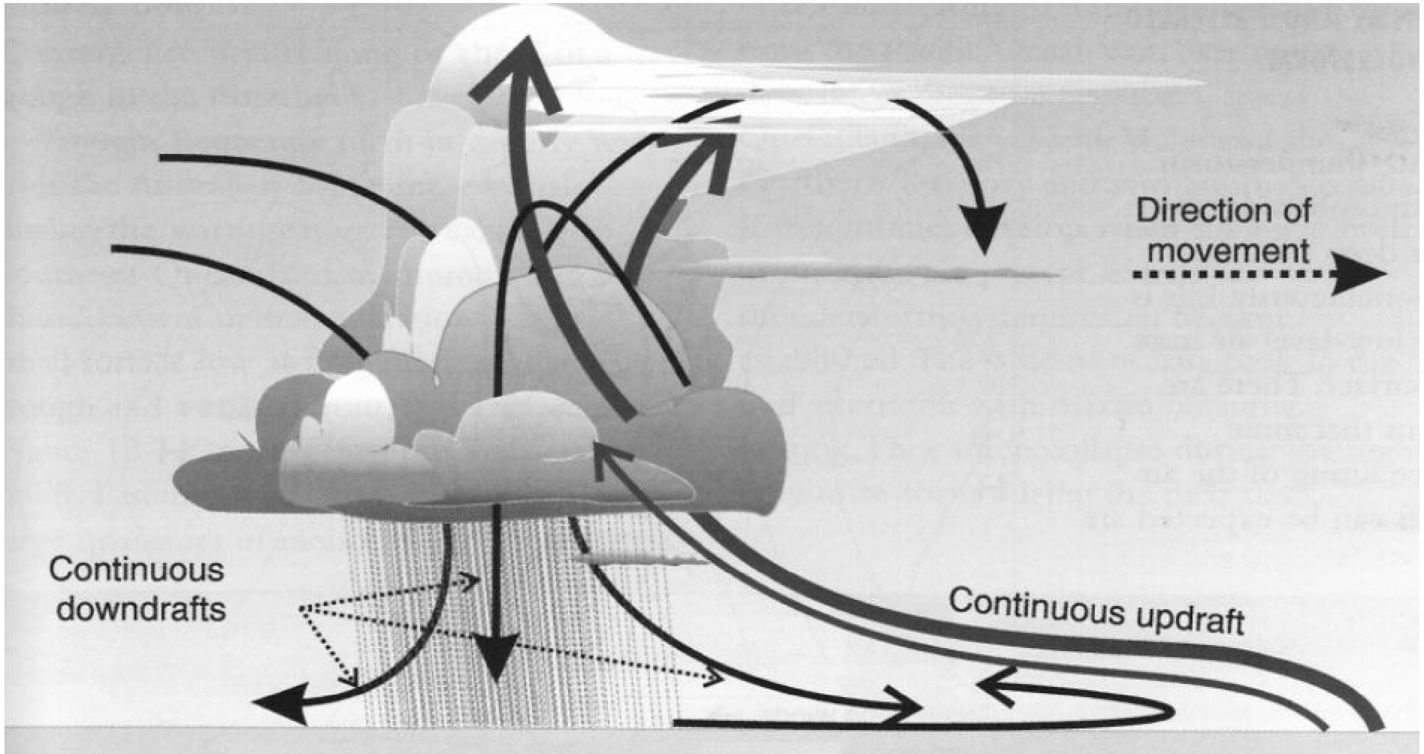
Stratos

More on clouds:

Downdraughts

Underneath cumulus clouds there can be both updraughts and downdraughts. The strength of the downdraughts may exceed the climb rate of the Aerochute, resulting in a forced landing or impact with the ground. When flying from an area of updraught to an area of downdraught we will usually experience turbulence, often very strong due to the changing wind directions.

