Ideal gas law: equation of state for a hypothetical gas that relates density (ρ), pressure (P, in units of Pascals, 100 Pa = 1 hPa = 1mb), temperature (T in units of Kelvin, 0°C = 273.15K; 10°C = 283.15K) and a gas constant (R). This law states that the density of a gas is proportional to pressure, but inversely proportional to temperature. Typically, we evaluate changes in air density at a constant pressure. Under this paradigm, one can see that warm air will be *less dense* than cool air.

$$\rho = {}^{P}/_{RT}$$

For dry air, R = 287 J K^{-1} kg^{-1}

The gas contant (R) changes depending on the molecular weight (M) of the gas in question whereby

$$R = {}^{8.3145\,J\,K^{-1}}/_{M}$$

Dry air, primarily composed of Nitrogen and Oxygen has approximately a molecular weight of 28.97 grams per mole; Or 0.02897 kg/mol. Wet air, containing H_2O (molecular mass of 18 g/mol), weighs less.

Hydrostatic equation: equation that describes the balance of forces between gravity (acting down) and the vertical pressure gradient force (acting upward). This can tell us the change in pressure (p in Pascals) with height (z in meters), useful for adjusting pressure to sea level.

$$\frac{\Delta p}{\Delta z} = -\rho g$$

Where g is the gravitation force of -9.8 m/s^2 , and ρ is density. Note that since air density depends on temperature, this equation will not work great where temperature varies substantially with elevation.

Hypsometric equation: by combining the ideal gas law and hydrostatic equation we can deduce an equation that relates the distance between two pressure surfaces (p_1 and p_2) to the mean temperature (T) of the layer.

$$\Delta z = \frac{R\bar{T}}{g} \ln \left(\frac{p_1}{p_2}\right)$$

This equation clearly shows that the warmer the air mass, the larger the distance between two pressure surfaces. It relates back to the Ideal Gas Law in that warmer air is less dense and thus occupies a larger column of the air.