PHY392S
Physics of Climate

Lecture 5

Supplementary slides

Temperature Inversions

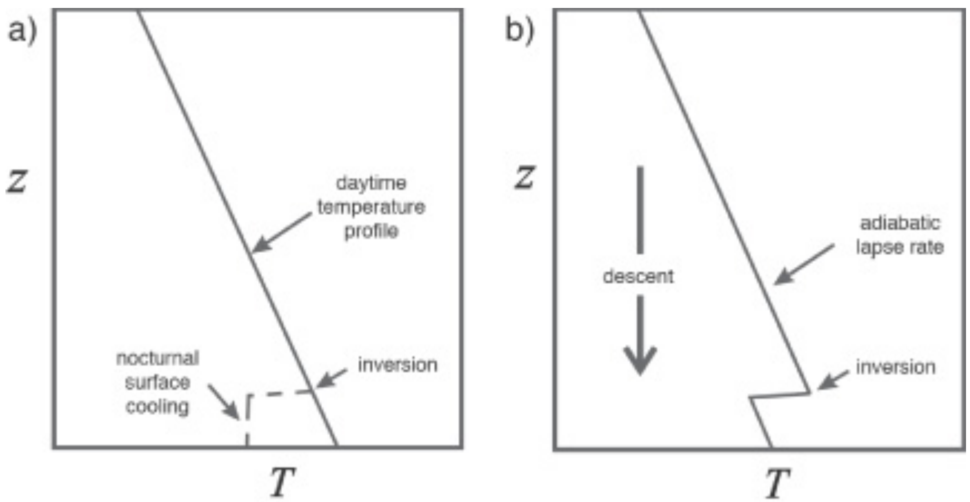
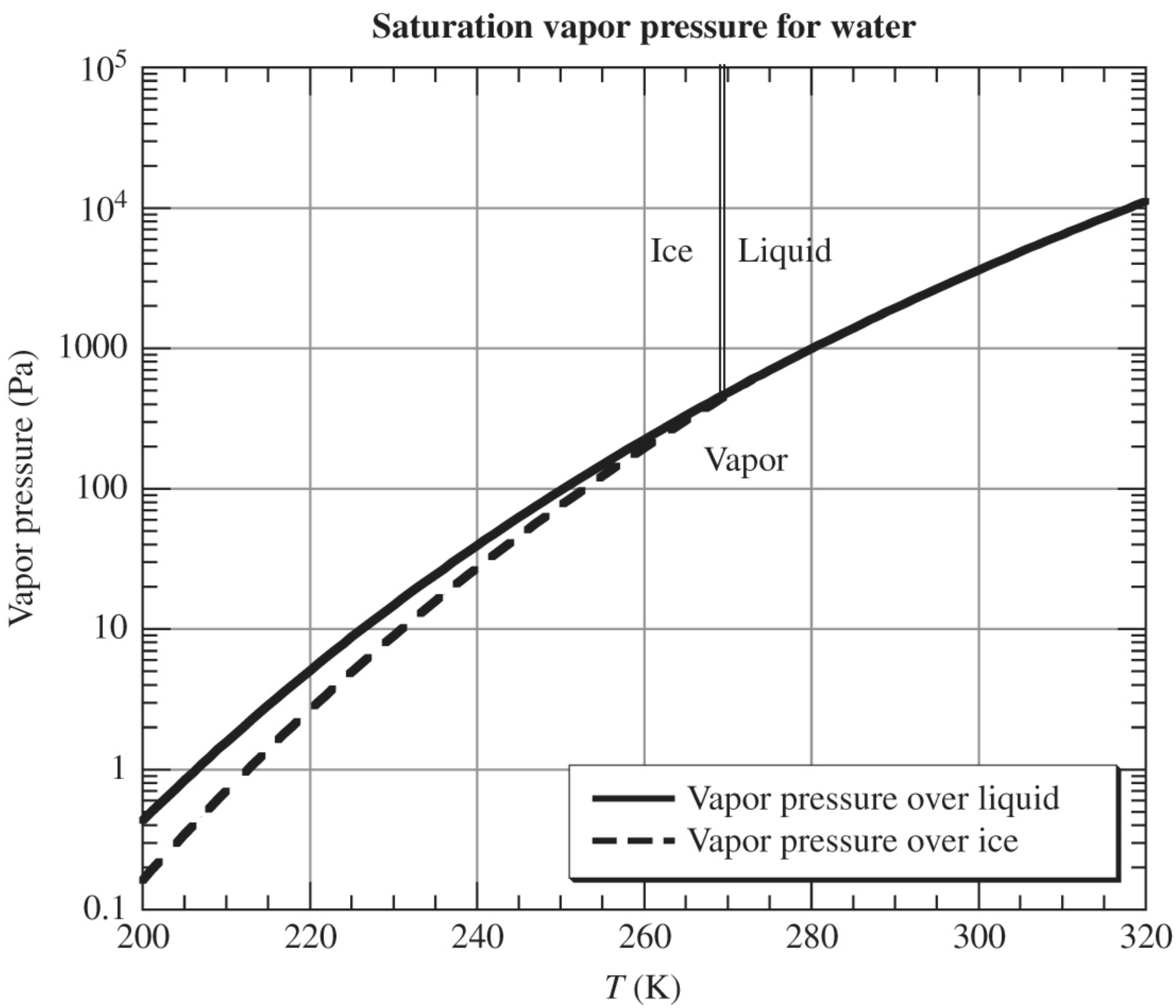


