Multiplicity

Changes in entropy are related to changes in multiplicity

$$ds = k_B \, d\ln \mu \qquad (1)$$

k_B ← Boltzmann constant

μ = multiplicity

In "human" terms: increasing disorder increases the entropy.

The potential temperature is also related to entropy:

$$ds = c_p \, d\ln\theta \qquad (2)$$

Equaling

$$c_p \, d\ln\theta = k_B \, d\ln\mu \qquad (3)$$

Integrating

$$c_p \int_{\theta_0}^{\theta} d\ln\theta = k_B \int_{\mu_0}^{\mu} d\ln\mu$$

$$c_p \ln\frac{\theta}{\theta_0} = k_B \ln\frac{\mu}{\mu_0}$$

Note: $\ln\frac{\theta}{\theta_0} = \ln\theta - \ln\theta_0$

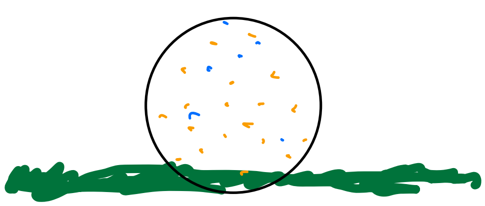
Rearranging and taking the exponential gives

$$\theta = \theta_0 \left(\frac{\mu}{\mu_0}\right)^{k_B/c_p}$$

The potential temperature tells us about the amount of "organization" of your microstate i.e., the arrangement of molecules in your parcel.

θ is a measure of molecular arrangement
larger θ, more "disorder"

Water vapor, saturation and phase changes:



Parcels at any given time (in the troposphere) will contain water vapor.

The parcel will never have 100% water vapor

Why?

* It turns out that the atmosphere can only "hold" a

certain amount of water vapor. When it reaches a max. value, it will start condensing.

This maximum value of water vapor that the atm (and parcels) can hold is referred to as the saturation value

So we have e_s = saturation vapor pressure
q_{vs} = " specific humidity
r_{vs} = " mixing ratio

Relative Humidity $\Rightarrow$ $RH = \frac{q_v}{q_{vs}} = \frac{e}{e_s}$

$RH \leq 1$ under most circumstances (except inside clouds)

Why is there a saturation value in the first place?

Enter the Clausius-Clapeyron Equation!

- Eqn. based on the 1st law of thermo that dictates the max. value of water vapor a parcel can hold.