Cloud Amounts

The amount of cloud observed or forecast to be present must be expressed in terms that can readily be understood by observers on the ground and pilots in the air alike. To an observer on the ground, it would appear sensible to express the amount of cloud as a fraction of the sky covered by cloud. This is indeed the method used. The amount of cloud cover is expressed in *oktas*, an okta being a unit representing one-eighth of the sky.

Many ask, Why not use tenths of the sky covered? The reason is that for international coding purposes, the figure 0 must be reserved for conditions where no cloud is present, and 9 is reserved for conditions where the sky is not visible (because of fog, for example). This leaves eight figures available, so we divide the sky into eight parts for expressing cloud amount. Thus, if a quarter of the sky is covered, we say that the cloud amount is 2 oktas, or $2/8$. Half of the sky covered becomes 4 oktas, or $4/8$. (See also Chapter 9.)

Moisture in the Atmosphere

Clouds are formed when water vapour in the atmosphere condenses into water droplets or, in below-freezing temperatures, into ice crystals. Water vapour is taken up into the atmosphere mainly by evaporation from the oceans and other bodies where water is present, or by sublimation directly from solid ice when the air overlies a frozen surface.

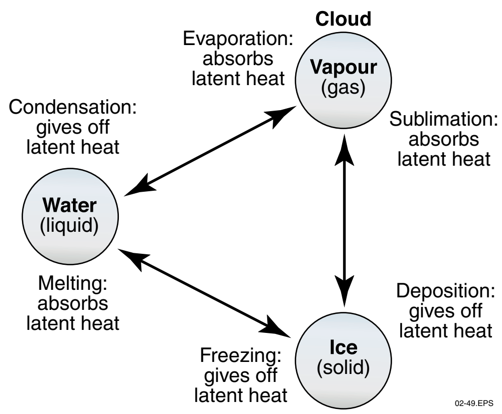

Figure 2-1 Three states of water.

Three States of Water

Water exists in three states: gas (vapour), liquid (water) and solid (ice). Water is not visible in its vapour state, but when the water vapour condenses to form water droplets, we see it as cloud, fog, mist, rain or dew. Frozen water in the form of ice crystals is also visible as high-level cloud, snow, hail, ice or frost.

Under certain conditions, water can change from one state to another, absorbing heat energy if it moves to a higher energy state (from ice to water to vapour) and giving off heat energy if it changes to a lower energy state (vapour to water to ice). This heat energy is known as *latent* (or *hidden*) heat and is a vital part of any change of state. The absorption or emission of latent heat is important in meteorological processes such as cloud formation and evaporation of rain (virga). The three states of water, the names of the various transfer processes and the absorption or giving-off of latent heat are shown in figure 2-1.

Relative Humidity

The amount of water vapour present in the air depends upon the amount of evaporation, which will be greater over wet surfaces such as oceans and flooded ground than over a desert or continent. The actual amount of water vapour in the air, known as *humidity*, is not in itself important; what matters is whether the air can support that amount of water vapour or not. When a parcel of air is supporting as much water vapour as it can, it is said to be *saturated* and have a *relative humidity* (RH) of 100%. Air supporting less than its full capacity of water vapour is said to be unsaturated, and will have a relative humidity of less than 100%. In cloud and fog, the relative humidity is 100% and the air is saturated; over a desert, relative humidity by day might be as low as 10%.

Chapter 6

Motion in the Atmosphere (Winds)

Definition of Wind

The term *wind* refers to the flow of air over the earth's surface. This flow is almost completely horizontal, with only about 1⁄1,000 of the total flow being vertical.

Despite being only a small proportion of the overall flow of air in the atmosphere, vertical airflow is extremely important to weather and to aviation, since it leads to the formation of clouds. Some vertical winds are so strong, like those in or below a cumulonimbus storm cloud, that they are a hazard to aviation and can destroy aeroplanes. In general, however, the term wind is used in reference to the horizontal flow of air. It is a pressure difference in the atmosphere (usually resulting from temperature differences) that initiates a wind. Air flows from an area of higher pressure to an area of lower pressure. In this chapter, we will generally confine our discussion to the wind in the layer at and below about 2,000 ft above the surface.

Measuring the Surface Wind

To measure and record accurately wind velocity at the surface is difficult. The movement of the air is affected by such things as the roughness of the ground, the type of surface, and the presence of buildings. To overcome these problems, the instruments used are located over open ground at a height of 10 m. The direction of the wind is measured using a wind vane, and the speed with an anemometer. To allow for fluctuations, the surface wind is reported as the mean value over the ten-minute period leading up to the time of the observation.

Reporting of Winds

Both the direction and strength of a wind are significant and are expressed thus:

- wind direction is the direction from which the wind is blowing and is expressed in degrees measured clockwise from north; and
- wind speed is expressed in knots.

Direction and strength together describe the wind velocity, which is usually written in the form 270/35, which is a wind blowing from 270°T at a speed of 35 kt.

Meteorologists relate wind direction to true north because of the relatively large geographic areas involved, often including areas of differing magnetic variation, so all winds that appear on forecasts are expressed in °T; for example, 34012KT or 340/12 on a forecast or meteorological observation means a wind speed of 12 kt from a direction of 340°T.

