

Thermal energy equation for a kg of air.

adiabatic heat added = T change + mechanical work
(Force \times displacement)

heating rate $\frac{Q}{\dot{m}}$ $\alpha = \frac{1}{\rho}$ specific volume

$Q = C_v \frac{dT}{dt} + p \frac{d\alpha}{dt}$
grab this sort of inconvenient

$= C_v \frac{dT}{dt} + \left[\frac{d}{dt} (p\alpha) - \alpha \frac{dp}{dt} \right]$

$\frac{d}{dt} (RT)$ adiabatic

$Q = (C_v + R) \frac{dT}{dt} - \alpha \frac{dp}{dt}$

moist or pseudo adiabatic

adiabatic

$+ L \frac{dq_{sat}}{dt} + Q_R + Q_{exc}$

(where saturated)

yay

We need a trick

$$\frac{Q}{T} = C_P \frac{dT}{dT} - \alpha \frac{dp}{dT} = \frac{d}{dT} (\text{something})$$

ideal gas
 $p\alpha = RT$

1. Divide by T

$$\frac{\alpha}{T} = \frac{R}{p}$$

$$\frac{Q}{T} = C_P \frac{dT}{dT} - R \frac{dp}{dT} (\ln p)$$

$$= C_P \ln(\Theta)$$

$S = C_P \ln \Theta$
 Entropy
 (J/kg K)
 (?)

easier to
 verify than
 derive!

$$\Theta = T \left(\frac{p_0}{p} \right)^{\frac{R}{C_P}}$$

"potential T"

if air compressed
 adiabatically to p_0
 $= 1000 hPa$
 $= 1005 Pa$

$$\frac{d}{dt} \left(\frac{\Theta}{K} \right) = \frac{Q}{C_P} \cdot \frac{1}{K}$$

no unit
 K/s

in
 = 0 adiabatic
 case

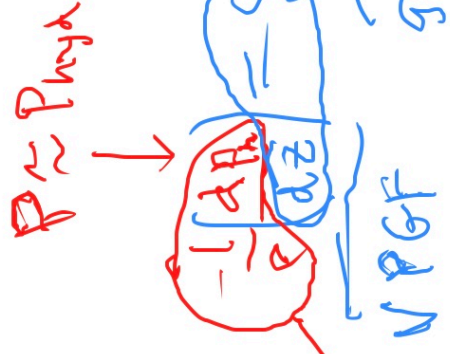
$$= L \left(\frac{d\epsilon_{sat}}{dt} \right)$$

for condensation
 process
 get

Other trick:

$$Q = C_p \frac{dT}{dt} - \alpha \frac{dp}{dt}$$

much clearer conceptually!



where we've we seen this?

$$= C_p \frac{dT}{dt} - g \frac{dz}{dt} \leftarrow \text{hydrostatic } z$$

enthalpy

grav.

potential energy

$$\underbrace{Q_{dry}}_{\text{adiabatic}} = Q = \frac{d}{dt} \left(\underbrace{C_p T + g z_h}_{\text{warmth}} \right)$$

acts just like θ

dry static energy

$$= L \left(\frac{d_{\text{sat}}}{dt} \right) + Q_{\text{rad}} + Q_{\text{cond, mix}}$$

latent energy of vapor

$$\underbrace{Q_{\text{net}} + Q_{\text{rad}}}_{\text{truly diabatic}} = \frac{d}{dt} (C_p T + g z + L q_v)$$

moist static energy