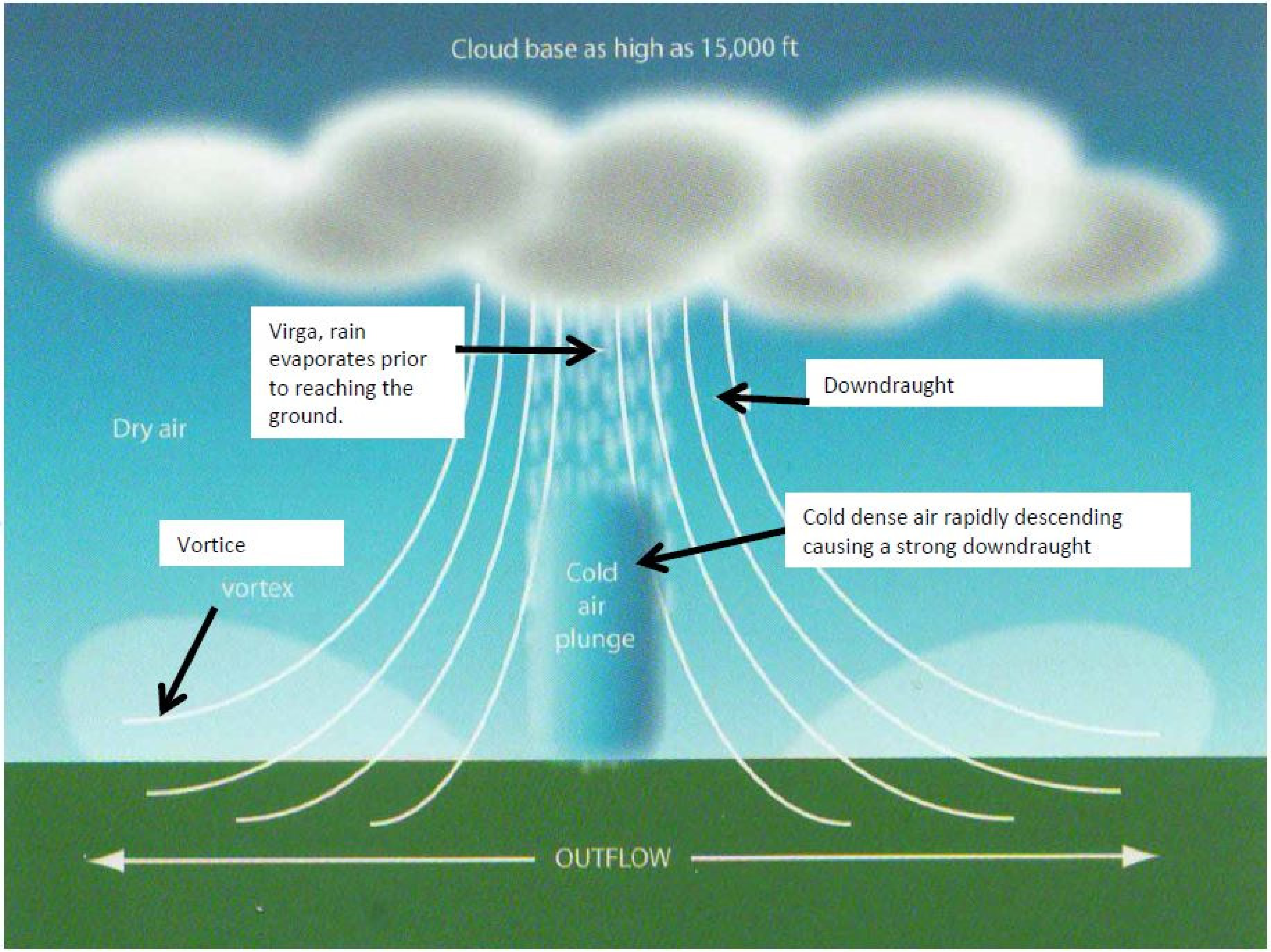
Always avoid flying in the vicinity of large Cumulus clouds.



TURBULENCE - CONVECTION

<u>Virga:</u>

Virga is rain that evaporates before it reaches the ground and may often be see coming out of the bottom of higher based cumulus clouds. When the rain evaporates it cools the air and the resultant cool column of air is heavier than its surroundings. The cooler air consequently rapidly descends forming a very strong downdraught which the Aerochute may not be able to out climb. Another name for this phenomena is a Microburst.



Always avoid flying in the vicinity of Virga.

