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METEOROLOGY FOR AUSTRALIA

CHAPTER 14 – VISIBILITY

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VISIBILITY

INTRODUCTION

Visibility is, by definition, the distance from a viewer (human or electronic) that objects can be both seen and clearly defined. **In other words visibility describes the clarity or transparency of the air. This transparency will not be affected by light or darkness.**

For a meteorologist that distance would be horizontal, seeing and defining known objects on the ground. For a pilot, flight visibility is the forward visibility from the flight deck and is usually assessed rather than defined as there aren't often fixed objects in the air! A pilot may assess visibility based on objects seen on the ground, but from any reasonable height this would be a slant visibility and not a true one. There are many factors that can affect visibility and because of its importance to the safety of flight, a good working knowledge of these factors is essential.

There are many conditions which could lead to the reduction of visibility, most importantly, when we are close to the ground, e.g:

- Fog (visibility less than 1,000 metres)
- Mist (visibility, greater or equal to 1,000 metres)
- Haze (Smoke, air pollution and dust)
- Dust and Sand Storms
- Precipitation
- Low Cloud
- Sea Spray and Salt Particles

FOG

As defined above, when the visibility is less than 1,000 metres due to suspended droplets of moisture, then a condition of fog exists. There are several types of fog caused by very different conditions and they are usually named after their method of formation. Each will be explained in turn.

a) Radiation Fog

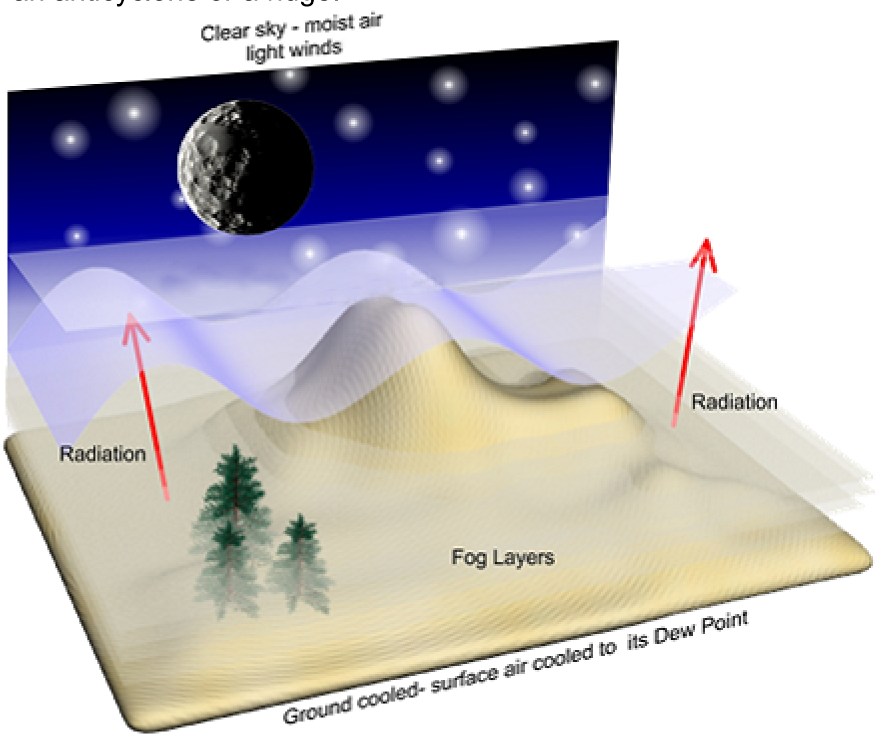
Radiation fog requires certain conditions before it will form:

- Moist air
- Clear night skies
- Light winds (3 to 7 kts)

The humidity of the air is usually a function of the air mass that is being experienced. In other words, if the air has been following a long sea track, then its **moisture** content will be high. An indication of a high Relative Humidity would be if the temperature were within 3° of the Dew Point. There are of course other contributory factors to the humidity of air, but these generally lead to different forms of fog.