Figure 4.16: (a) Low-level inversions are commonly produced during calm winter nights from radiative cooling of the surface. (b) A trade inversion created by descent and adiabatic warming typical of subtropical regions.

Phase Diagram for H_2O



[From Pierrehumbert, 2010]

Phase Diagram for H_2O

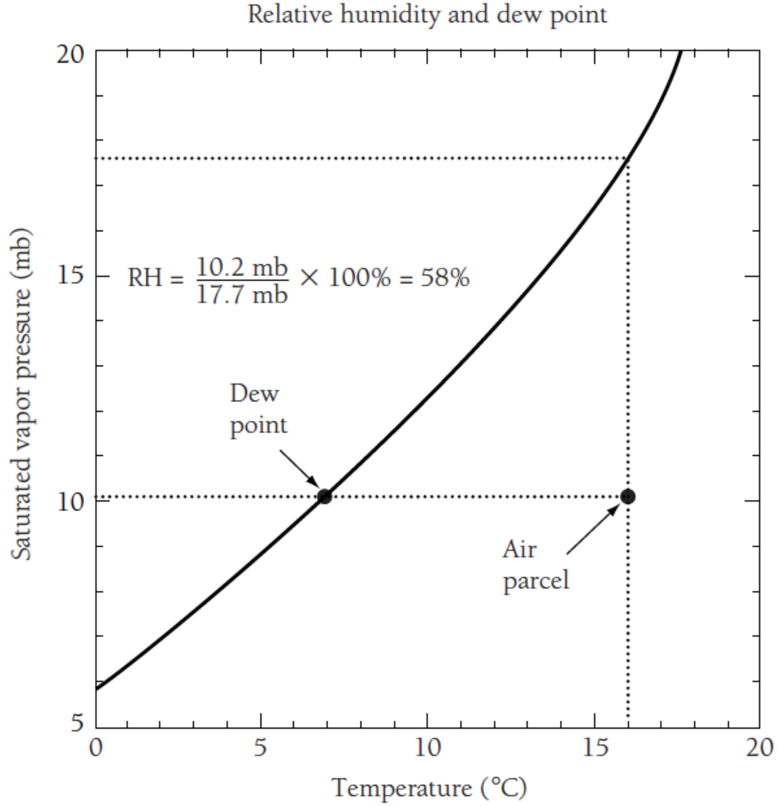


Figure 4.8a Relative humidity and the dew point.

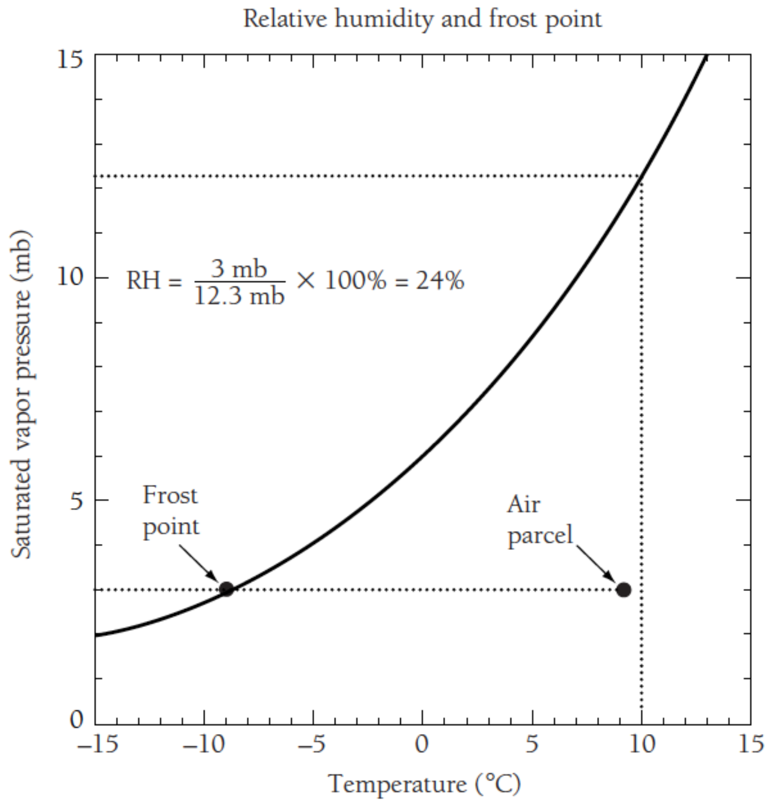


Figure 4.8b Relative humidity and frost point.