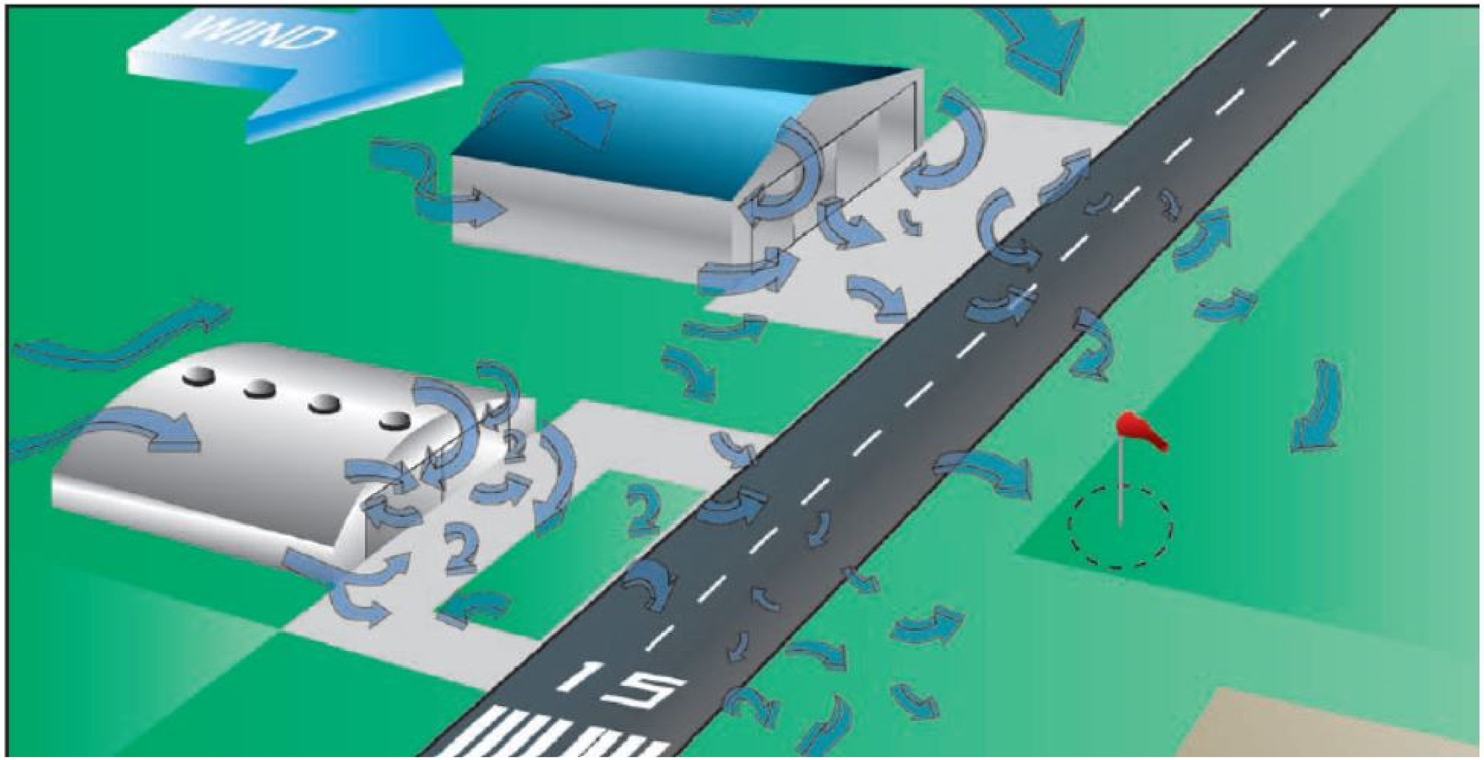
TURBULENCE - TOPOGRAPHY

Topographic turbulence is due to the wind flowing over obstacles or terrain/mountains.

