LESSON 7
METOROLOGY

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.

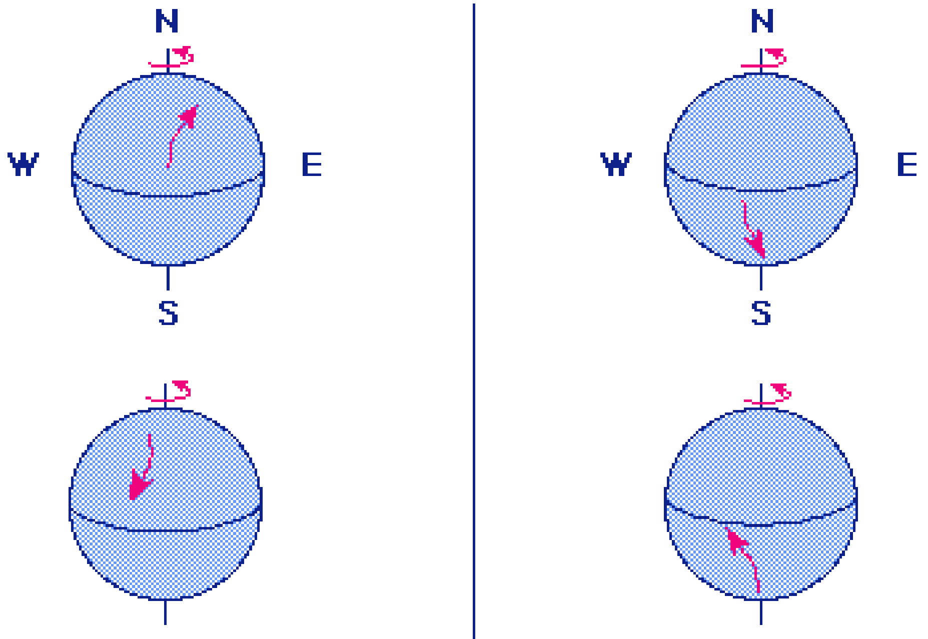
CORIOLIS FORCE

The Earths rotation creates an apparent force that deflects 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 acts on all moving objects and is responsible for the direction that wind blows from.

•The Coriolis Force is **strongest** at the north and south poles and **zero** at the equator.

• The Coriolis effect is greater on faster moving objects.

•Although the Coriolis Force is weak and has very little influence on small air masses, it has a large effect on the movement of large pressure systems.



Deflection to the right in the Northern Hemisphere

Deflection to the left in the Southern Hemisphere

Coriolis deflects moving objects to the left in the southern hemisphere

THE SYNOPTIC CHART and WIND FLOW

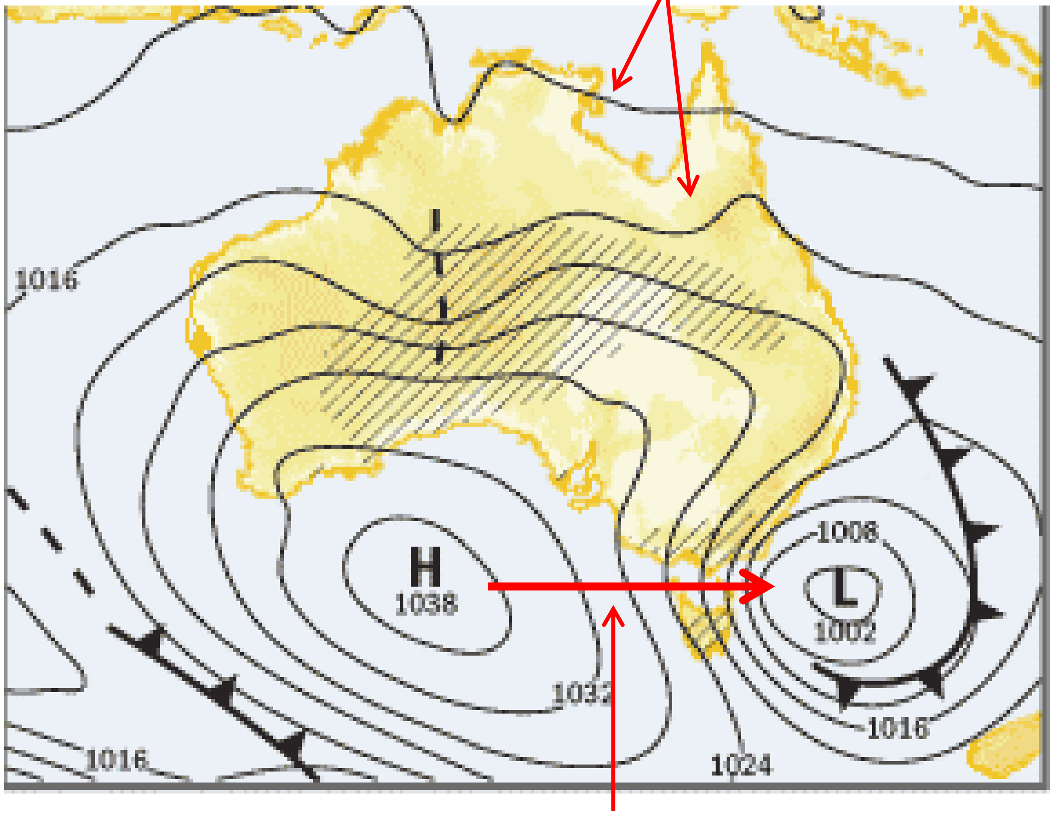
A synoptic chart shows the weather over a large area. The most commonly used synoptic chart shows the surface air pressure, as shown in the diagram. The air pressure is measured in Hectopascal (hPa). Lines on the pressure chart show places of equal pressure and are called **"Isobars".**

Isobars spaced well apart means less pressure gradient force and lighter winds.

Note that the chart has areas of high pressure and low pressure.

Normally the air will try and flow from the high pressure area to the low pressure area. This is called the **Pressure Gradient Force.**

The greater the pressure difference between the high and the low pressure systems, the closer together will be the isobars and the stronger the wind.



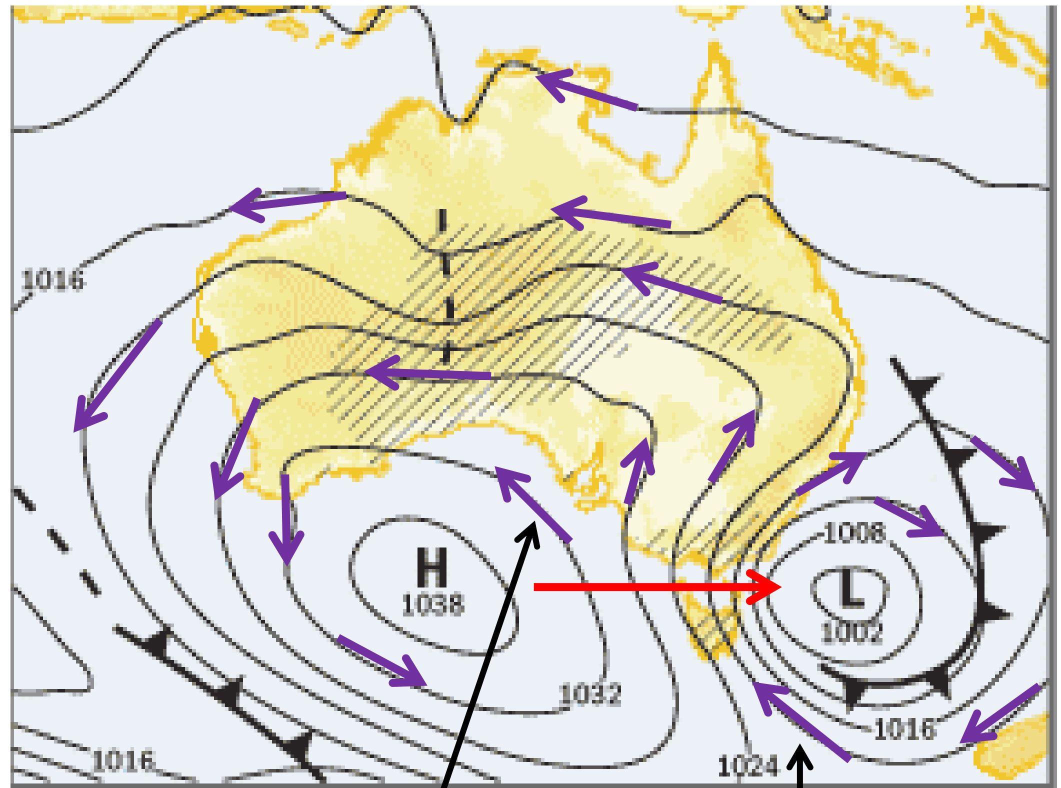
Pressure Gradient Force tries to moves the air from the high to the low pressure

