LAPSE RATES : AN INTRODUCTION

A Lapse Rate is a decrease in temperature with increasing height in the atmosphere.

ENVIRONMENTAL LAPSE RATE (ELR)

The main lapse rate is the ELR which is the change in temperature up through the atmosphere at any time. It is normally a decrease in temperature since the atmosphere is mostly transparent to the Solar Radiation from the sun, allowing the surface of the earth to heat up which in turn transmits its heat to the atmosphere.
The temperature of the atmosphere generally decreases for approximately 10 km up from the surface in the Troposphere. The upper limit of the Troposphere is the Tropopause, here temperatures start to rise again as the Stratosphere starts.
The Tropopause is, then, marked by a Temperature Inversion, where temperature rises with height rather than falling.
The ELR may change hourly, daily, seasonally and will depend on the air mass or air stream affecting any given area. Despite being a general loss of temperature with increasing height there may be Isothermal layers where temperature does not change with height or ground inversions may form at the surface or mid-troposphere inversions may form due to subsidence.
The ELR is measured with a Radiosonde attached to a weather balloon that transmits data on temperature, humidity and pressure as it rises up through the atmosphere.

ADIABATIC LAPSE RATES

If a parcel of air rises up through the atmosphere the air cools at an Adiabatic Lapse Rate. The parcel of air is said to be ‘discrete’, having no interaction with the surrounding environmental air, and cools merely because it is rising into a zone of lower pressure and therefore expanding. If unsaturated air rises and expands it is doing work for which energy is needed, the air therefore loses heat energy at the Dry Adiabatic Lapse Rate (DALR) a set rate of approximately 10 C / 1000 m. Dry Adiabats are shown as straight lines at an angle on the temperature/height diagram.

If the parcel of rising air cools to its Dew Point temperature it becomes saturated with water vapour and any further cooling will cause condensation to take place. This occurs at the Condensation Level or Lifting Condensation Level (LCL), illustrated by the cloud base. Above this level or height air continuing to rise cools at the Saturated Adiabatic Lapse Rate (SALR), which is less than the DALR due to the release of the Latent Heat of Condensation. The mean SALR is around 6 C / 1000 m, but the SALR is, in fact, a changing rate of cooling as warm air hold more moisture than cold air and more condensation will occur lowering the SALR. At 20 C air temperature the SALR is around 4 C / 1000 m, whereas at -40 C (in the upper Troposphere) it is around 9 C /1000 m, much closer to the DALR. Saturated Adiabats are shown as curved lines on the temperature/height diagram.

STABILITY / INSTABILITY

A comparison of the ELR with the respective DALR's and SALR's is very important in a study of the stability / instability of air masses. If the rising parcel of air is cooler than the surrounding environmental air it will be heavier than that surrounding air and tend to descend (stability).

If, however, the parcel of air has a higher temperature than the surrounding environmental air it will be lighter and tend to rise, form cloud and possibly precipitation (instability).

The ELR, as determined by Radiosonde ascents is, therefore, of vital importance in determining the chances of uplift of air, and the associated cloud and precipitation.

Cloud and precipitation can still form in a stable atmosphere if there is Forced Ascent, such as at Frontal boundary or an Orographic barrier.

If the ELR is between the DALR and the SALR there is Conditional Instability, where air forced to the condensation level and beyond may eventually becomes warmer and lighter than the environmental air and rise due to its positive buoyancy.

The Tropopause Inversion essentially acts as a limit to rising air, as the air above this level will be warmer than the rising air and there will be negative buoyancy. The tops of clouds such as Cumulonimbus are often seen at this height.