CHAPTER 10

METEOROLOGY NOTES FOR THE GPL EXAM

1. Different global air masses

Isobars are lines on a map joining places of equal atmospheric pressure. Pressures are written on the pressure map in millibars and tenths of millibars. Areas of low pressure are called depressions or lows. Highs are also referred to as anticyclones. Other features on a weather map are troughs (of low pressure), ridges (of high pressure) and cols (regions of fairly uniform pressure between two highs or two lows).

Pressure decreases with height. The approximate relationship between pressure and altitude is 100 MB drop per 1000 meters up to 6000 meters and then 100 MB drop per 2000 meters.

Pressure systems move from West to East. However, this does not necessarily mean that the air within it moves. Air movement is determined by the pressure gradient.

Buys-Ballot's Law.

If you stand with your back to the wind in the northern/southern hemisphere, atmospheric pressure decreases towards your left/right.

Low-level wind is deflected slightly away from the geostrophic direction towards low pressure.

Atmospheric situations that produce particularly strong winds aloft, often channel these winds into imaginary tubes which are called jet streams.

Wind direction (the direction **from** which the wind blows) is reported in degrees true or in points of the compass.

Wind backs when its direction changes in an **anticlockwise** sense and it veers when the direction turns **clockwise**.

2. Formation of cold and warm fronts.

A mass of warm (or cold) air replacing a mass of cold (or warm) is referred to as a warm or cold front. An occlusion is where two fronts merge.

3. Different types of cloud formations.

If air blowing up a mountainside reaches its condensation level - the level at which cooling by ascent produces saturation - then cloud will form. Such cloud is called orographic cloud. Any resultant rainfall is called orographic rain.

Convection clouds (cumulus) are formed when an airstream flowing over a relatively warm surface is heated from below and rises into relatively cold air. If these upward convection currents are sufficient to support soaring flight in a glider they are called thermals. Sometimes cumulus clouds grow into cumulonimbus clouds that tower upward to 30,000 ft or more before spreading out into an anvil-shaped top. These thick convection clouds usually produce heavy showers of rain, hail, sleet or snow and sometimes thunder and lightning. Convection clouds can also be formed by airflow patterns well above surface level.

In weather systems such as fronts air rises very slowly over broad areas. If the ascent causes condensation, a relatively smooth broad layer cloud is formed which is known as a variety of the stratus type of cloud.

A third cause of air being lifted up to its condensation level is turbulence. Being somewhat of a mixture between stratus and cumulus types, this cloud is called stratocumulus; but if it forms at a very low level it usually looks so grey and formless that it is called stratus.

There are two main classes of cloud formation: cumuliform and stratiform (or heap clouds and layer clouds). By international convention clouds are classed into 10 main types. Latin names are used: cirrus (hair), cumulus (heap), stratus (layer) and nimbus (shower).

Cirrus	Ci	High	Detached white or mostly whitelicate filaments, or patches, or narrow bands.
Cirrocumulus	Cc Ci-Cu	High	Thin white patch, sheet or layer of cloud composed of very small elements in the form of grains or ripples more or less regularly arranged.
Cirrostratus	Cs Ci-St	High	Translucent, whitish veil of cloud generally producing halo phenomena.
Altocumulus	Ac Alto-Cu	Med	White or grey patch, sheet or layer of cloud composed of rounded masses or rolls
Altostratus	As Alto-St	M/H	Greyish cloud sheet without halo phenomena and through which the sun is barely visible.
Nimbostratus	Ns Nb-St	L/M/ H	Grey cloud layer thick enough to blot out the sun.
Stratocumulus	Sc St-Cu		Low grey or whitish patch, sheet or layer of cloud composed of rounded masses or rolls.
Stratus	St	Low	Generally grey cloud layer with fairly uniform base.
Cumulus	Cu	L/M/ H	Detached clouds developing vertically in the form of rising mounds with cauliflower-shaped tops.
Cumulonimbus	Cb Cu-Nb CuNim Cu- Nimb	L/M/ H	Dense cloud with considerable vertical extent, in the form of a mountain or huge towers. At least part of its upper portion is usually smooth or striated; and nearly always flattened; this part spreads out in the shape of an anvil or vast plume.