THE SYNOPTIC CHART and WIND FLOW

The **Coriolis force** deflects the air to the left in the Southern Hemisphere. This means that the wind flowing from the high pressure to the low pressure due to the Pressure Gradient Force will be deflected to the left.

The result is that the wind follows the isobars and flows **anticlockwise around a high pressure** and **clockwise around a low pressure** system. The direction of wind flow is reversed in the northern hemisphere.

By looking at the pressure chart we can see the direction that the wind is blowing by looking at the isobars. The lines of the isobars represent the wind direction.



The pressure gradient force moves the air from the high to the low but the Coriolis force deflects the moving air to the left. The result is the wind direction follows the Isobars.

Wind direction follows the isobars

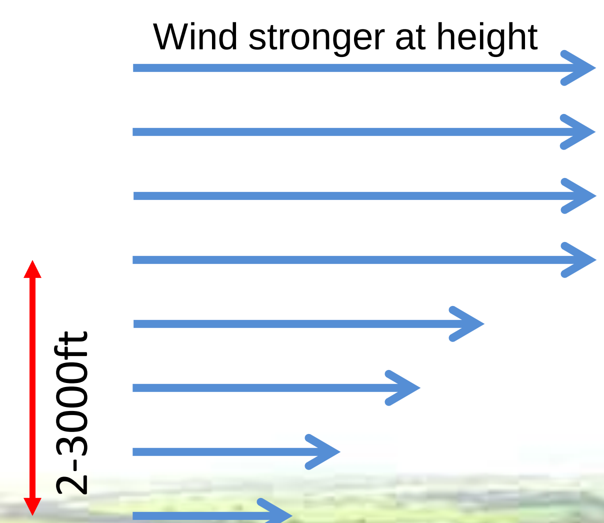
WIND CHANGES WITH HEIGHT

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.



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

LOCAL WINDS

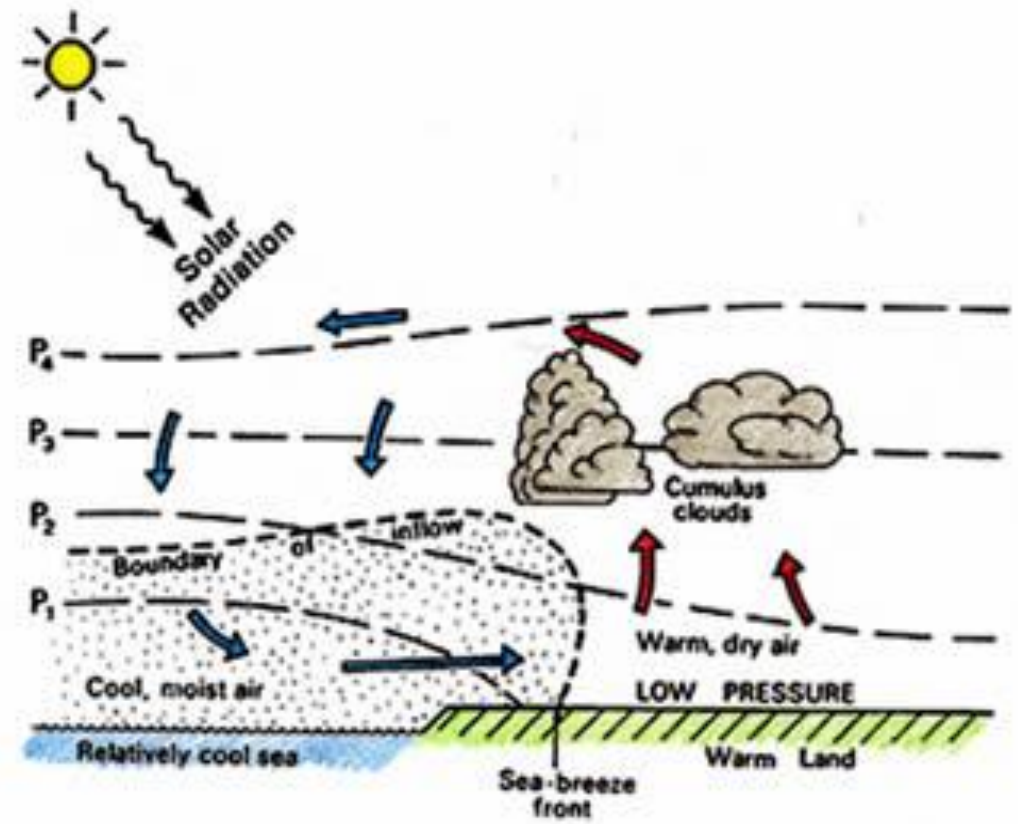
The surrounding terrain and weather conditions can result in local winds found only in the immediate vicinity. These winds will be different to the large area winds as shown on the synoptic chart. Some of the more common local winds are described on the following pages.

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 is heated up more than the ocean. This results in the air over the land rising. The air pressure over the land is decreased and the air mass over the water moves in to replace the rising, lower pressure air. A circulation pattern is set up until the water and air are the same temperature.

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

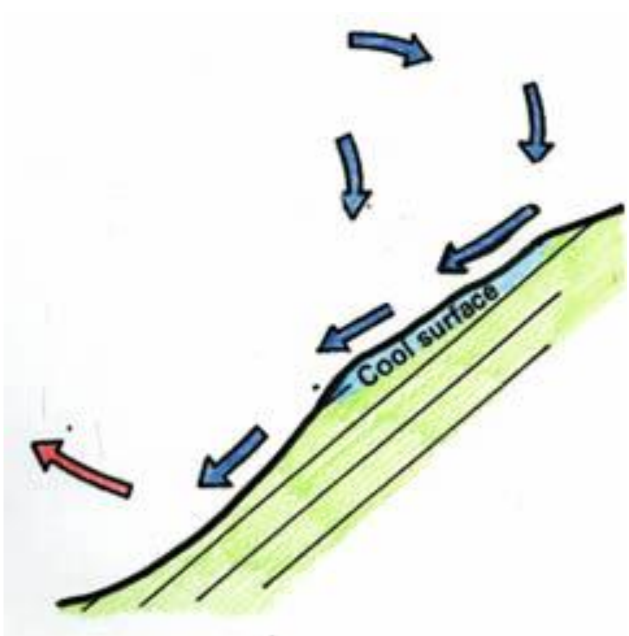


At night the effect is reversed with the water being cooler than the land. The result is a land breeze blowing from the land to the water.

