Buoyancy and Entropy

Specific Volume: $\alpha = 1/\rho$

Specific Entropy: s

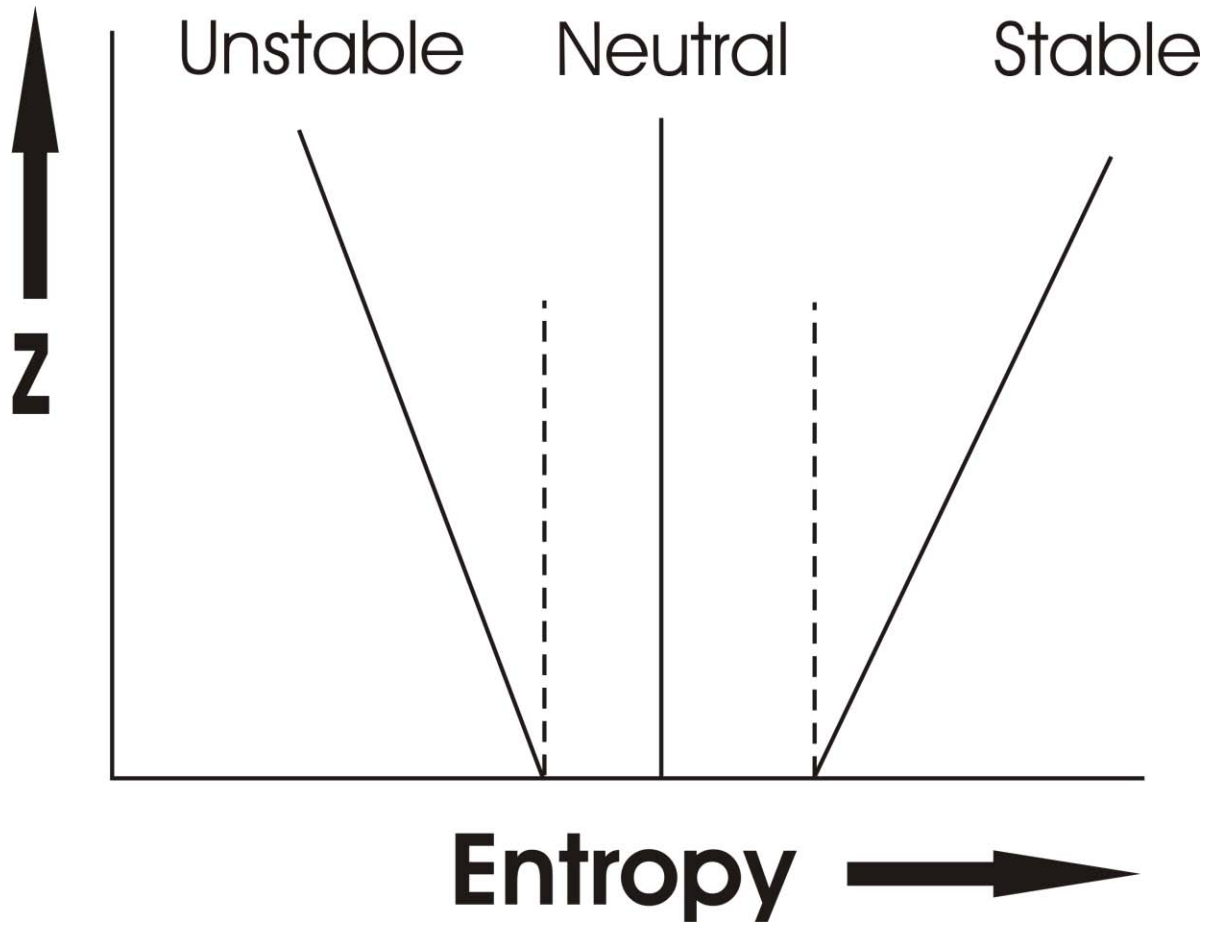
$$\alpha = \alpha(\quad ,$$

$$(\delta\alpha)_p = \left(\frac{\partial\alpha}{\partial s}\right)_p \delta s = \left(\frac{\partial T}{\partial p}\right)_s \delta s$$