The location of the height levels in the temperate regions is as follows:

High	16,500-45,000 ft
Medium	6,500-23,000 ft
Low	0-6,500 ft

Cloud amount is usually reported in eighths of the sky covered. Sometimes the internationally convened word, oktas, is substituted for eighths.

4. Lapse rate.

Radiation heat from the sun is called insolation. Temperature decreases with height until the tropopause. Below the tropopause is the troposphere. Immediately above is the stratosphere. Clouds are rarely found in the stratosphere. The tropopause is higher over the tropics than over the Poles. The rate of change of temperature with height is called the lapse rate. An inversion is when the temperature increases with height. An isothermal layer is when the temperature does not change with height. The Dry Adiabatic Lapse Rate (DALR) is 3°C per 1000 ft of height.

A decrease in temperature greater than the DALR is called a super-adiabatic lapse rate. It is often found over sun-heated ground up to a few hundred feet in temperate climates and a few thousand feet in hotter regions. A bubble of air rising through a lapse rate generally greater than the DALR will become warmer than its surroundings and would therefore be propelled further upwards.

The layer in which the general temperature lapse rate inhibits random vertical air movements is called stable while the layer whose lapse rate boosts vertical motion is called unstable. An inversion is a very stable layer. At night, nocturnal radiation can cause a very low-level temperature inversion.

5. Thermal formation.

To a glider pilot a thermal is any convective current of rising air in which he can gain height. Where the rising air is cloudless, the thermal is called a dry thermal. Heat from the ground is transferred to the air close to the surface. If the airstream that has been heated is relatively cool then the heated air will become buoyant and tend to rise into the cooler air higher up. Atmospheric conditions usually impose a lid on the height to which dry thermals ascend. The area between this lid and the ground surface is referred to as the (dry) thermal layer. When thermals from ground level extend up into cloud the layer from ground level to the cloud base will be called the dry thermal layer.

As the ground heats up during the course of the day the depth of the thermal layer will increase. If the heating is sufficient to raise the top of the dry thermal layer above the top of the temperature inversion, the depth of thermals will increase sharply and the rate of rise of the air temperature will slow down because the sun's heating is now becoming spread throughout a greater depth. The surface air temperature at which this transition from slow to rapid development of thermals occurs is sometimes called the trigger temperature. After this trigger temperature has been reached the thermals usually become moderate or strong and may be somewhat rough. The height to which a dry thermal layer develops is usually limited by a stable layer or temperature inversion.

Bright, shiny clouds are developing and usually produce better lift. Better lift can also be expected on a sunny, windward side of a convection cloud.

[Refer to Chapter 15 (page 177) of Wallington]

6. Ridge lift formation.

When the wind meets a substantial barrier, such as a hill, ridge or mountain, most of it is forced to rise and go over it. This is called ‘hill’ or ‘ridge’ lift and the strength of the lift is dependant on both the wind velocity and wind direction.

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7. Lee wave formation.
(See also Chapter 18)

Conditions favourable for the formation of lee waves.

1. A layer of low stability at low levels.
2. A stable layer above the lower layer.
3. An upper layer of low stability in the troposphere.
4. A wind of about 30 kph or more across a hill or mountain ridge.

An increase of wind speed with height without much change of wind direction adds to the likelihood of wave formation. The amplitude of the wave is at its maximum in the stable layer.

The gap between the cloud over the mountain (if any) and the first wave cloud is known as the fohn gap.

8. Inversions.

[Refer section on Lapse Rate]

9. Air pressure and how it affects altimeter readings.

The ICAO Standard Atmosphere is specified as follows:

1. Pressure of 1013.25 MB at MSL.
2. Temperature of 15°C at MSL.
3. A temperature lapse rate of 1.98°C per 1000 ft.
4. An isothermal atmosphere from an altitude of 11 km (36000 ft) upwards.

Every millibar fall of MSL pressure brings the pilot 30 ft lower than his altimeter reading.

10. Dew point.

If air that is saturated with water vapour is cooled it becomes supersaturated. The excess of water vapour normally condenses on to microscopic particles of dust and salt in the atmosphere and forms minute droplets that become visible as fog or cloud. Precipitation occurs when water in the form of drops, interlocking ice crystals or pellets of ice and water fall out of cloud.