LOCAL WINDS

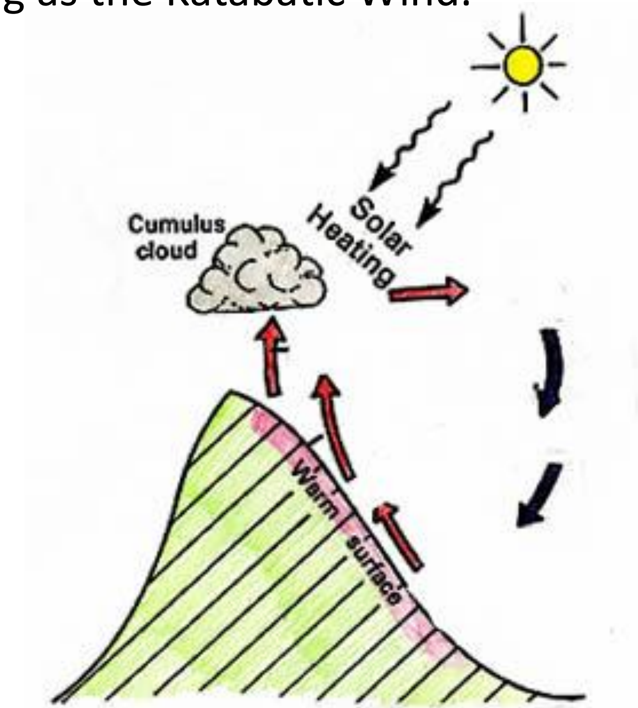
Katabatic Wind:

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.

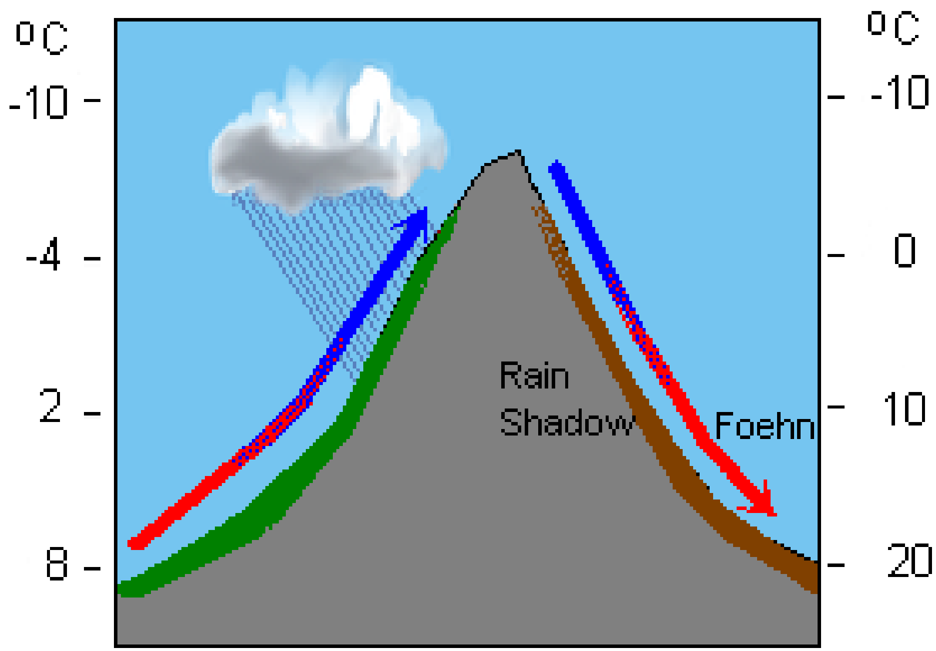


LOCAL WINDS

Foehn Wind:

A Foehn wind (pronounced “fonn”) is the result of air being lifted up the slope of a mountain, cooling as it is lifted and becoming saturated. This saturated air loses moisture due to rain or snow on the up slope. The air moves down the other side of the mountain it would normally warm by the same amount that it cooled on the up slope however, since there is less water content in the air it warms at a greater rate.

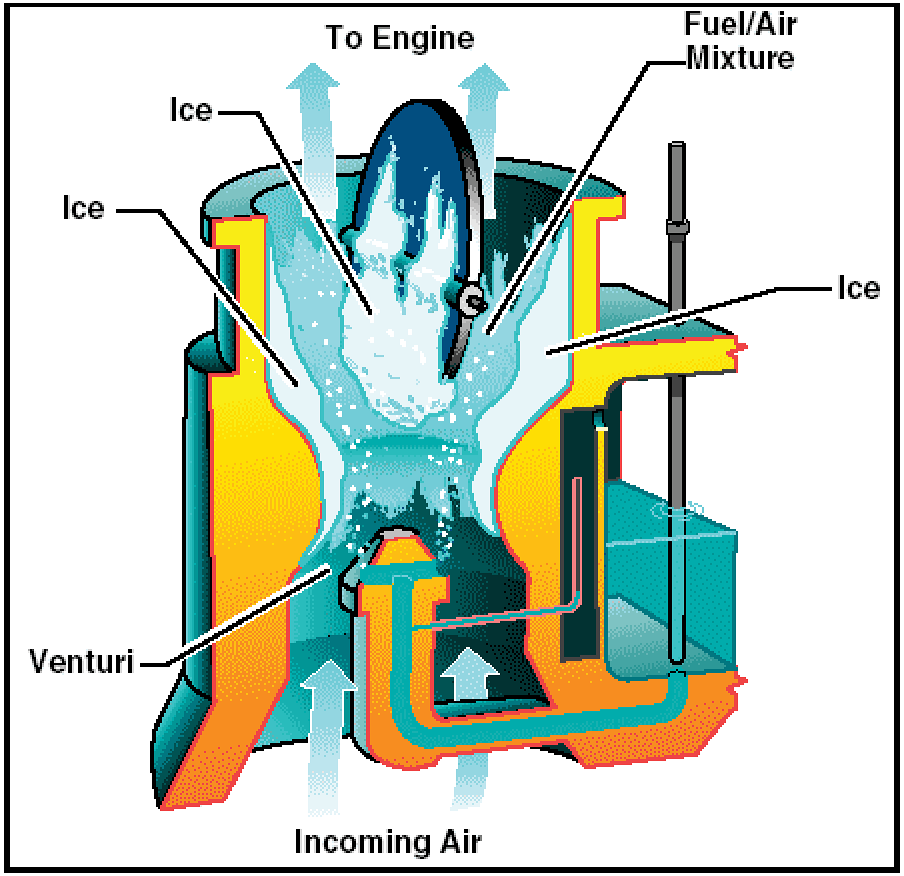
The result is a wind on the downwind side of the mountain that is warmer, dryer and less dense than the wind on the upwind side of the mountain. This warmer wind is known as a **Foehn Wind**.



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 the Aerochute 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 from the airstream, cooling it.