The second requirement, **clear night skies**, is so that maximum night time cooling of the land can take place. The process of Terrestrial Radiation has been explained in Chapter 3. If the sky wasn't clear, then the long wave radiation would be trapped under any cloud present.

When the land is cooled the air in contact with it is also cooled (conduction). Should this air now cool to its Dew Point then several things could happen. If there is no wind then the moisture in the air would just condense out as dew. If the air cooled to its Frost Point (the temperature at which water vapour will sublimate as ice) then everything would be coated with frost. If, however, there were just **a light wind (3 to 7 kts)** then the light turbulence would stir the cold air into a deeper layer and condense out as a layer of fog usually only a few hundred feet deep. The meteorological condition to produce these light winds would be a high-pressure system, either an anticyclone or a ridge.



Conditions for the Formation of Radiation Fog

Should the wind be stronger than 7 kts, then the increased turbulence created would cause the air to mix, producing low Turbulence Cloud.

The most common time of day for Radiation Fog to form is just after dawn, when the land is starting to be heated, producing the light winds required. However, if conditions are favourable, fog can form any time during the night.

Radiation Fog, in Australia, usually occurs in autumn, and winter when the temperature requirements are most frequently met. It will often form in valleys first as cooling by radiation is assisted by katabatic cooling and because valleys usually contain some sort of natural water, increasing the humidity of the air. Radiation Fog does **not** form over the sea as there is little or no Terrestrial Radiation, or anywhere Terrestrial Radiation may be limited.

Dispersal of Radiation Fog can be by several ways, usually by getting rid of one or all of the requirements for its formation**. A common method is to heat the air to above its Dew Point.** This happens naturally as the sun heats up the land during the day, usually burning off the fog by mid to late morning. If, however, a layer of cloud has covered the fog, then this heating may be very slow and indeed the fog may not clear for some time (weeks in some cases!)

An increase in **wind speed above about 7 knots** can also lift the fog although there may still remain the problem of low cloud. This change to the wind might come about by a change in the pressure system.

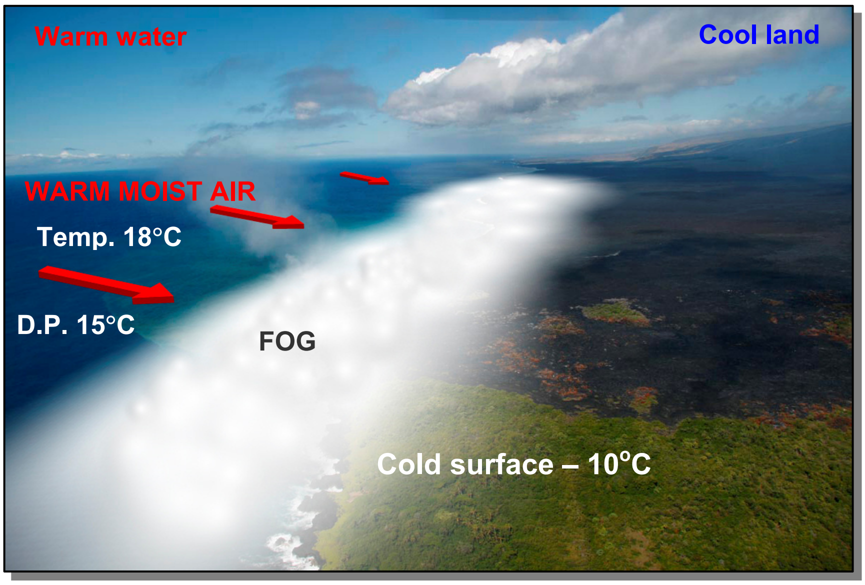
Finally, a change in the air mass could introduce drier air, reducing the required moisture.

b) Advection Fog

The word advection means *the horizontal movement of air,* and that is exactly how advection fog forms.

