ATM 241, Spring 2020
Lecture 4c
Moist Convection

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Marshall & Plumb
Ch. 4

In this section…

Definitions

- Specific humidity
- Saturation specific humidity
- Relative humidity
- Dew point temperature
- Lifting condensation level
- Moist static energy
- Conditional stability
- Equivalent potential temperature

Questions

- How does moisture affect convection?
- What differentiates dry and moist convection?
- Why is convection a prominent feature of the tropics?
- What are the global hotspots for convection?

Water in the Atmosphere

Definition: Specific humidity q is the mass of water vapor per mass of air:

$$q = \frac{m_v}{m_d + m_v} = \frac{\rho_v}{\rho} \qquad \rho = \rho_d + \rho_v$$

If an air parcel experiences no condensation or evaporation then specific humidity is conserved following the fluid parcel.

Water in the Atmosphere

Definition: Saturation-specific humidity q_* is the specific humidity at which saturation occurs:

$$q_* = \frac{e_s/R_v T}{p/RT} = \left(\frac{R}{R_v}\right)\frac{e_s(T)}{p}$$

where $e_s(T)$ is the saturated partial pressure of water vapor, obtained from the **Clausius-Clapeyron relationship**.

A function of both saturation vapor pressure and air pressure.

Water in the Atmosphere

Question: What is the behavior of saturation specific humidity with altitude?

Assume: Constant lapse rate environmental profile

$$T = T_0 - \Gamma z$$

Show: In hydrostatic balance leads to pressure

$$p(z) = p_0 \left(1 - \frac{\Gamma z}{T_0}\right)^{g/R\Gamma}$$

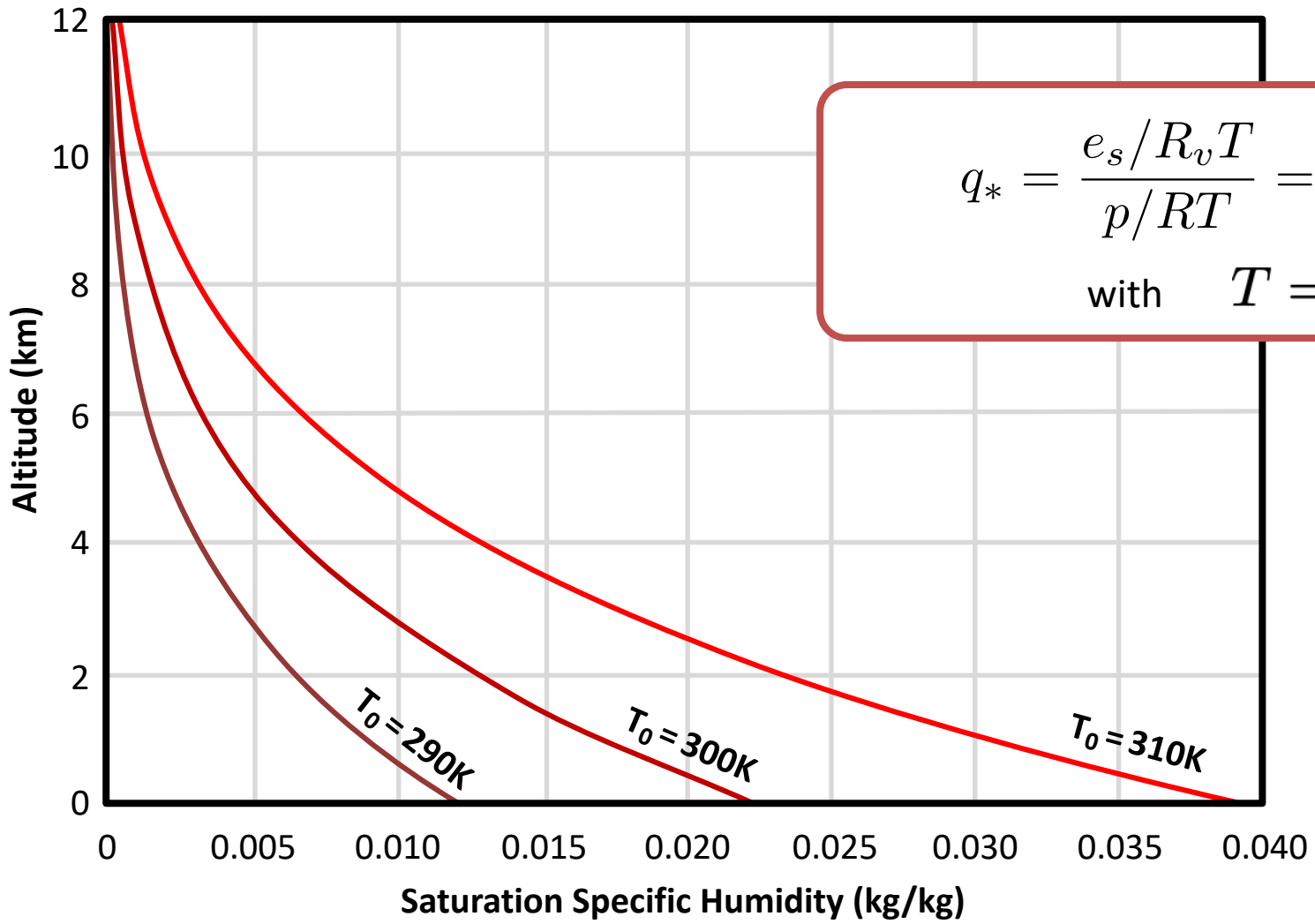
Use:

$$e_s(T) = 6.1094\ \text{hPa} \times \exp\left(\frac{17.625T}{T + 243.04}\right) \quad T \text{ in °C}$$

Plug this all into:

$$q_* = \frac{e_s/R_v T}{p/RT} = \left(\frac{R}{R_v}\right)\frac{e_s(T)}{p}$$

Water in the Atmosphere



$$q_* = \frac{e_s/R_v T}{p/RT} = \left(\frac{R}{R_v}\right)\frac{e_s(T)}{p}$$

with $T = T_0 - \Gamma z$

Water in the Atmosphere

Definition: Relative humidity RH is the ratio of specific humidity to the saturation specific humidity (often expressed as a percentage)

$$RH = \frac{q}{q_*} \times 100\%$$

Definition: Dew point temperature is the temperature at which an air parcel becomes saturated (100% relative humidity), when cooled at constant specific humidity. If temperature drops further, then water vapor in the air will begin to condense.

Definition: The **lifting condensation level (LCL)** is the altitude at which a rising air parcel reaches saturation (due to adiabatic cooling on ascent).