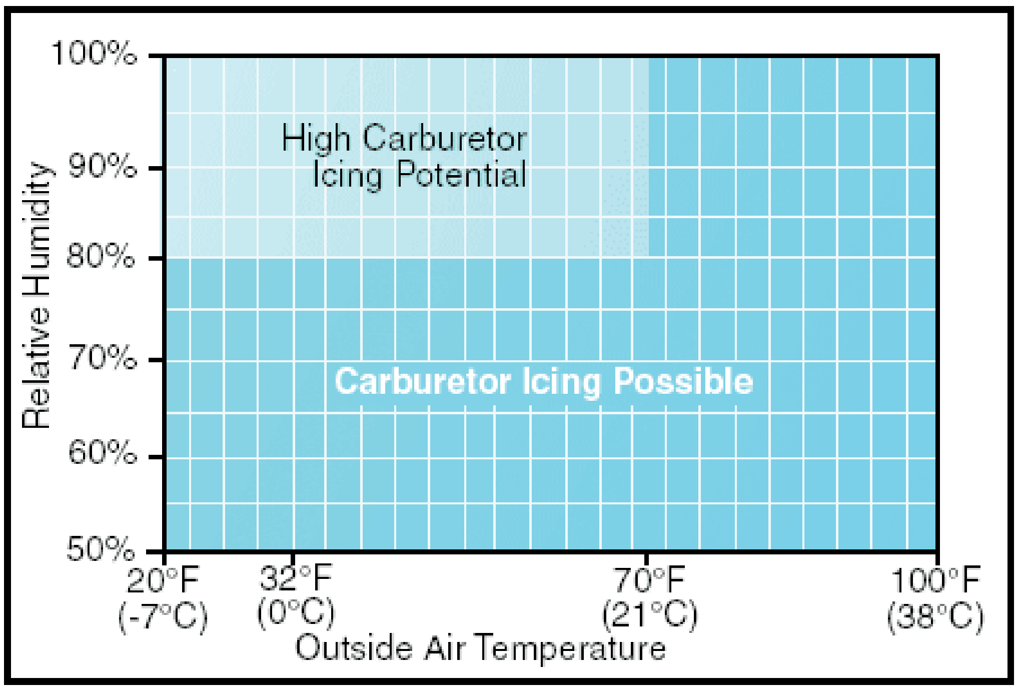
The temperature in the carburettor can drop below the freezing point of water, and if the air is humid, ice can form inside the carburettor. As the ice builds up, less air can pass through the carburettor, causing a drop in power and, in severe cases, the engine will eventually fail.

ICING

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.

Also, since there is less air acceleration through the carburettor at full-throttle operation, icing is usually less of a problem than part throttle operations.



INVERSION

1. Normal Atmosphere:

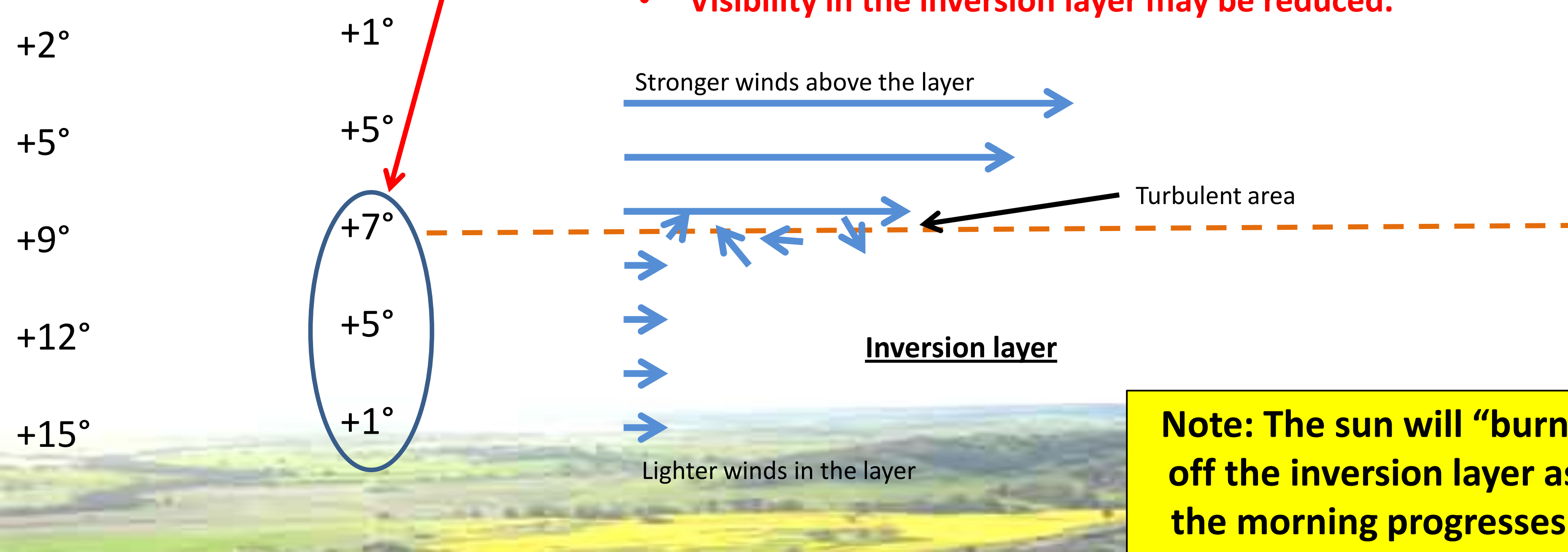
In the atmosphere the temperature generally decreases with height. This temperature drop is approximately 2° each 1000ft of height increase.

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 tcalled an **INVERSION LAYER.** This stable layer traps pollutants and isolates the surface from the stronger winds above.

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.**



Note: The sun will "burn" off the inversion layer as the morning progresses.

TURBULENCE

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

Turbulence is felt in the Aerochute as a gain or loss of height, rocking of the cockpit from side to side or back and forth. It can also be seen in the parachute as an in-out movement of the cells.

Note: The Aerochute should not be flown in conditions of severe turbulence. The take-off wind limitations of the Aerochute usually do not allow this to occur.

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

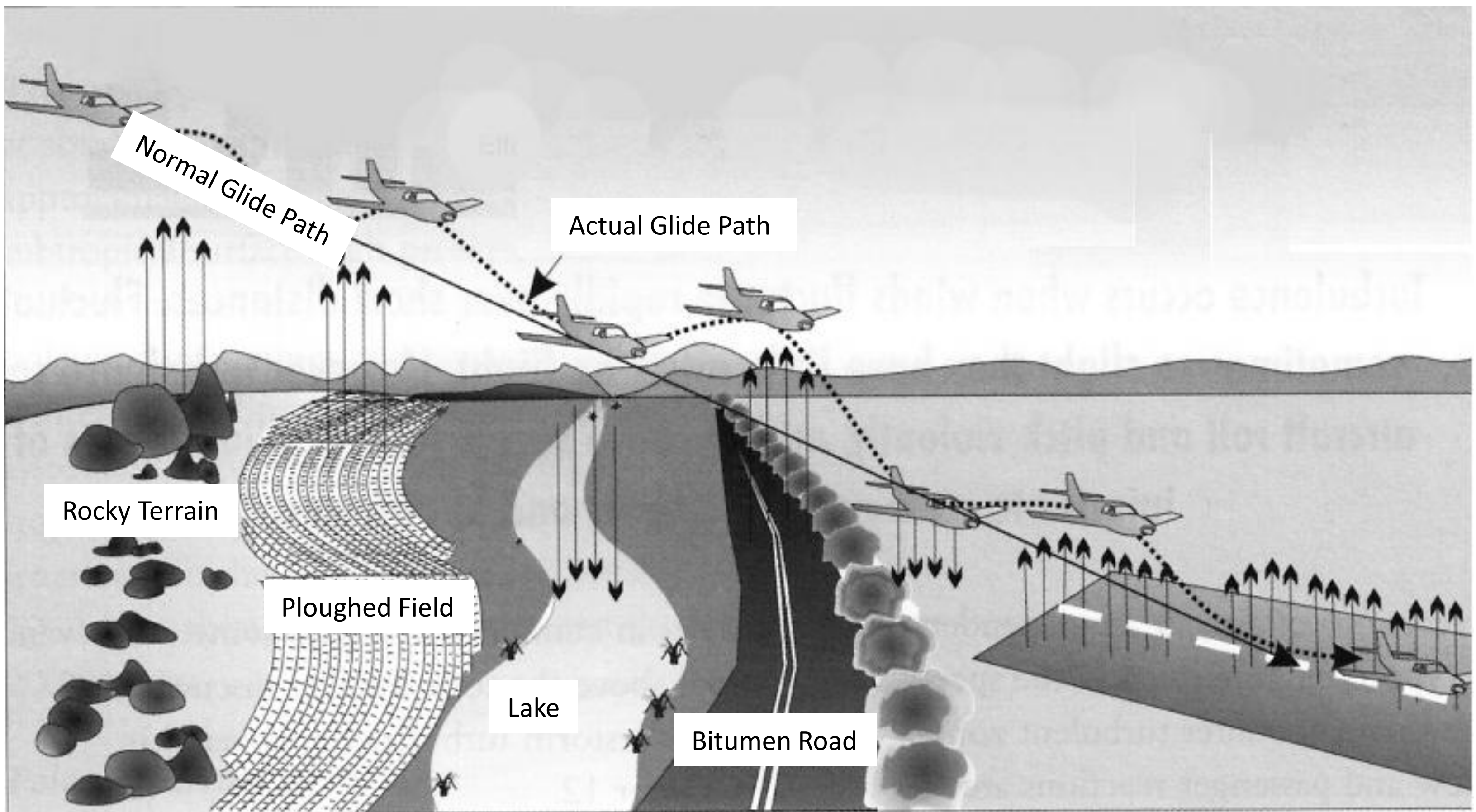
The main causes of turbulence that effect us in the Aerochute are:

Convection
Topography
Aircraft wake
Weather fronts

TURBULENCE - CONVECTION

Convective turbulence is due to the transfer of heat.

<u>Thermals:</u>
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 compared to a grassed area.



TURBULENCE - CONVECTION

Convective turbulence is due to the transfer of heat.

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

Convective turbulence is due to the transfer of heat.

Clouds:

If there is enough moisture in the air, the rising air can cause clouds. These clouds can range from small ”fair weather” convective clouds to large thunder storms. Flying into clouds is not allowed in recreational aviation (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 in the Aerochute. ”Strataform” or “Stratus” clouds are the clouds with a “layered” appearance and are not associated with strong turbulence.

Cumulus

Stratus

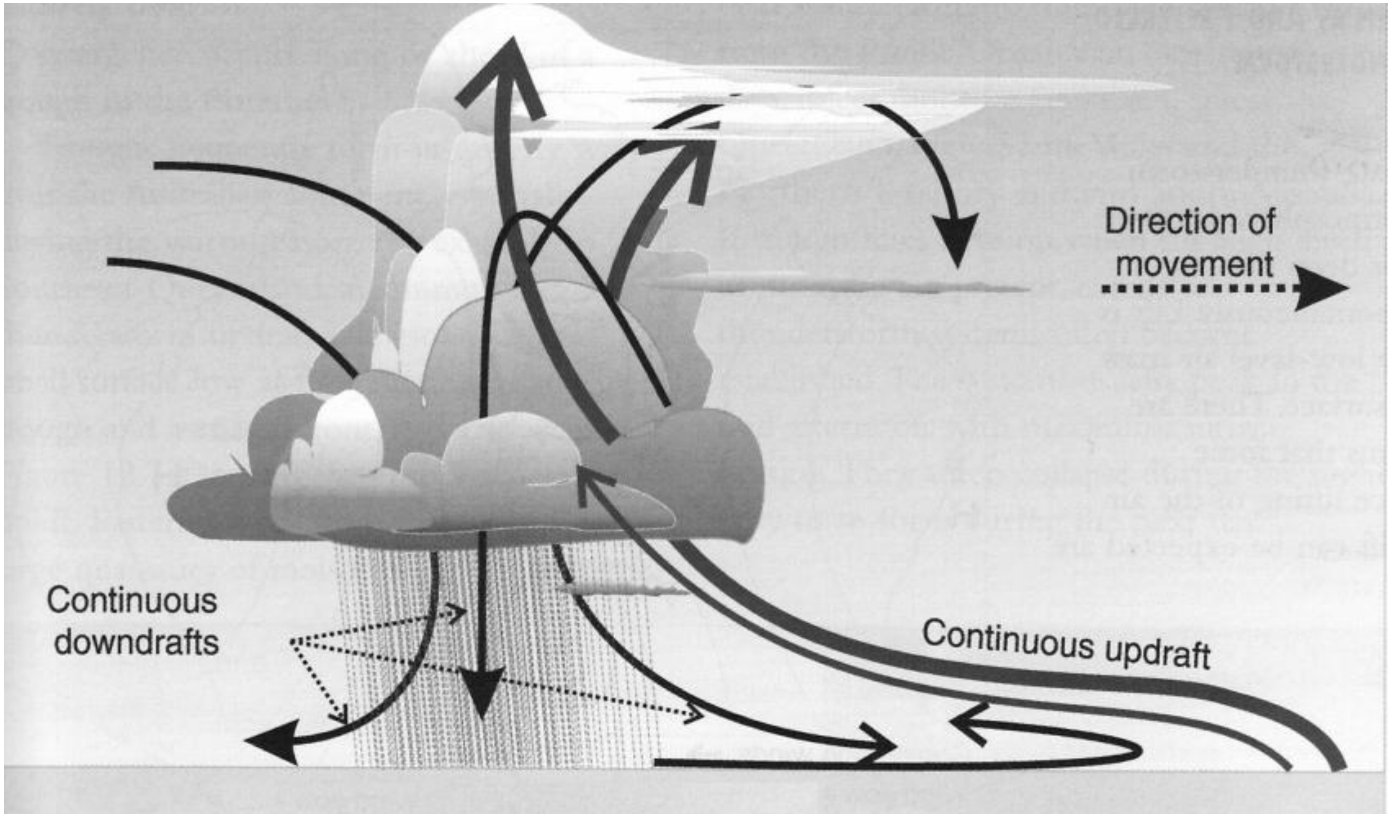
TURBULENCE - CONVECTION

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.