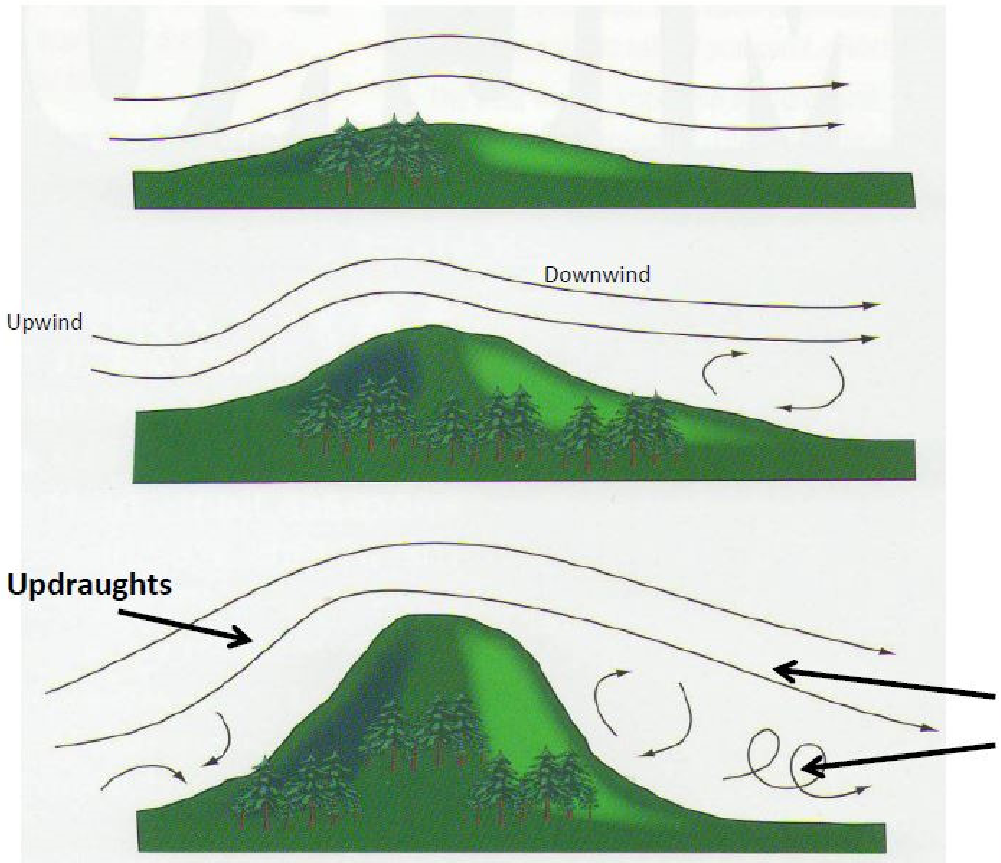
<u>Obstacles:</u>

The wind flowing over obstacles such as buildings or trees can cause turbulence on the downwind side. Turbulence can be as far downwind as 5 times the height of the obstacle.

Flying or taking off on the <u>upwind</u> side of obstacles can avoid this turbulence.



TURBULENCE - TOPOGRAPHY



Terrain/Mountains:

The wind flowing over terrain can turn turbulent on the downwind side. The strength of the turbulence increases with the strength of the wind and the height of the terrain.

Also, on the upwind side of the terrain there is rising air (updraught) while on the downwind side there is descending air (downdraught). The strength of the downdraught may exceed the climb rate of the Aerochute!

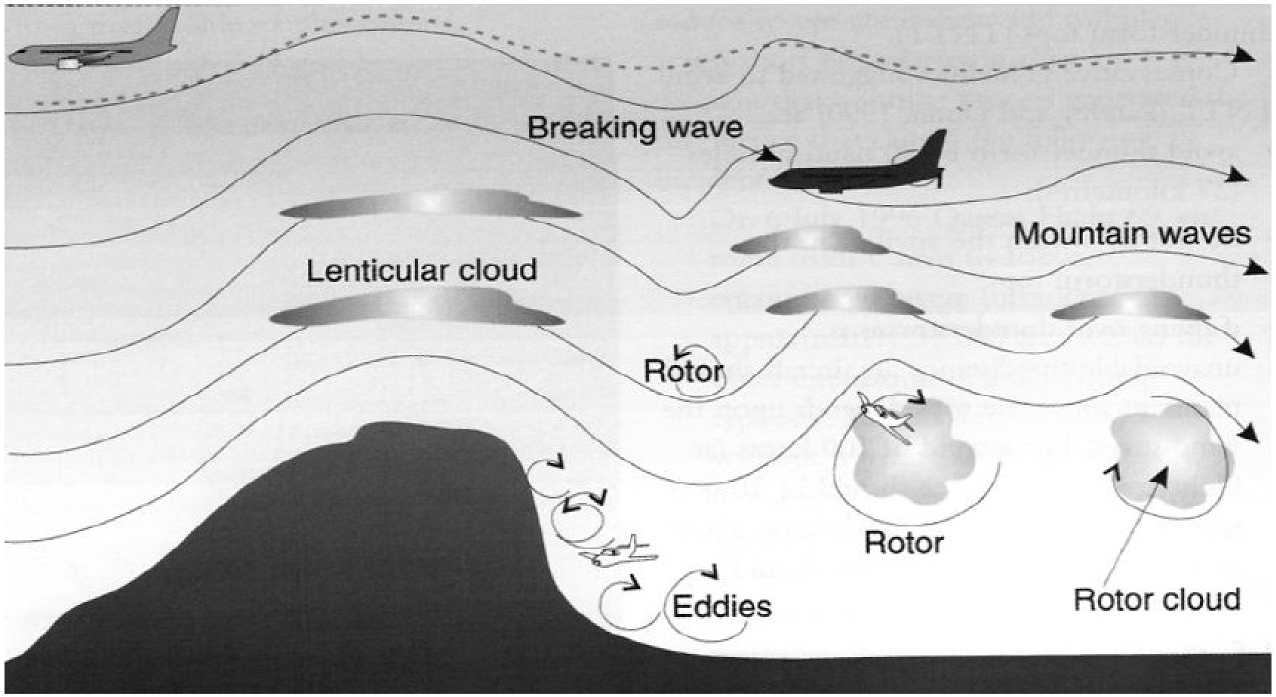
In significant winds fly <u>upwind</u> of high terrain or mountains!

TURBULENCE - TOPOGRAPHY

Mountain Waves:

In certain conditions the wind over a mountain range can form a "Mountain Wave" where the airflow is similar to an ocean wave with areas of up draughts, downdraughts and rotors where the air rolls over on itself. This mountain wave can exist for large distances downwind of the mountain.