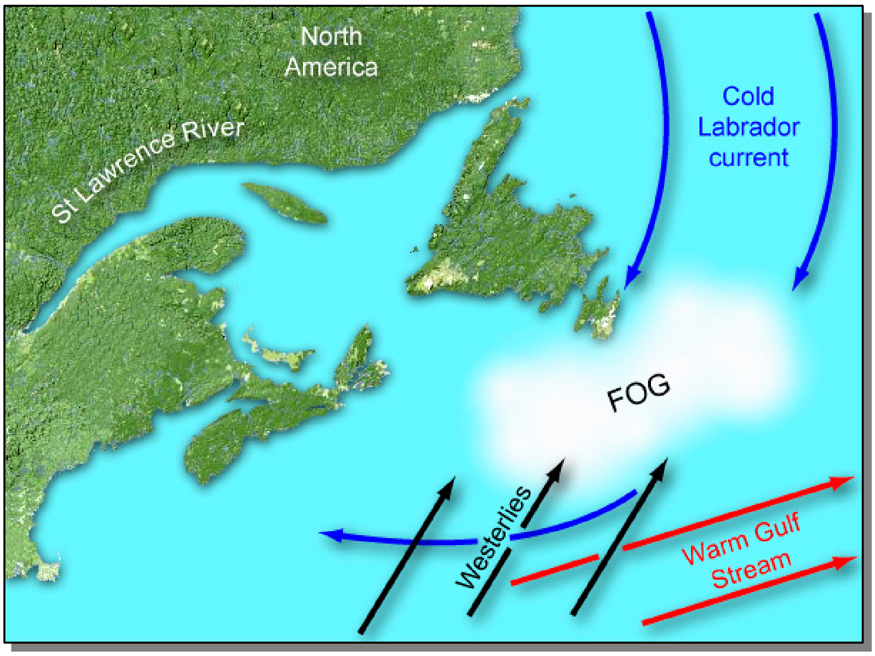
As we already know **warm air is wet air.** In other words, warm air is capable of holding a lot more moisture than cold air. Should some warm, very moist air move horizontally over a cold surface (either land or sea) then the air in contact with this surface will cool, reducing its temperature and increasing its Relative Humidity.

Should the R.H. reach 100% the water vapour will condense out and fog will form. Because wind strength is not a factor in its formation, it can survive in very windy conditions and indeed does so in, for example, southern Victoria. The fog will be typically 100 to 1,500 feet thick.