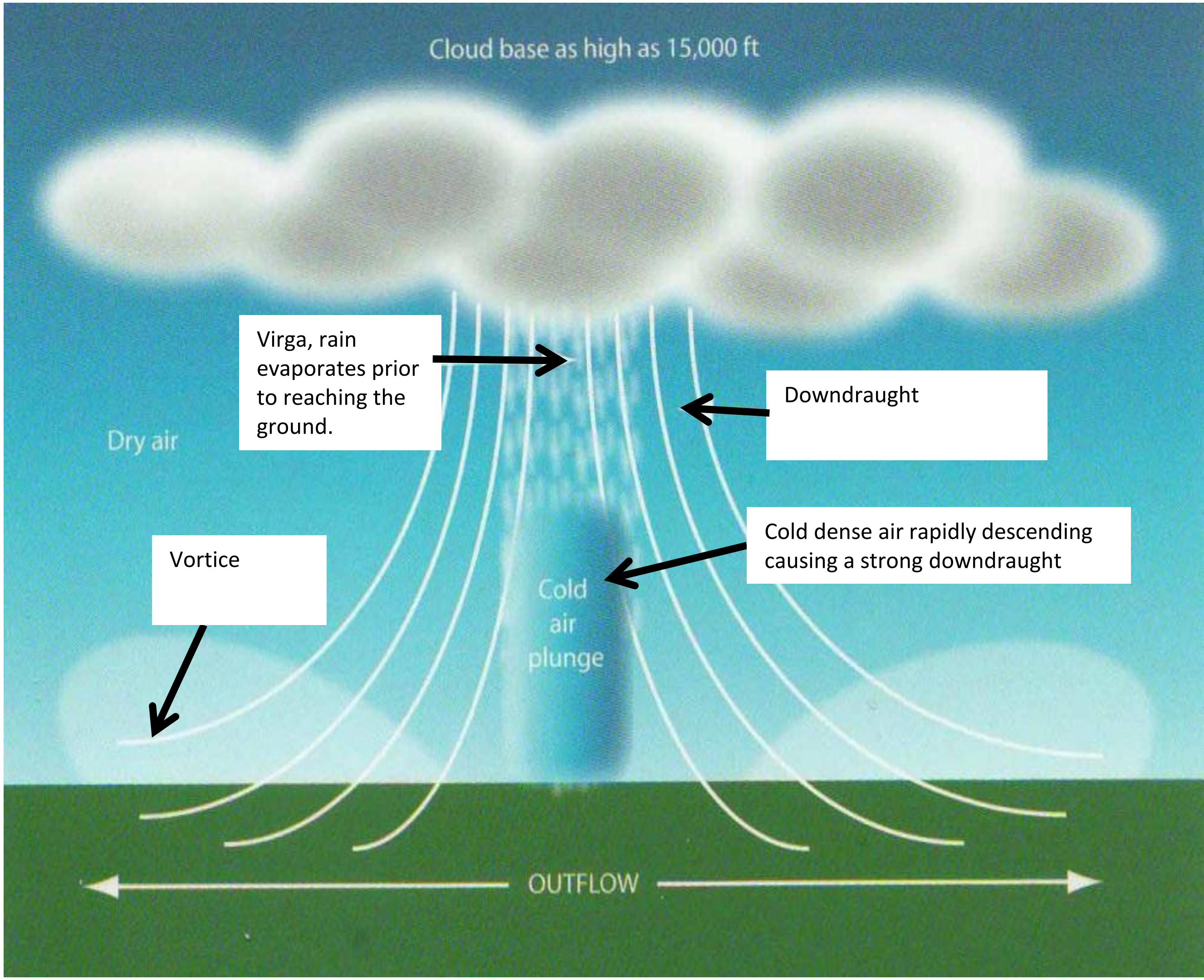


TURBULENCE - CONVECTION

More on clouds:

<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.



Always avoid flying in the vicinity of Virga.