The mountain wave may be invisible however, if there is cloud around it may be characterised by Lenticular cloud or Rotor cloud as shown in the diagram.



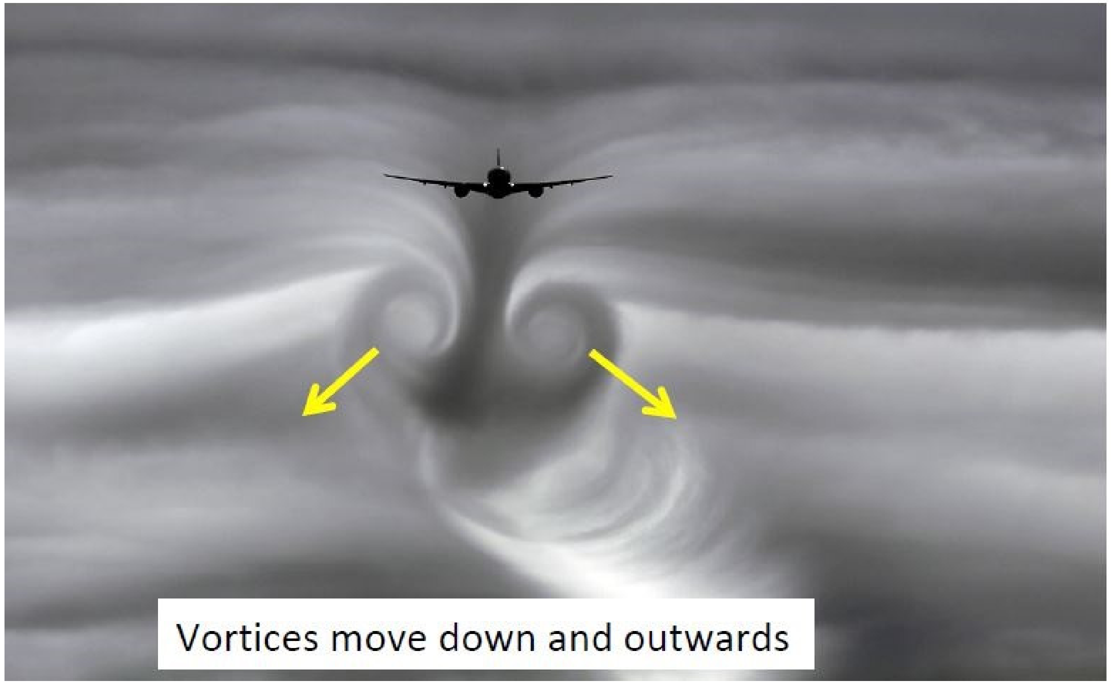
Avoid the downwind areas of mountains in windy conditions!

TURBULENCE – AIRCRAFT WAKE

Aircraft wake turbulence is caused by the vortices generated from lift off the wings.

The lift from an aircrafts wings generates swirling vortices behind the aircraft, one from each wing tip. This is due to the air spilling around the wingtips from the high pressure below the wing to the lower pressure above the wing. These vortices can be very severe and may remain in place for several minutes after the aircraft has passed.

Large, heavy aircraft generate more lift. This means that the vortices are strongest behind large aircraft.



The vortices move downward and outward from the wingtips of the aircraft.

Consequently we **should avoid flying below and to the rear of aircraft**.

Note that light aircraft also produce vortices, however as the aircraft is light, and does not procuce significant amounts of lift, the vortices are not severe.