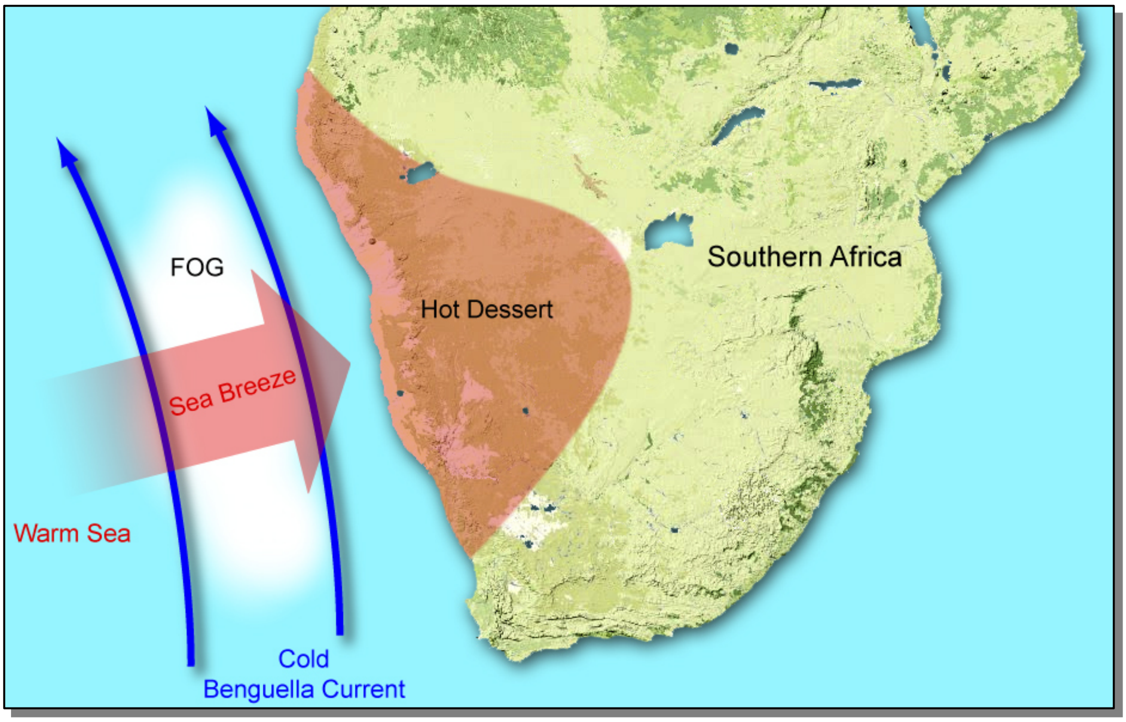


Conditions for the Formation of Advection Fog

There are many examples of regular advection fog areas throughout the world including the two illustrated below.



The Labrador Current in the West Atlantic



The Benguella Current in the East Atlantic

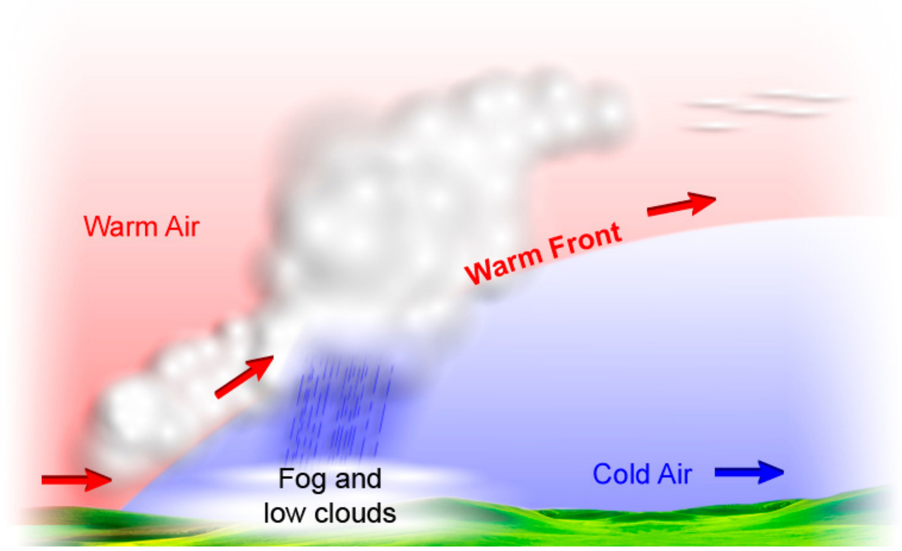
Although all the previous examples of Advection Fog implied that the air must be flowing over water, in some cases the air could start its movement over land. It must, however, be warm air, so that if it has a subsequent sea track, it can pick up enough moisture to eventually condense out when it reaches a cold surface.

Dispersal of Advection Fog only comes about by a change in the air mass, with drier air being introduced (the new air mass must have had a shorter sea track).

c) Frontal Fog

As is implied, Frontal Fog forms in association with fronts, or more specifically, a warm front. At a warm front, warm air rises over cooler air. The rain produced by this process will fall from the warm, rising, air. This will in turn significantly increase the Relative Humidity of the cooler air and water vapour may condense out as either low cloud (fractostratus) or less commonly, as fog. It moves with the front so it disperses as the front moves away.

+



d) Steam Fog (Arctic Sea Smoke)

Steam fog occurs when a cold moist air mass flows over a much warmer body of water.

The evaporation of water vapour from the warm water surface causes the air above the surface to become saturated and it will condense. Because the surface is warmer, convection currents give the "steaming" appearance.

A surface inversion is required to prevent any instability from dispersing the fog vertically.

The reference to Arctic Sea Smoke is because this type of fog is common in Arctic regions when cold air moves over open water.

