Saturation of Moist Air

- Clausius-Clapeyron equation at dew point

$$\frac{dp}{dT} \approx \frac{L_{lv}}{T v_v} \quad (4.18)$$

$$v_v = \frac{R_v T}{p}$$

$$\frac{dp}{dT} = \frac{L_{lv} p}{R_v T^2} \quad (4.19)$$

$$\frac{dp}{p} = \frac{L_{lv}}{R_v T^2} dT$$

$$d\ln p = \frac{L_{lv}}{R_v T^2} dT$$

$$\frac{d\ln p}{dT} = \frac{L_{lv}}{R_v T^2}$$

$$\frac{d(\ln e)}{dT_D} = \frac{L_{lv}}{R_v T_D^2} \quad (6.18)$$

Clausius Clapeyron

- Recall by integration between two temperatures we had

$$\int_{e_1}^{e_2} d(\ln e) = \int_{T_1}^{T_2} \frac{L_{lv}}{R_v T^2} dT \quad (4.21)$$

to yield

$$\ln\frac{e_2}{e_1} = -\frac{L_{lv}}{R_v}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \quad (4.22)$$

or

$$e_2 = e_1 \exp\left[-\frac{L_{lv}}{R_v}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)\right] \quad (4.23)$$

Dewpoint and Humidity

- Integrating from ambient to saturation

$$\ln\frac{e_s}{e} = -\ln\mathcal{H} = \frac{L_{lv}}{R_v}\left(\frac{1}{T_D} - \frac{1}{T}\right)$$

or equivalently

$$\mathcal{H} = \exp\left[-\frac{L_{lv}}{R_v}\left(\frac{T - T_D}{T T_D}\right)\right] \quad (6.19)$$

- Dew point depression ($T-T_D$)

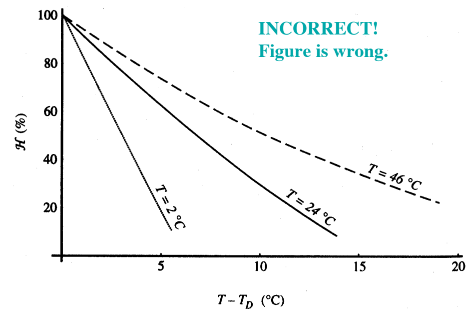
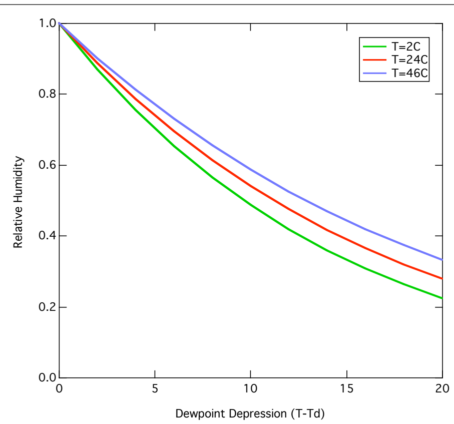


Figure 6.2 Dew–point depression. As the relative humidity increases, the difference between the ambient temperature and the dew-point temperature (i.e., the *dew–point depression*) decreases. As the ambient temperature decreases, the dew–point depression becomes less sensitive to changes in the relative humidity.



Cumulus Cloud Base Altitude Calculator

Cloud Base Altitude = ((((temperature - dew point) / 4.5) * 1000) + measure station altitude)

Assumes:
-The rate at which air cools as it rises is averaged at 5.5°F per 1000 feet
-The dew point also decreases at about 1.0°F over the same distance.

http://www.csgnetwork.com/estcloudbasecalc.html

Lecture Ch. 6b

- Moist adiabatic ascent of air
- Equivalent temperature
- Aerological diagrams

Curry and Webster, Ch. 6
For Tuesday: Read Ch. 7 (look at but don't solve Prob. 3)

Equivalent Potential Temperature

- Accounts for liquid water heating

$$\theta_e = \theta \exp\left(\frac{L_{lv} w_s}{c_{pd} T}\right) \qquad (6.48)$$

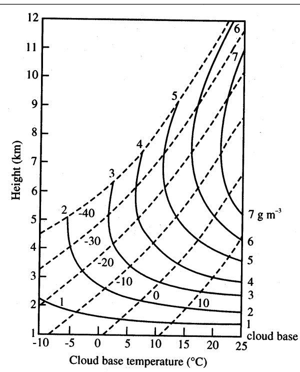


Figure 6.5 Adiabatic liquid water mixing ratio as a function of height above the cloud base and cloud base temperature. (After Goody, 1995.)

a.k.a. Stuve diagram

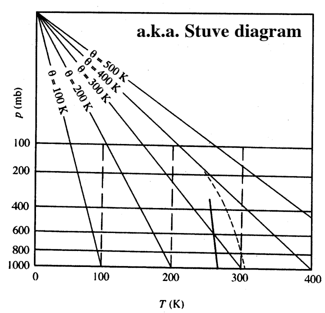


Figure 6.6 Construction of the pseudo-adiabatic chart.

the surface. Thus the ordinate may be proportional to $-\ln p$ (the *Emagram*) or to p^{R/c_p} (the *Stuve diagram*). The Emagram has the advantage over the Stuve diagram in that area on the diagram is proportional to energy. Before the advent of computers,

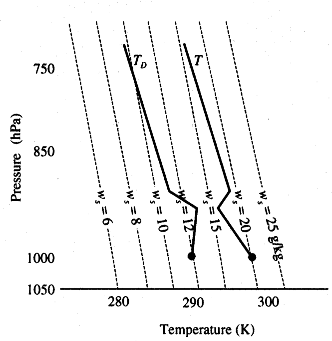


Figure 6.7 Determination of w, w_s, and T_D given the vertical profiles of temperature and dew-point temperature.

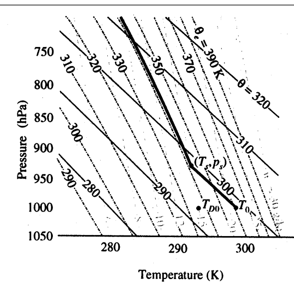


Figure 6.8 Adiabatic ascent of a parcel from p_0. The parcel initially ascends dry adiabatically along the constant potential temperature line that passes through (T_0, 1000 hPa). As the parcel ascends, the saturation mixing ratio decreases while the actual mixing ratio remains the same. At the point at which the actual mixing ratio of the parcel is equal to the saturation mixing ratio, the parcel becomes saturated. Further lifting of the parcel occurs along the saturated adiabat that passes through the point, (T_s, p_s).

$$\theta_e = T_e \left(\frac{p_0}{p}\right)^{R_d/c_p}$$