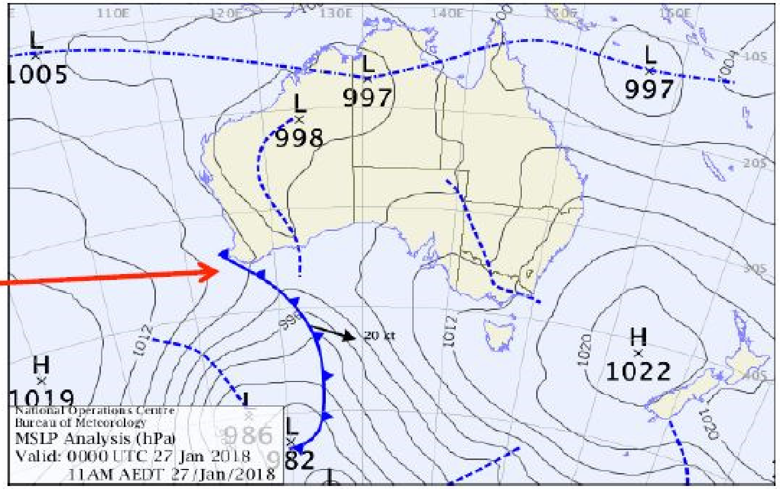
TURBULENCE – WEATHER FRONTS

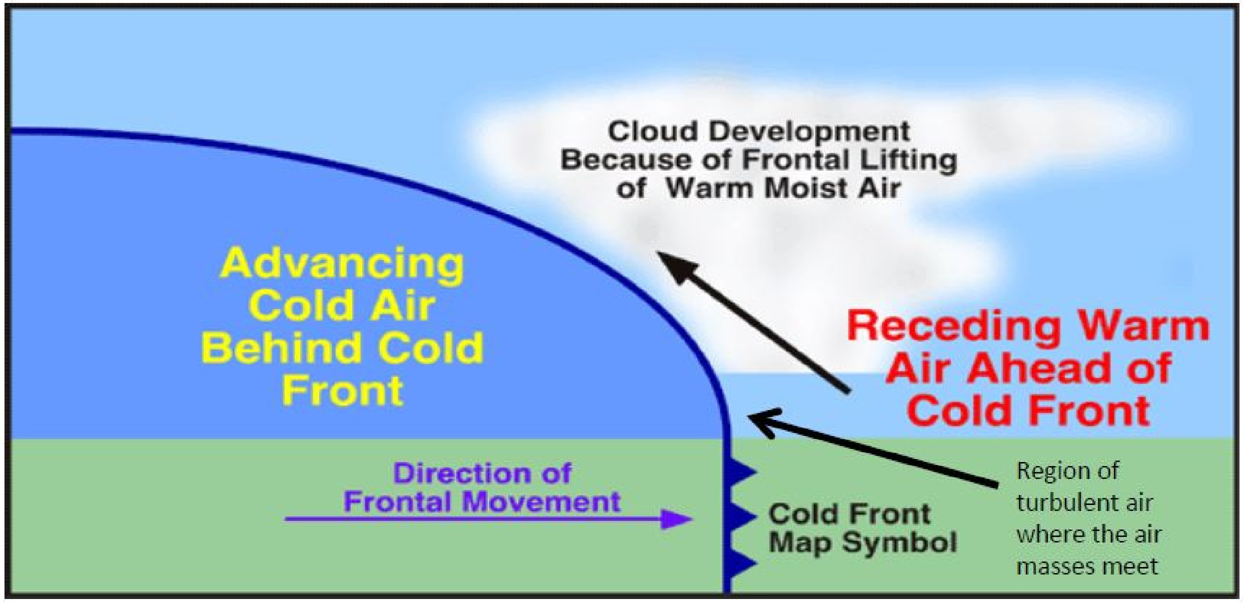
Cold Front:

A cold front is where a cooler air mass moves in a replaces a warmer air mass. Because the cold air mass is denser than the warm air mass it is replacing the cold front tends to "slide" in under the warm air as shown in the diagram.

The frontal area is associated with strong turbulence, is usually very wide front and can extend several thousand feet into the atmosphere. **Avoid flying if a front is passing, land and go flying when the weather stabilizes!**

Cold front on a synoptic chart





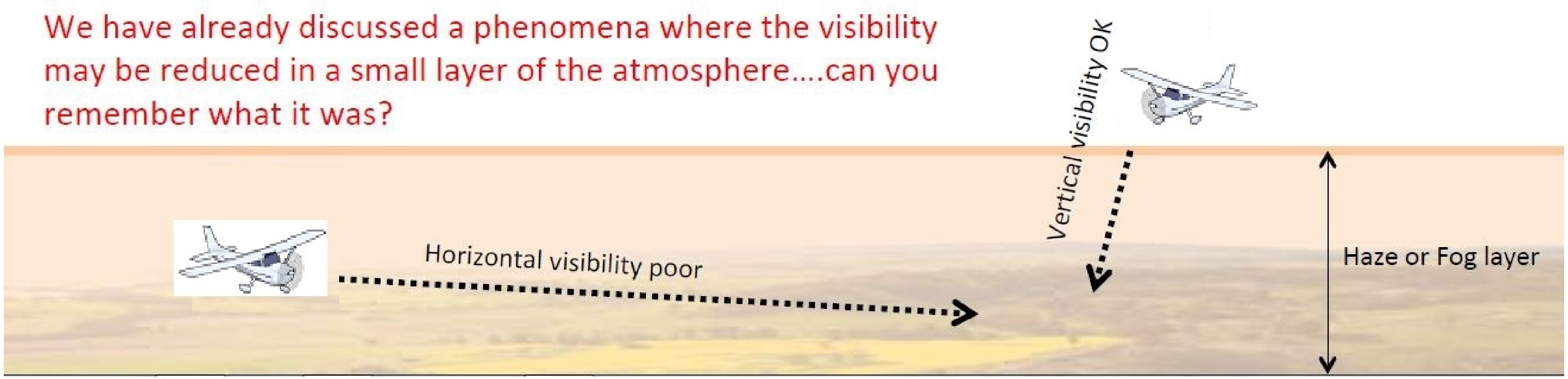
VISIBILITY

When referring to aviation and meteorology, visibility refers to the **horizontal distance** that you can see. Recreational aviation is restricted to flying in visual meteorological conditions (VMC) which is a minimum visibility of 5000 meters however, it is worth discussing the most probable forms of reduced visibility that we may accidentally encounter.