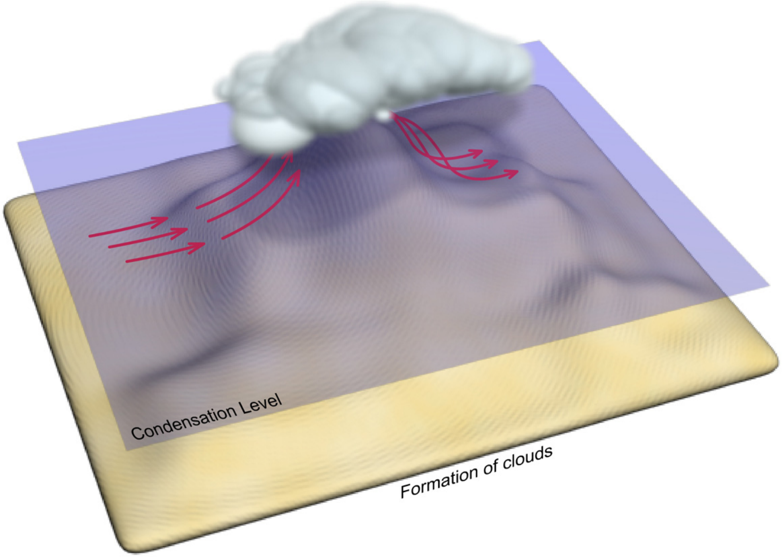
Steam Fog is usually shallow, but aided by katabatic effects, can be quite deep in valleys and fjords. Warming air or a breaking of the surface inversion will clear the fog.

e) Thaw Fog

Thaw fog is a type of advection fog. Warm air moving over a snow-covered surface will often produce widespread fog while the snow is thawing. The melting snow both cools the air and increases its moisture content as it evaporates. It is a particular feature of central and Eastern Europe in the spring.

f) Hill Fog

Hill Fog, as its name implies, is associated with high ground. In reality it is cloud in contact with the high ground, reducing visibility to less than 200 metres. It can be formed orographically when stratiform cloud is produced on the up-slopes of high ground, or it may be that the ground is high enough to protrude into a pre-existing layer of cloud. It will disperse when the conditions for the formation of the clouds are removed, or the cloud base rises.



MIST

Mist is when, due to water droplets in suspension in the air, visibility is reduced but not to less than 1,000 metres. It can form in any of the same ways as fog but is obviously not as big a hazard to flying. Beware however, mist could be the early indication that conditions exist for the formation of fog!

HAZE (SMOKE, AIR POLLUTION AND DUST)

Haze is when, due to solid particles in suspension in the air, visibility is reduced. There are no specific figures pertaining to this reduction in visibility.

The solid particles which contribute to the production of haze can come from many sources eg. Industrial activity, fires (bush fires in Australia or clearing scrub), vehicle emissions or wind lifted dust. The sources abound, but haze is not often a serious problem because all these particles, when spread throughout the atmosphere, will have very little effect on visibility.

There are however, certain conditions when they can present a more serious reduction to the visibility. For instance, if there is an **inversion**, then the particles may be trapped underneath it, and this increased concentration could well reduce visibility significantly. Furthermore, at the end of a long dry period of weather, the land could be very dusty indeed, and aided by wind, if the dust is lifted, then visibility could be locally very poor.

Another large factor in the effect of haze is the time of day. If there is any haze present, then as the sun sets, visibility into sun will be greatly reduced. The same of course holds true of sunrise when there is also an increased likelihood of there being a low level inversion to make matters worse. Against this though is the fact that not so much in the way of smoke etc. is produced during the night.

Generally haze is cleared by an increase in wind speed, precipitation, or a breaking of an inversion.

One last word of warning, with a lot of solid particles in the atmosphere, it is possible that they could act as hygroscopic nuclei and assist the formation of fog. This could occur in Relative Humidities of as low as 80%.

DUST AND SAND STORMS

Dust and sand storms can be widespread and cover large areas of Australia, North Africa, and The Middle East, especially in later summer and autumn. They are not however confined to desert regions, as many agricultural areas also possess enough dust to have a storm of their own.