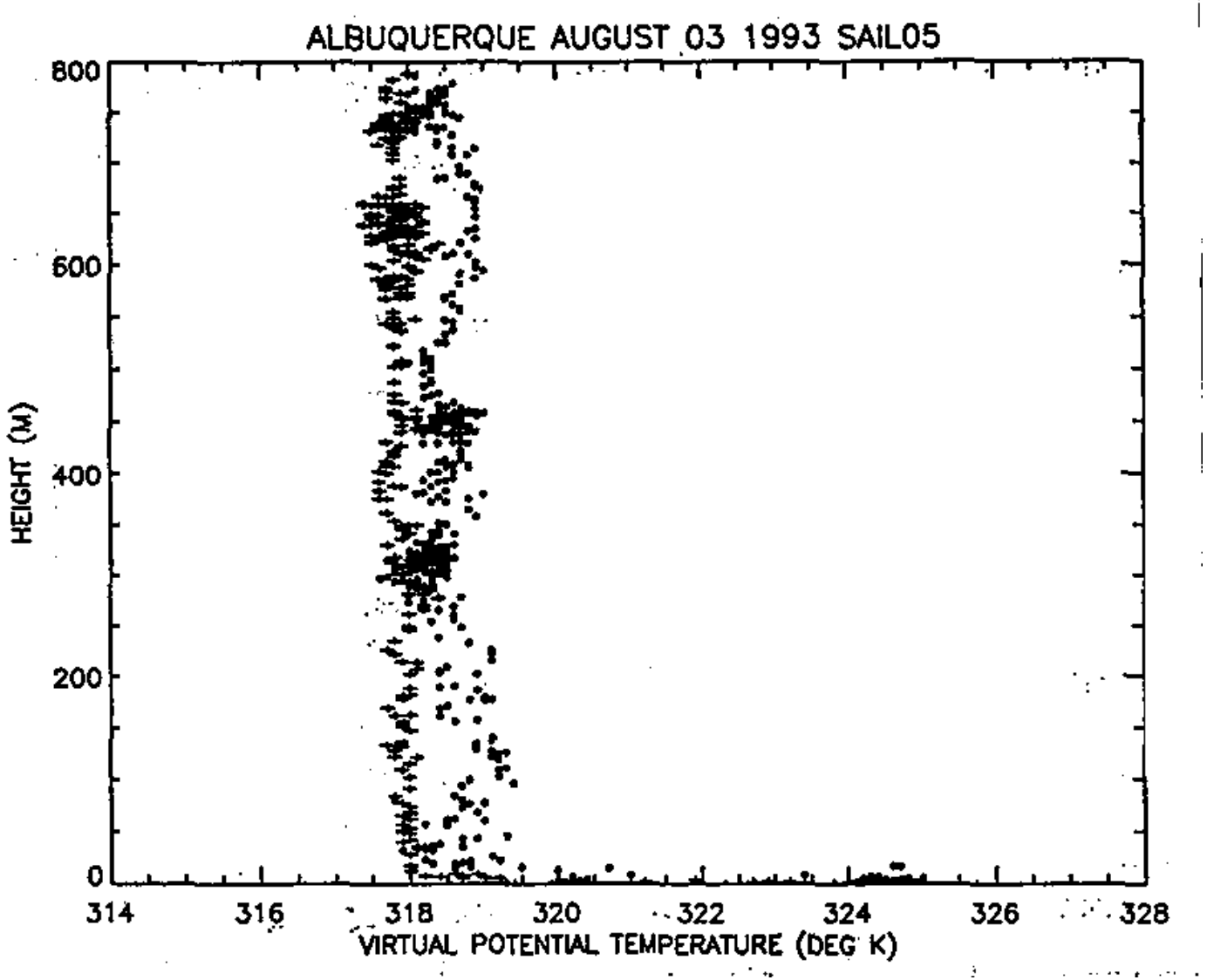
$$B = g\frac{(\delta\alpha)_p}{\alpha} = \frac{g}{\alpha}\left(\frac{\partial T}{\partial p}\right)_s \delta s = -\left(\frac{\partial T}{\partial z}\right)_s \delta s \equiv \Gamma\,\delta s$$

Note: For ideal gas: $\Gamma = g/c_p$

Earth's atmosphere: $\Gamma = 1\,K/100\,m$



Model Aircraft Measurements (Renno and Williams, 1995)



Water Variables

Mass concentration of water vapor (*specific humidity*):

$$q \equiv {M_{H_2O}}/{M_{air}}$$

Vapor pressure (partial pressure of water vapor): e

Saturation vapor pressure: e^*

C-C: $$e^* = 6.112\, hPa\, e^{\frac{17.67(T-273)}{T+30}}$$

Relative Humidity: $$H \equiv {e}/{e^*}$$

The Saturation Specific Humidity

Ideal Gas Law:

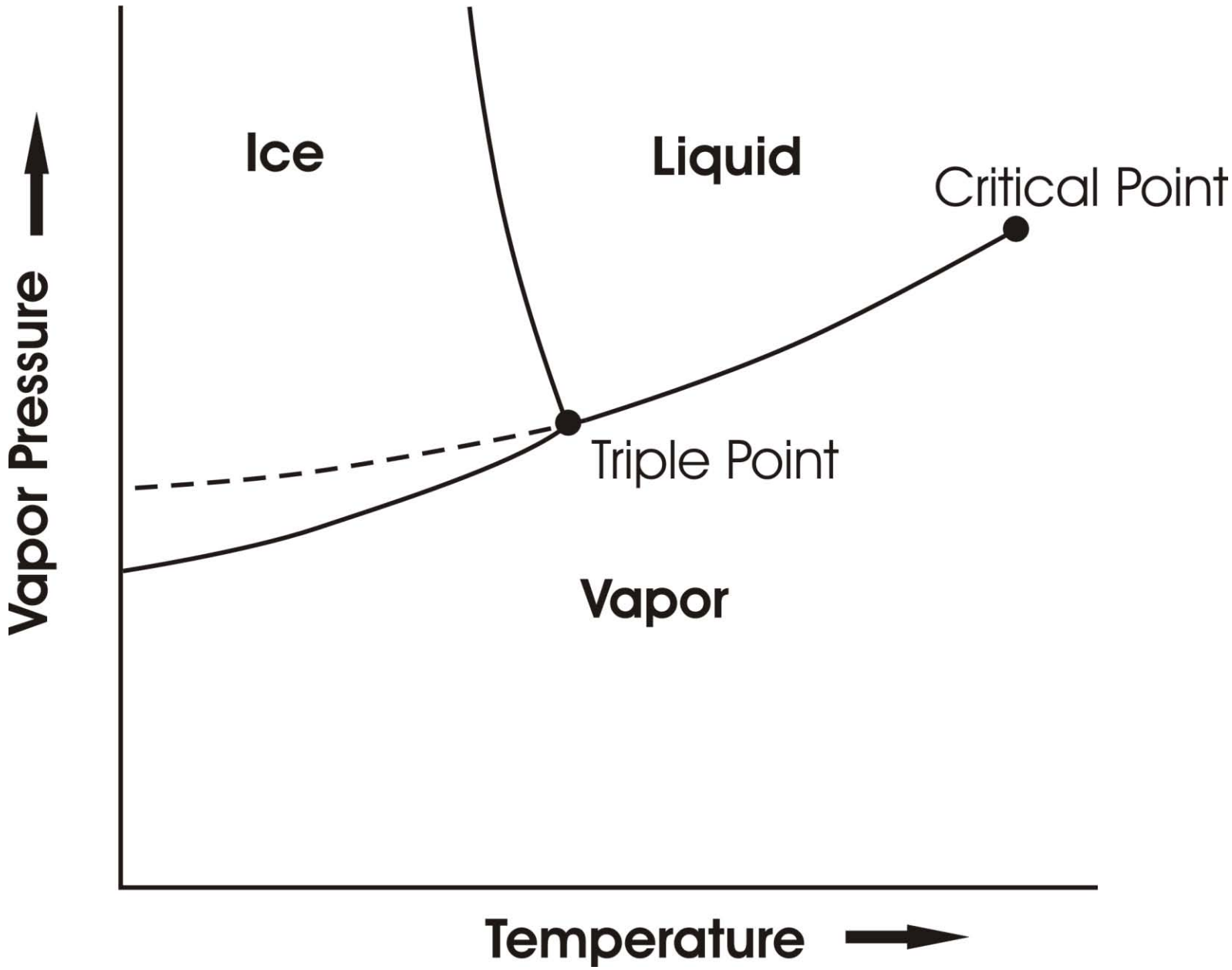
$$p = \rho \frac{R^* T}{\bar{m}}$$

$$e = \rho_v \frac{R^* T}{m_v}$$

$$q = \rho_v / \rho = \frac{m_v}{\bar{m}} \frac{e}{p}$$

$$q^* = \frac{m_v}{\bar{m}} \frac{e^*}{p}$$

Phase Equilibria



Bringing Air to Saturation:

$$e = qp\left(\bar{m}/m_v\right)$$

$$e^* = e^*(T$$

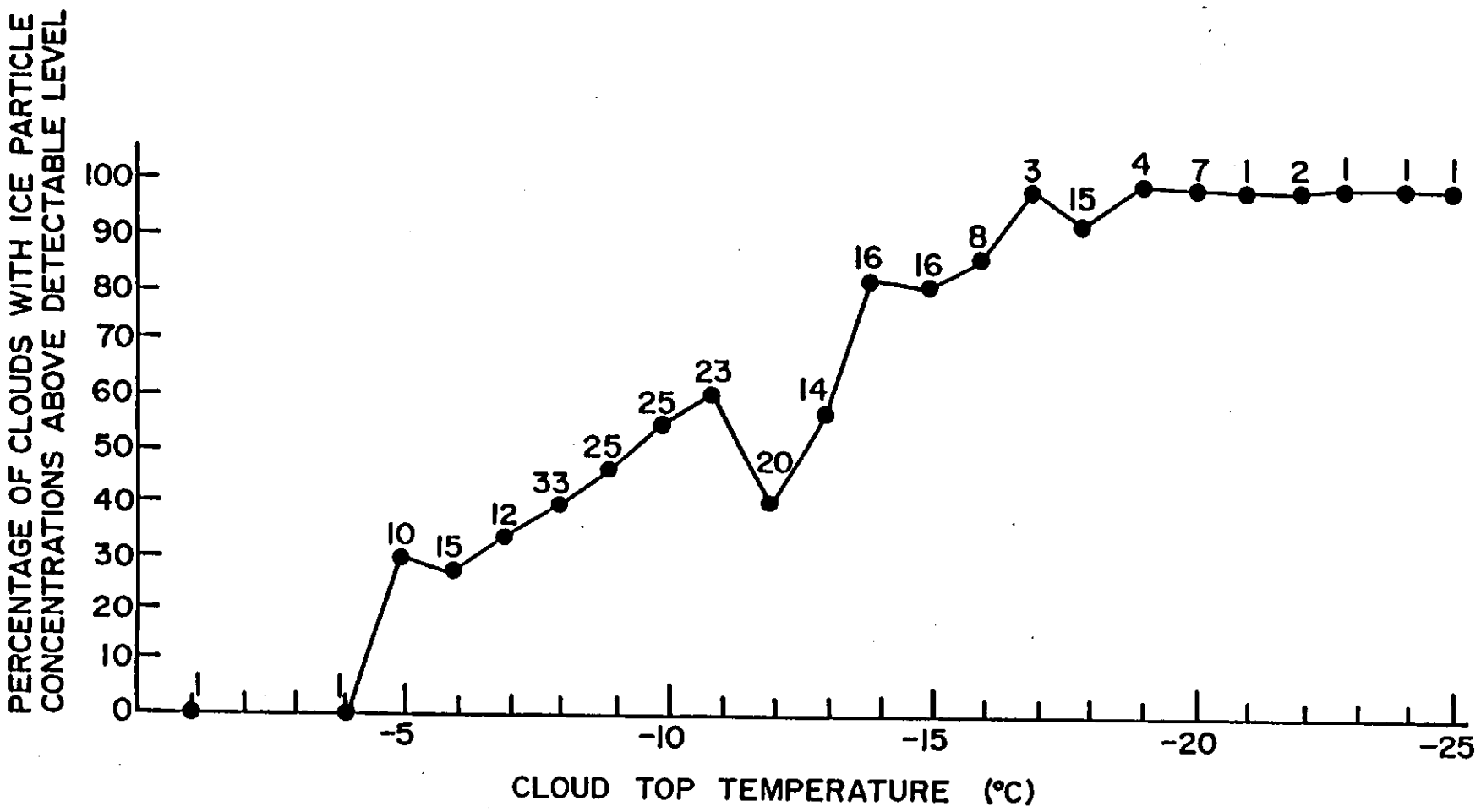
1. Increase *q*

2. Decrease *e* (T)*

When Saturation Occurs…

- Heterogeneous Nucleation
- Supersaturations very small in atmosphere
- Drop size distribution sensitive to size distribution of cloud condensation nuclei

Ice Nucleation Problematic



Precipitation Formation:

- Stochastic coalescence (sensitive to drop size distributions)
- Bergeron-Findeisen Process
- Strongly nonlinear function of cloud water concentration
- Time scale of precipitation formation ~10-30 minutes

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