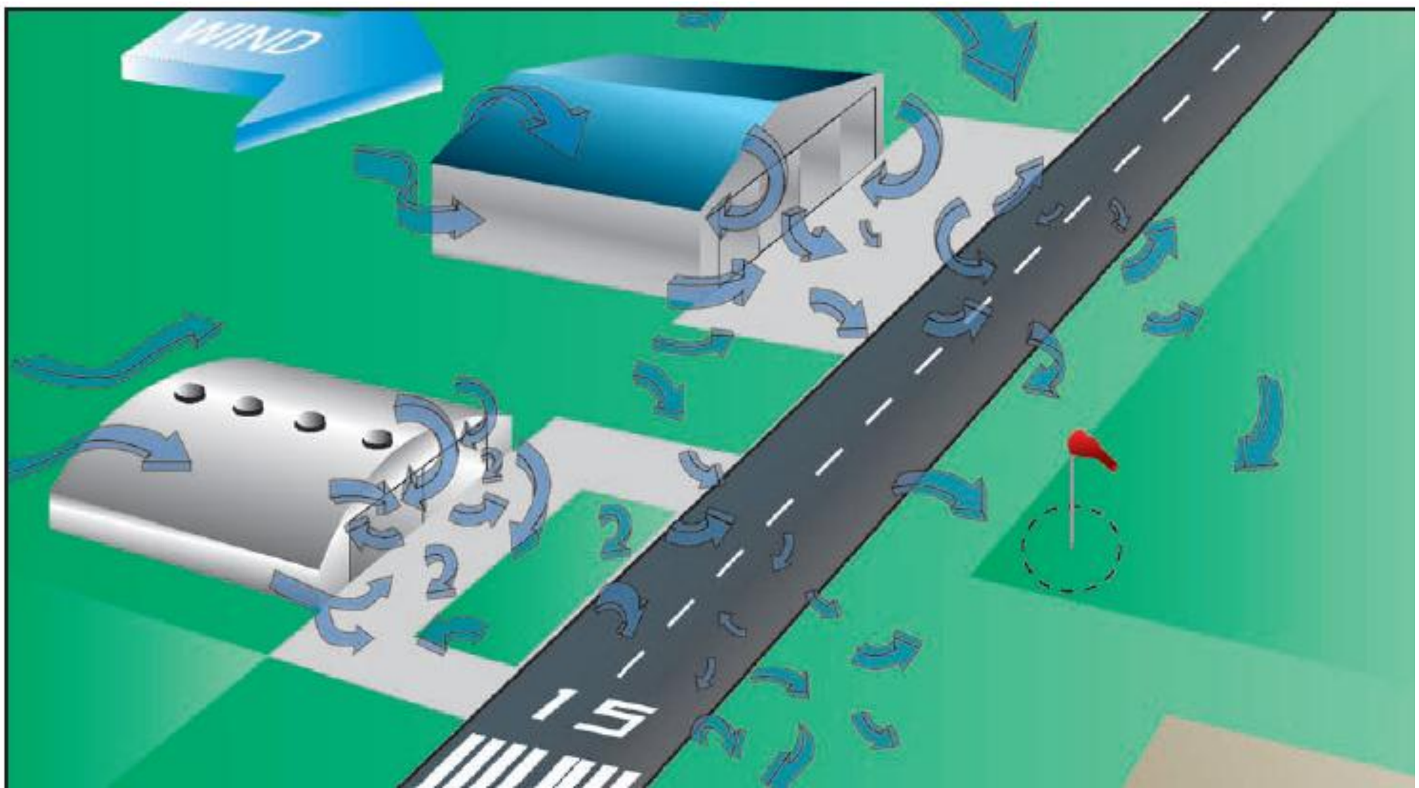
TURBULENCE - TOPOGRAPHY

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

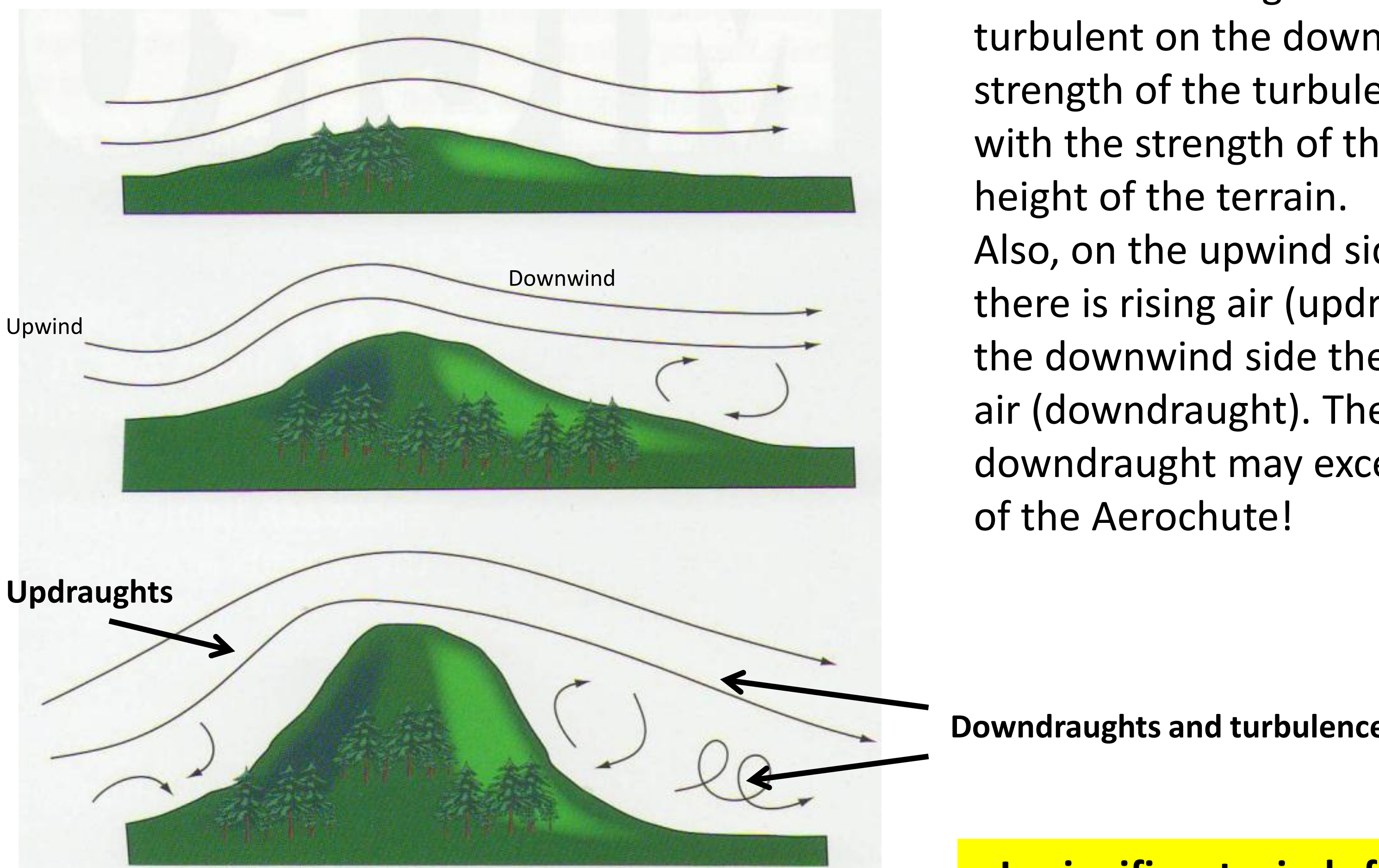
<u>Obstacles:</u>

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



<u>Terrain/Mountains:</u>

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!

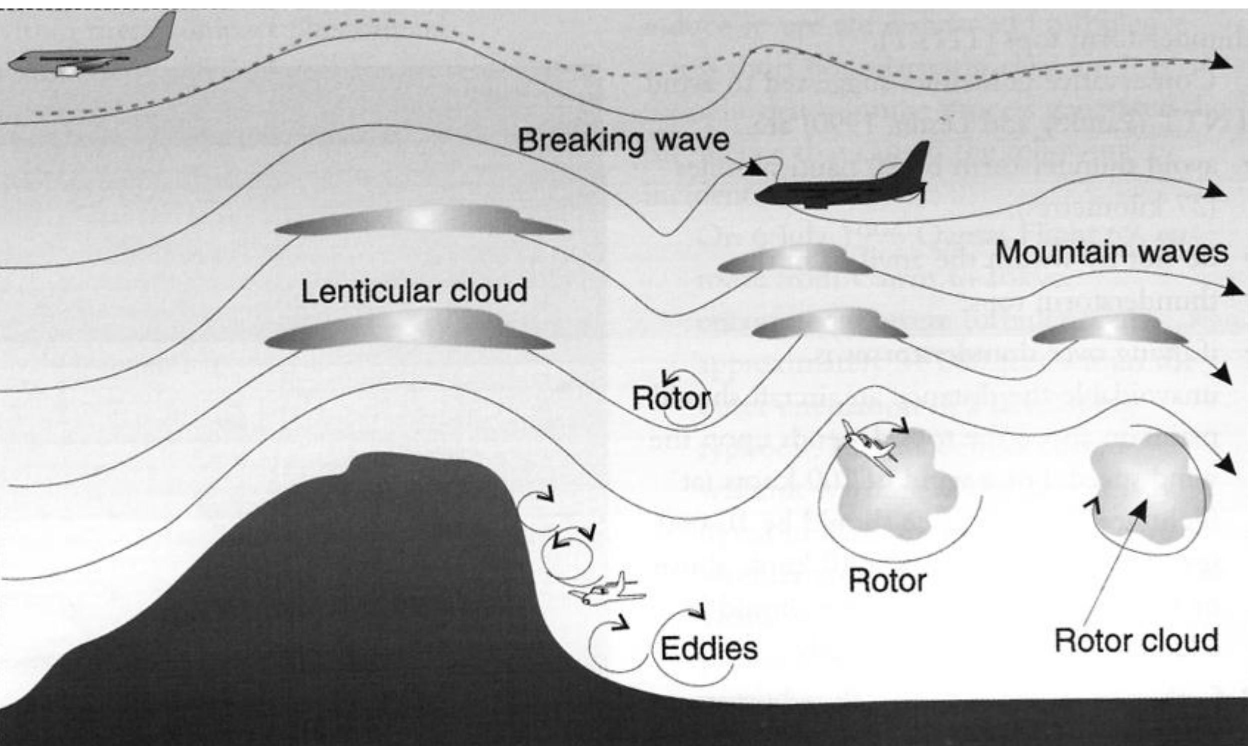
In significant winds fly <u>upwind</u> of high terrain or mountains!

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.



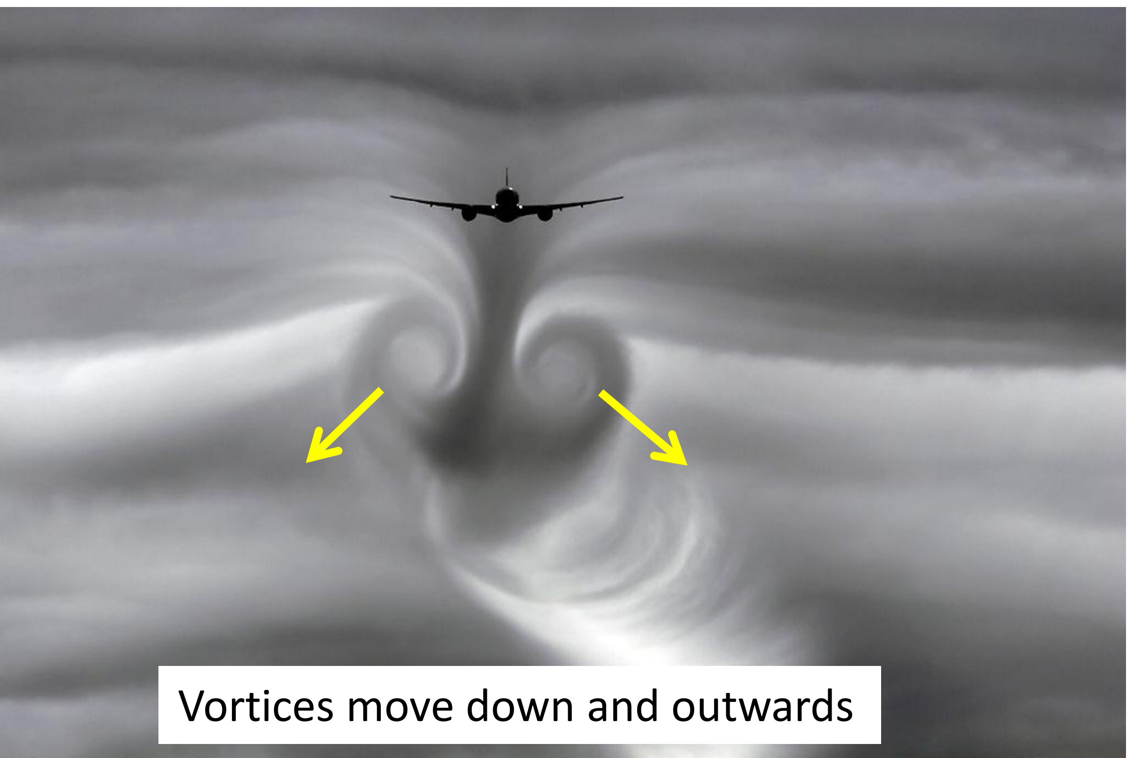
Avoid the downwind areas of mountains in windy conditions!