Dust or sand is raised from the ground by a **strong wind** (at least 11 to 16 kts). The height lifted to depends on the particle size. If these particles are now lifted further into the atmosphere by **unstable conditions** or **very strong convection** then the reduction in visibility can affect several thousands of feet (e.g. In a central Australian summer, there is sometimes no horizon below 25,000 ft.). Close to the source of the particles visibility could be less than the fog limit of 1,000 metres which is, by definition, when blowing dust becomes a "storm". They tend to be short lived phenomena in that they will blow through quite quickly.

Volcanic dust can also create a serious visibility problem, with an active volcano propelling dust well up into the atmosphere, maybe even up to the tropopause. There are of course other more serious effects of volcanic dust in large quantities, but that comes under Turbine Engines rather than meteorology!

On a smaller scale, convection can cause the lifting of dust producing "whirlpools" or "eddies", called Dust Devils. These are easily seen and avoided, but an encounter can create quite a lot of turbulence.

PRECIPITATION

Drizzle and Rain

Drizzle is an important factor in reducing visibility and its effect is explained by the very large number of water particles in a given volume of air, as compared to light rain. It is very similar in nature to fog. Drizzle commonly restricts visibility to between **400 and 3,000 metres**.

Light rain on the other hand, has virtually **no effect** on visibility.

In temperate latitudes, **moderate rain** can reduce visibility to **5 - 10 km**, while the **heaviest rain** rarely causes a reduction to less than **1,000 metres**.

In tropical regions however, a **"torrential downpour"** has been known to reduce visibility to **50 - 500 metres**.

Sleet and Snow

Although sleet does reduce visibility, it is not as significant as drizzle or heavy rain. **Snow** on the other hand, can have a serious effect. Both falling snow and blowing snow can reduce the visibility to below the fog limits of **1,000 metres**. **Heavy snow** may lead to visibilities of the order of **50 to 250 metres.** An additional problem caused by blowing snow is that as well as the possible reduction in visibility, there may be no discernible horizon. This is the classic white-out experienced by mountaineers and skiers.

LOW CLOUD

Low cloud has an obvious effect in that within most cloud, visibility may be reduced to something in the order of only a few metres. There is however, a well defined boundary, in that when within cloud, visibility is very poor, but when outside of that cloud, visibility is governed by all the factors affecting it so far discussed in this Chapter.

SEA SPRAY AND SALT PARTICLES

In very strong winds, sea spray or blown salt particles can indeed reduce visibility, but in such conditions, this slight reduction is of little importance when compared to the other flying problems which would exist.

EFFECTS OF ATMOSPHERIC STABILITY ON VISIBILITY

Stable Atmosphere

The most likely type of cloud in stable conditions would be stratiform, so any precipitation is likely to be light. If the precipitation is drizzle though, then visibility will be reduced. Stable conditions also lend themselves to the formation of fog (both radiation and advection). Inversions are likely, so the effect of haze will probably be more significant.

Unstable Atmosphere

Cumuliform cloud may form if sufficient moisture is present. Precipitation could then occur, reducing visibility significantly in snow, heavy showers or rain. Between showers, visibility is generally very good due to the dispersal of any solid particles. Dust and sandstorms may develop, if conditions are suitable, with their associated reduction in visibility.

VISIBILITY ON THE APPROACH

Effect of Shallow Fog Layer

When starting the final approach from well above a shallow fog layer, where the whole of the runway or runway lighting is visible at the start of the approach, there is a strong possibility that the far end of the runway will progressively disappear as the aircraft gets lower. Under these conditions, a reduction in the initial descent gradient may make it possible to keep the whole of the runway lighting in sight throughout the approach.

Flight in Rain

Rain on the windscreen can have two opposite effects. It can reduce the intensity of light reaching the pilot's eyes, and can therefore make the runway appear further away than it is, or, conversely, it may cause the runway lights to "bloom" and appear larger and closer than they really are. Care must be taken to avoid an inadvertent descent below a safe approach path, when subject to such illusions.

A heavy rain shower moving quickly towards an aircraft will blot out the horizon, and attempts to maintain attitude visually in these circumstances often results in an increasing nose down pitch attitude being adopted.

