Answer on Question #84277 - physics - Thermodynamics

1.Define adiabatic lapse rate?

Answer :

The decrease of an atmospheric variable with height, the variable being temperature unless otherwise specified. In general, a lapse rate is the negative of the rate of temperature change with altitude change, thus

$\gamma = -\, dT/\, dz$

where γ is the lapse rate given in units of temperature divided by units of altitude, T = temperature, and z = altitude.

The mathematics of the adiabatic lapse rate can be derived from thermodynamics, which defines an adiabatic process via: $PdV = -VdP/$ the first law of thermodynamics can be written as

$mCvdT - VdP\,\gamma = 0$

Also since $a = V\ m$: and $\gamma = C\text{p}/\ Cv$ we can show that $PdT - adP = 0$

where $C\text{p}$ is the specific heat at constant pressure and a is the specific volume.

Assuming an atmosphere in hydrostatic equilibrium: $dP = -\rho g dz$ where g is the standard gravity and ρ is the density. Combining these two equations to eliminate the pressure, one arrives at the result for the dry adiabatic lapse rate (DALR).

$\Gamma d = -\, dT/\, dz = g/\, CP$ = 9.8 °C/km

The presence of water in the atmosphere complicates the process of convection. Water vapor contains latent heat of vaporization. As air rises and cools, it eventually becomes saturated and cannot hold its quantity of water vapor. The water vapor condenses (forming clouds), and releases heat, which changes the lapse rate from dry below the cloud to moist in the cloud. The release of latent heat is an important source of energy in the development of thunderstorms. The moist adiabatic lapse rate varies strongly with temperature. A typical value is around 5 °C/km (2.7 °F/1,000 ft) (1.5 °C/1,000 ft). The saturated adiabatic lapse rate is given approximately by:

$$\Gamma\text{w} = \text{g}\,(1 + \frac{\text{Hvr}}{\text{RsdT}})\,/(\text{Cpd} + \frac{H_v^2 r}{R_{sw}T^2})$$

Where: Γw = Wet adiabatic lapse rate, K/m

g = Earth's gravitational acceleration = 9.8076 m/s^2

Hv = Heat of vaporization of water, = 2501000 J/kg

Rsd = Specific gas constant of dry air = 287 $Jkg^{-1}k^{-1}$

Rsw = Specific gas constant of water vapour = 461,5 $Jkg^{-1}k^{-1}$

r = The mixing ratio of the mass of water vapour to the mass of dry air

T = Temperature of the saturated air, K

Cpd = The specific heat of dry air at constant pressure, = 1003,5 $Jkg^{-1}k^{-1}$