When water vapour condenses back into liquid form it gives up its latent heat to its surroundings. This release of latent heat has a significant effect on the rate of decrease of temperature of a rising bubble of saturated air. When such a saturated bubble ascends it expands, cools and thus becomes supersaturated. Its excess water vapour condenses and gives up latent heat to the air. So the decrease of temperature is less than the DALR. In fact, the physical properties of air and water are such that the temperature of a rising bubble of saturated air decreases at about half the DALR at low levels in the atmosphere. This lapse rate of about 0.5°C per 100 m, applicable to rising saturated air is known as the Saturated Adiabatic Lapse Rate (SALR). The concept of stability applies to layers of saturated air in a similar fashion to stability in dry air.

Relative Humidity is the actual water content of the air expressed as a percentage of the amount required for saturation. Another method of expressing the moisture content of the air is to state its dew point which is the temperature to which air must be cooled (without changing its pressure) to bring it to the point of saturation.

11. Sea breeze fronts.

Air over the land is heated more quickly than the air over the sea. A consequence of this is a slight rise of pressure over land at a height of about 3000 ft and a slight seaward flow of air at the same level. Air at low level flows from the sea to the land. The transition zone between the cool moist sea air and the dry air inland is frontal in that it comprises a horizontal temperature gradient. Thus, a sea- breeze front can be considered as a shallow ephemeral species of cold front. The wedge-like cool sea air acts like a ridge. Warm inland air rises ahead of the wedge-like advance of cool air from the sea. If the inland air is not too dry, the ascending air is marked by a line of cloud, usually cumuliform.

The wedge moves inland. On occasion over island or peninsula land formations, stationary or lenticular clouds form over the area where the opposing sea breezes meet. Lift will be found under the lenticulars. In temperate latitudes a sea breeze seldom penetrates more than 80 km inland. It produces a narrow "wall" of convection that is similar to a cloud street. In most cases the width of the lift area is so narrow that circling flight cannot be sustained. If the "wall" is not shown by the formation of clouds, the lift has to be located by variometer, adjusting the location of the search according to the time of day. On both sides of the belt of lift heavy sink will be found.

12. Effects of the wind gradient on a glider.

Moderate or strong winds suppress the development of thermals from ground sources. The effect of wind shear on thermals is worth noting. If the wind increases by about 5 kph per 1000 ft of ascent, the shear will give a turbulent distortion to the thermal and make it almost impossible to fly.

With less of a wind shear thermals retain some semblance of their bubble shape as they rise, but will drift downwind.

13. Tephigram. (Temperature / Pressure diagram).*See Figures I - IV at the end of this chapter.*

The midnight tephigram can be obtained the next morning from the Weather Office by Fax. It is useful for predicting expected gliding conditions for the day i.e., cloudbase, unstability, thermal strength, and likelihood of wave conditions *(See figure V.).* Because of its usefulness, pilots should try to understand it.

The tephigram is constructed by overlaying five sets of lines, namely *(See figure I.)*

- *isobars,*
- *isotherms,*
- *saturated mixing ratio* (or *dew-point) lines,*
- *dry adiabatic* (each one representing the dry adiabatic lapse rate)
- *wet adiabats* (each representing the wet adiabatic lapse rate)
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Only one set of lines is curved *(wet or saturated adiabats);* the others are nearly straight *(isobars) or* linear *(dry adiabats, isotherms* and *saturated or wet mixing ratio* or dew-point) isopleths, with isotherms and dry adiabats crossing at right angles.

An important characteristic of the

tephigram is that it allows changes in energy or work done during a cyclic process to be represented by the area enclosed by lines representing the process. This characteristic greatly enhances the usefulness of the tephigram, particularly in the evaluation of the thermal instability of the atmosphere.

Pressure, temperature and moisture data obtained from *radiosonde* instruments carried aloft by meteorological balloons are recorded by ground telemetry stations and are plotted on tephigrams to provide a vertical sounding of the atmosphere at standard times. Radar tracking of the balloons allows the variation of wind speed and direction throughout the troposphere and lower stratosphere to be determined at the same time.

Norman's Theorem:

On a tephigram if one takes a line from Surface Temperature up and along the DALR + a line from Surface Dew-point along isohygrics + Surface Wet-bulb along SALR lines the three meet at a point which is the condensation level.

As an approximation the condensation level can also be found by using the expression: -

(Temp. - Dew-point) x 410 = Cloudbase in Feet *(Cloudbase)*

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Look out

Look out

Look out

Look out

Look out

and even

more

Look out