Effect of the Sun's Position

The distance at which ground objects can be recognised from the air may vary with the relative position of the sun or even a fairly full moon. Because of the minimum glare that a pilot will experience when looking down-sun, ground features will be seen to greater ranges than when looking into the sun. On the other hand, in bright moonlight when there is no problem with glare, objects can be most easily identified when looking towards the moon, when reflection can help in their recognition.

VISIBILITY IN FORECASTS AND REPORTS

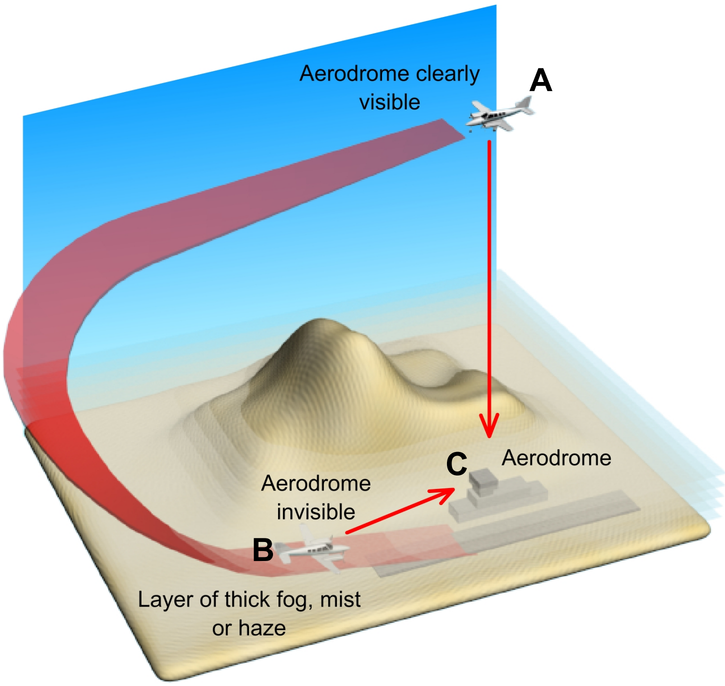
Visibility in forecasts and reports (METARs) will be covered in depth in the Meteorology Practical syllabus. This is just an introduction so that you can start to equate theory with practise!

Horizontal Visibility

This is a visibility given in an Area weather forecast. It refers to the in-flight visibility expected

Slant Visibility

This is the visibility as seen from the flight deck during an approach, when a pilot looks at features on the ground.



A slant can be significant in terms of visibility. Using the above diagram as an example, a pilot at point ‘A’ might be able to see the runway (‘C’) quite clearly. By the time the pilot has reached point ‘B’ though, the amount of haze that they must now look through may well mean that the runway can no longer be seen. To the pilot at ‘A’, an apparently good visibility might in reality be rather poor.

Runway Visual Range (RVR)

This is the maximum distance that can be seen, in the direction of **take-off** or **landing,** on a given runway, from the average eye level of a pilot. This distance may be shown in a METAR (Meteorological Routine Aerodrome Report). eg. R26/1,000 (Runway 26, runway visual range is 1,000 metres).

Runway Visual Range is passed on to aircraft if the visibility falls to 1500m or less.

In a METAR the minimum visibility observed or forecast is always given. (Remember - ground level, not flight visibility is given).

In a METAR, if the minimum visibility covers more than half the aerodrome, or when visibility is fluctuating rapidly and directional variations cannot be given, this is the only visibility report.

A METAR will have directional variation indicated when the minimum visibility is less than 5,000 metres and the visibility in another direction covering more than half the aerodrome is at least 50% greater. If this occurs, the minimum visibility will be given first with the direction indicated by one of the 8 points of the compass, followed by the higher visibility without a compass point.

e.g. METAR YPPF 281120Z 30015KT 1000SE 8000

In clear language, the actual weather at Parafield is:

Wind is 300/15 knots, visibility is 1,000 metres to the south east, with the greatest visibility being 8,000 metres elsewhere.