Runways, however, are described in terms of their magnetic direction, so that when an aeroplane is lined up on the runway ready for take-off, its magnetic compass and the runway direction should agree.

The wind direction relative to the runway direction is important when taking off and landing. For this reason, winds passed to the pilot by ATC have direction expressed in degrees magnetic. This is also the case for the recorded messages on the automatic terminal information service (ATIS) that a pilot can listen to on the radio at some airports.

Drifting Thermals

A drifting thermal usually takes the form of a whirling current of rising air, often manifest by the dust that it lifts from the ground as *dust devils* or *willy-willies.* This is hazardous to aircraft operating close to the ground. It may lift a column of dust up to 9,000 ft AGL and even higher in the outback during hot summer conditions. Apart from an adequate heating source and unstable air, light winds or calm conditions are necessary for the development of a dust devil.

Dust devils usually last for a period of less than 30 min but may last for up to an hour. They vary in diameter from as little as 10 ft (3 m) up to 300 ft (100 m) or more. Unless there is sufficient dust at the surface to make the entire structure visible, it is difficult to determine the vertical extent of an individual dust devil. When the ambient temperature is in the order of 30°C, it is likely that the temperature of the ground may exceed 40° in places. Given an average lapse rate, it is then possible for the air in the system to rise to 10,000 ft. Dust devils are more commonly observed in open countryside during the summer months (possibly into autumn) and during the afternoon. They are not often observed in forest country, although they do sometimes occur over the monsoon forests of northern Northern Territory and Western Australia. They are also unlikely to occur over water.

The distinct danger associated with dust devils lies in the risk of the pilot losing control of the aircraft during take-off or landing should the aircraft be unlucky enough to enter one while close to the ground. An equally serious hazard, but less likely is the possibility of suffering structural damage resulting from extreme aerodynamic loads being imposed on the airframe while flying through one at any height. Sharp-edged gusts associated with dust devils may be experienced at any altitude to 10,000 ft, so if there is evidence of dust devils on the ground below, it would be wise to slow down and cruise at turbulence penetration speed.

The use of polarised sunglasses has been found to aid the detection of dust particles, particularly at high altitudes where the dust content is much less than at lower levels. The presence of hawks and eagles can also aid in the detection of high-level thermal activity; similarly, the presence of these birds near country aerodromes at low level can also warn of the development of dust devils close to the ground, particularly in hot dry weather.

Inversion Turbulence

The character of inversions is such that aircraft flying in their vicinity will be subjected to varying degrees of turbulence. The nature of an inversion is such that sharp temperature changes occur in the air through a shallow layer. It is also often the case that a marked windshear will occur through the layer, and the degree of turbulence in individual cases will be governed by the depth of the inversion and the amount of change in the wind and temperature through it. To this must be added the fact that the performance of the aeroplane flying or on climb through the inversion will be affected, and that the relative effect of any inversion will be governed by the amount of spare performance available. Thus the following factors affect the degree of inversion turbulence:

- the depth of the inversion layer;
- the amount of the temperature rise through the inversion;
- the value of any vertical windshear through the inversion; and
- the speed of the aircraft (IAS).

Frontal Turbulence

A front has the potential to produce the worst-known turbulence, whether or not it is associated with thunderstorms. This is largely the result of the horizontal windshear through the front. On occasion, the windshear can approach 180° with gale force winds on either side of it. If the frontal zone is narrow (less than ½ nm), this can produce

Summary Of Weather Conditions

A summary of the weather conditions associated with the passage of the whole frontal depression system illustrated is as follows.

Warm Front

The approach of a warm front is characterised by the following:

- direction and speed of approach is generally towards the east at less than 20 kt;
- cloud developing well ahead of the front, thickening and lowering as the front approaches;
- wind from the north-east;
- barometric pressure falling; and
- rain beginning 150 nm ahead of the surface position.

Passage of the warm front is characterised by the following:

- wind backs around to the north-west;
- rain eases and stops;
- cloud clears to the south-east;
- temperature rises;
- relative humidity decreases; and
- barometric pressure steadies.

Warm Sector

In the warm sector, the amount of cloud depends on the temperature, humidity and lapse rate of the air mass in the region. As might be expected in the warm sector, the actual temperature tends to remain fairly high, while the barometric pressure is generally steady.

Cold Front

The approach of a cold front is characterised by the following:

- the formation of cirrus cloud, funnelling to the south west;
- general speed of advance of 15 to 50 kt;
- wind from the north-west, backing and strengthening;
- temperature increasing, especially in summer;
- barometric pressure falling; and
- cumulus and possibly cumulonimbus with increasing rain.

The passage of a cold front is characterised by the following:

- wind backs to south-west;
- temperature falls;
- humidity rises;
- pressure starts to rise;
- possible thunderstorm/squall; and
- low cloud.

Behind the Front

Once the front has passed, there is normally a fairly rapid clearing if the slope of the front has been steep. However, over the sea, clearing showers may occur if the air behind the front is moist and unstable.