$$\text{Relative humidity} = \frac{\text{water vapour content of air}}{\text{water vapour capacity of air}}$$

[From McElroy, 2002]

Moist Convection

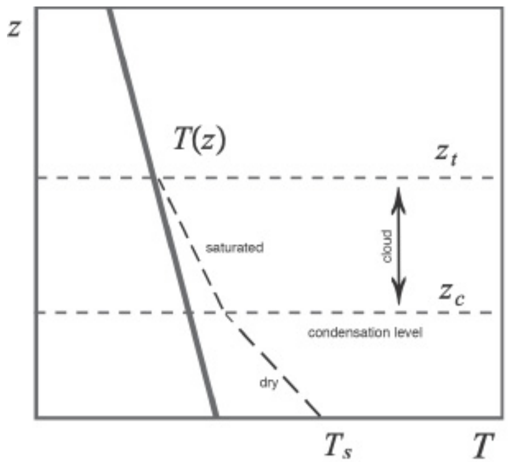


Figure 4.18: The temperature of a moist air parcel lifted in convection from the surface at temperature T_s will follow a dry adiabat until condensation occurs at the condensation level z_c. Above z_c, excess vapor will condense, releasing latent heat and warming the parcel, off setting its cooling at the dry adiabatic rate due to expansion. Thus a moist parcel cools less rapidly (following a moist adiabat) than a dry one, until neutral buoyancy is reached at z_t, the cloud top. This should be compared to the case of dry convection shown in Fig. 4.11.

Convection and Clouds

(b) TWO-BOX MODEL

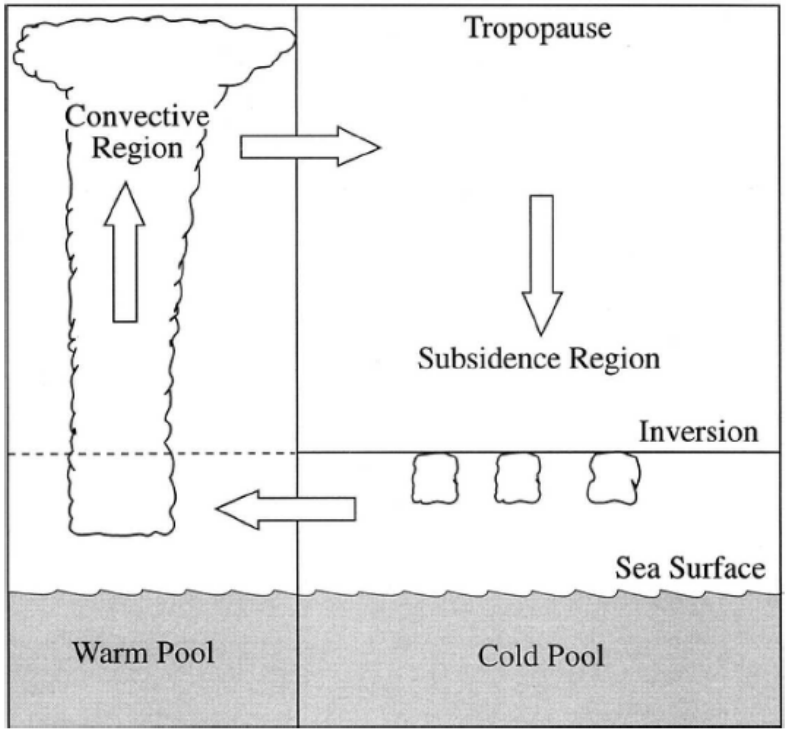
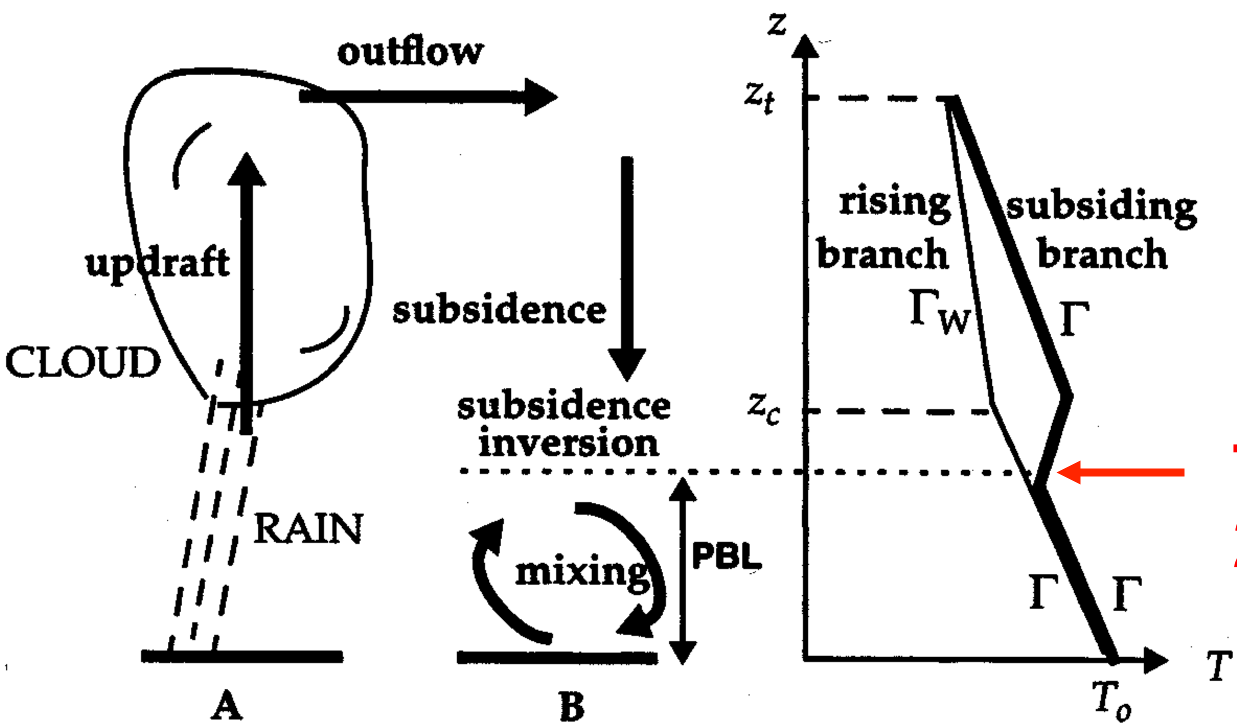