FOG is the suspension of very fine water droplets resulting in less than 1000 meters visibility. It is usually formed on cool clear nights when the cool ground cools the lower layers of humid air until the dew point is reached. A very light wind is also required to mix the saturated air in the shallow layer above the ground. If there is no wind then a frost will result.

HAZE is a result of suspended particles in the atmosphere, usually smog or smoke from bushfires. As mentioned earlier, it is common for haze to be greatest when an inversion is present.

Aviation Risks: The greatest hazard posed by fog or haze is the reduced **horizontal** visibility when compared to the visibility when looking **vertically** down at the ground. If you are flying over the top of a field looking down through a layer of haze or fog, you may see the ground OK because the distance viewed is small. When you come in for an approach and look horizontally through the fog or haze, the forward visibility may reduce to a dangerous level.



CLOUD TYPES

As recreational pilots we will be experience the types of clouds that are found in the lower levels of the atmosphere, that is, especially below 5000ft. The look of the cloud helps us identify the type of cloud and its properties. The following general guidelines apply to cloud names:

Nimbus cloud type (Ns) – Nimbus means rain bearing, is usually darker in colour and usually results in rain or drizzle.

Cumulus cloud type (Cu) – Cumulus means piled up and can look like a “Cauliflower” and has vertical development. They are generally white and fluffy with little or no rain.

Stratus cloud type (St) – Stratus cloud is a layered cloud with a level base and little vertical development.

Rarely are the pure types of clouds mentioned above seen. Most clouds are a combination of the above cloud types.

The low level cloud types and general properties are listed below.

Nimbostratus (Ns): A stratified cloud looking like a grey sheet or layer. Heavy continuous rain or snow with **little turbulence.**

Cumulus (Cu): Fine weather Cu are small white and fluffy and produce little or no rain. They have **light to moderate turbulence** in their vicinity. Cu are convective clouds (formed by thermal activity) and will have rising air associated with their formation.

Large Cumulus (Cu): Generally look like Cauliflowers and have large vertical development with associated showers of rain or snow. **Turbulence can be severe** below them or in the vicinity.

Cumulonimbus (Cb): Often develop into thunderstorms, Cb have very large vertical development and may have an anvil shape at the top. **Dangerous to be near** due to very high levels of turbulence, possible lightning, rain, updraughts and downdraughts.

Stratocumulus (Sc): Grey stratified cloud with which drizzle may be associated. **Light to moderate turbulence** may be expected beneath.

Stratus (St): Thin and ragged with the sun able to be seen through. **Little associated turbulence**.

CLOUD COVERAGE

When describing the amount of cloud coverage we divide the sky into eights, called OKTAS.
8 OKTAS would indicate that the sky is completely overcast while 4 OKTAS indicates half the sky is covered by cloud.

The coverage is abbreviated as follows:

SKC Sky Clear 0 OKTAS

SCT Scattered Cloud 1 - 4 OKTAS

BKN Broken Cloud 5 - 7 OKTAS

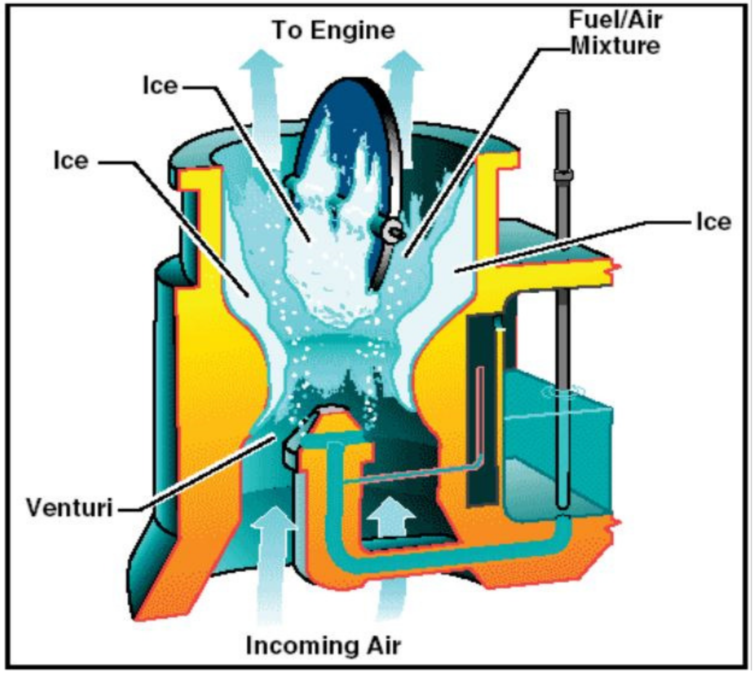
OVC Overcast Cloud 8 OKTAS

Another weather term you will see is "CAVOK", (Ceiling and Visibility OK) which is used to indicate good visibility above 10kms and no cloud below 5000' AMSL.