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.



Vortices move down and outwards

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

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

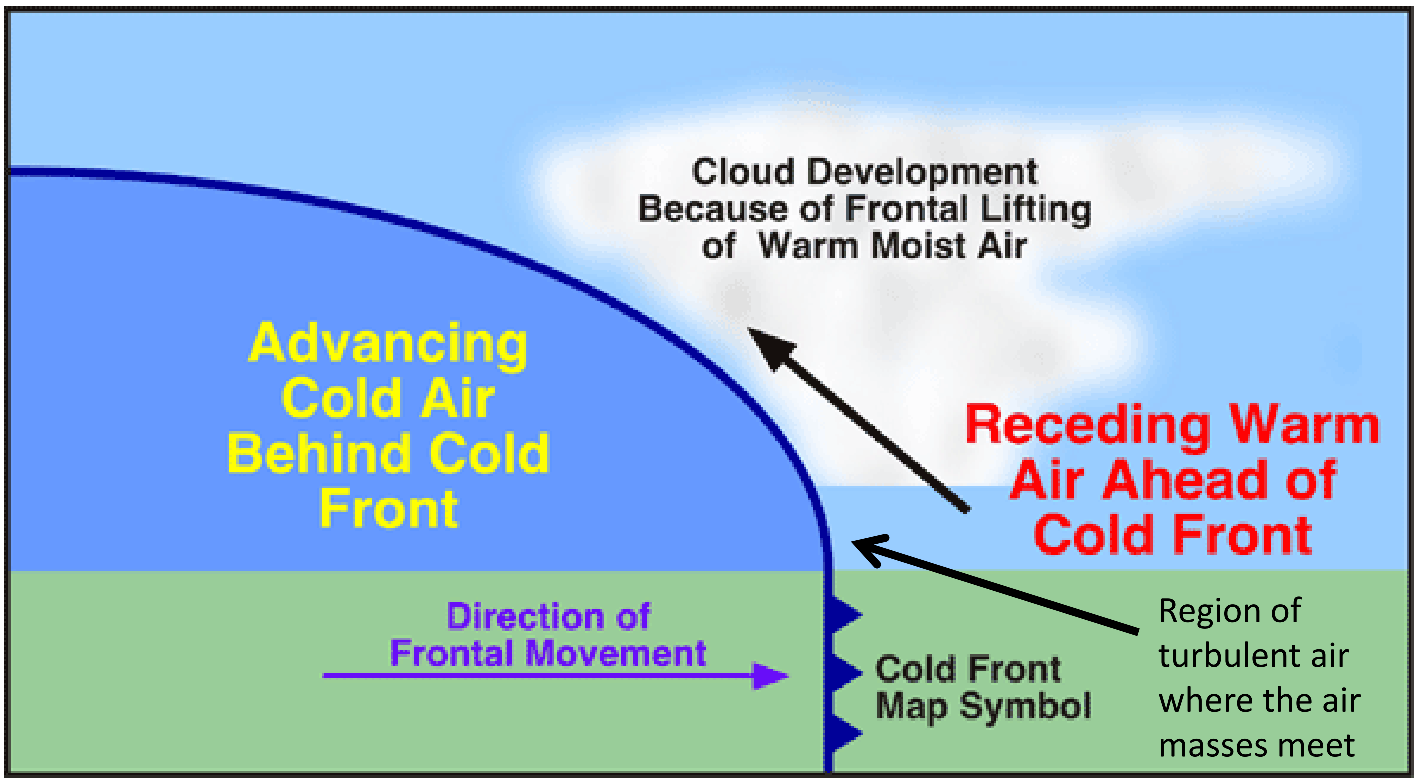
Note that the Ram Air parachute is a wing and also produced vortices however, as the Aerochute is only light weight, the parachute doesn't produce significant amounts of lift and the vortices are not severe.

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!**



VISIBILITY

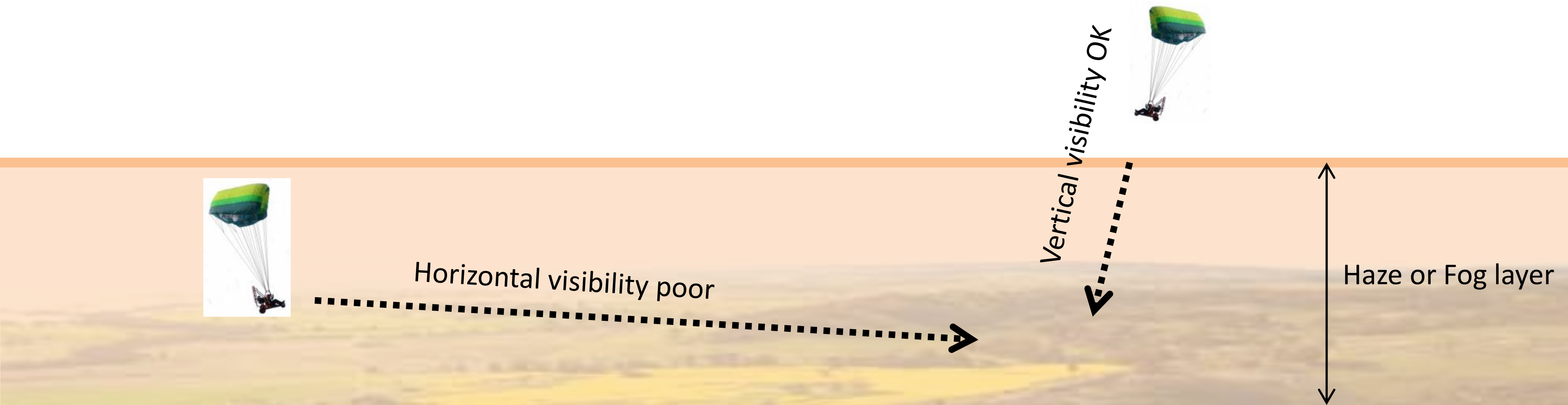
When referring to aviation and meteorology, visibility refers to the **horizontal distance** that you can see.

Recreational aviation is restricted to flying in visual meteorological conditions (VMC) which is a visibility of 5000 meters however, it is worth discussing the most probable forms of reduced visibility that we may accidentally encounter.

FOG:
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:
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, 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.

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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**

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/False?
2. Due to the Coriolis Force, what direction does the air flow around a high pressure system in the southern hemisphere?
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. What is a Foehn wind?
9. On a calm, cold night would you expect a wind to develop that flows up or down the side of a large mountain?
10. What would you expect the flying conditions to be if you flew into Virga?
11. Which cloud has the most turbulence associated with it, Cumulus cloud or Stratus cloud?
12. What is the most likely name of a cloud that resembles a Cauliflower in shape?
13. What are the dangers associated with flying in the vicinity of a large Cumulus cloud?
14. What direction do the wake vortices travel behind an aircraft in flight?
15. 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?
16. On the upwind side of a mountain in moderate wind conditions would you expect the air to be rising (updraught) or descending (downdraught)?