ICING

As recreational aviation pilots we don't fly into clouds. This greatly reduces the risk of icing however, icing can occur in clear air and at temperatures above freezing. The greatest icing hazard facing light aircraft is

Carburettor icing.
Icing occurs when the air contains significant levels of water vapour. As the air is drawn into the engine through a carburettor it is cooled sufficiently to cause the water vapour to condense out and freeze in the vicinity of the Butterfly Valve.
This cooling occurs because of two reasons:



1. The air pressure drops due to the expansion caused by engine suction and the increase in speed through the butterfly valve (in part-throttle operation). This drop in air pressure lowers the air temperature, and

2. The liquid gasoline being introduced into the airstream must evaporate, and the heat of evaporation is extracted fror

The temperature in the carburettor can drop below the freezing point of water, and if the air is humid, ice can form inside the carburettor. As the ice builds up, less air can pass through the carburettor, causing a drop in power and, in severe cases, the engine will eventually fail. Temperature drops of 20 °C or more are often encountered within the carburettor, so ice can build up even when the outside air temperature is well above freezing.

It is surprising that cold winter weather is less prone to icing, since cold air contains much less moisture. A warm day with high humidity is considered the most likely conditions for carburettor icing.

To overcome icing, our aircraft have Carb Heat to warm the air and melt the ice. This may take several minutes to take effect. Refer to your aircraft's POH for more detail.

Section 4 - WEATHER FORECASTS

In aviation, a weather forecast is a prediction of what the weather will be over a period of time. A weather report states what the actual weather is a specific time.

Civil Aviation Orders state that if we are flying away from "the vicinity of the aerodrome" then we must obtain a valid weather forecast. The content of this forecast would include the wind direction and strength, air temperature, cloud and any significant weather likely to be encountered during the period of the flight. The forecasts are available from the internet.

Synoptic Charts: http://www.bom.gov.au/watl/pressure/index.shtml
This site gives a 4 day synoptic forecast and can be used as an "overview" of the expected winds
Meteye: http://www.bom.gov.au/australia/meteye/
This site gives the forecast winds, temperatures and weather for any place in Australia and is easy to use.
Willy Weather: https://wind.willyweather.com.au
This site gives the winds and general weather for any location in Australia and is easy to use
Weatherzone - GinGin: http://www.weatherzone.com.au/local/local.jsp?lt=aploc&lc=14995

NAIPS: https://www.airservicesaustralia.com/naips/Account/Logon
This is primary weather site for aviation activity in Australia and include NOTAMS about dangers that may exist at airports and surroundings. All pilots are required to check NAIPS before they fly to ensure it is safe to use the airspace (especially around YBHL due to RAAF activity and restricted airspace)

Revision

1. The pressure gradient force is a result of the air trying to flow from the low pressure area to the high pressure area. True or False?
2. Due to the Coriolis Force, what direction does the air flow around a high pressure system in the southern hemisphere? Clockwise or Anticlockwise?
3. If the isobars on a pressure chart are closely spaced, is the surface wind likely to be strong or weak?
4. What is an Inversion?
5. What flying conditions can normally be associated with an inversion?
6. In moderate wind conditions, is it best to fly on the upwind or downwind side of a large hill?
7. What effect does the friction layer have on the wind strength?
8. On a calm, cold night would you expect a wind to develop that flows up or down the side of a large mountain?
9. What would you expect the flying conditions to be if you flew into Virga?
10. Which cloud has the most turbulence associated with it, Cumulus cloud or Stratus cloud?
11. What is the most likely name of a cloud that resembles a Cauliflower in shape?
12. What are the dangers associated with flying in the vicinity of a large Cumulus cloud?
13. What direction do the wake vortices travel behind an aircraft in flight?
14. On the downwind side of a large hill you notice lens shaped clouds. What could you expect the flying conditions to be like in the vicinity of these clouds?
15. On the upwind side of a mountain in moderate wind conditions would you expect the air to be rising (updraught) or descending (downdraught)?
16. What is the best internet site to gather weather and safety information for pilots?