FIG. 3. Two conceptual representations of the relationship between cloudiness and large-scale atmospheric circulation in the Tropics: (a) structure of the tropical atmosphere, showing the various regimes, approximately as a function of SST (decreasing from left to right) or mean large-scale vertical velocity in the midtroposphere (from mean ascending motions on the left to large-scale sinking motions on the right). [From Emanuel (1994).] (b) Two-box model of the Tropics used by Larson et al. (1999). The warm pool has high convective clouds and the cold pool has boundary layer clouds. Air is rising in the warm pool and sinking across the inversion in the cold pool.

[Bony et al. 2006]

Subsidence Inversion



typically
2 km altitud

Fig. 4-17 Formation of a subsidence inversion. Temperature profiles on the right panel are shown for the upwelling region *A* (thin line) and the subsiding region *B* (bold line). It is assumed for purposes of this illustration that regions *A* and *B* have the same surface temperature T_0. The air column extending up to the subsidence inversion is commonly called the planetary boundary layer (PBL).

[courtesy, D. Jacob]

Impact of Convection on the Temperature Profile

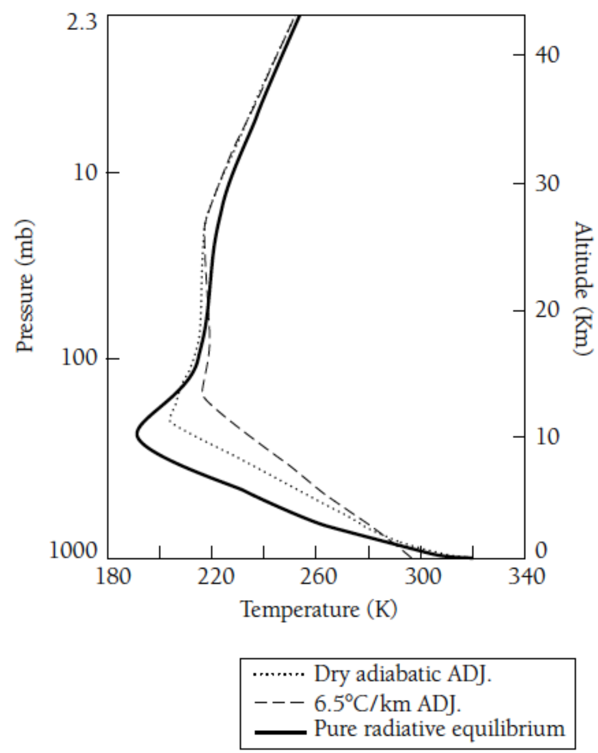
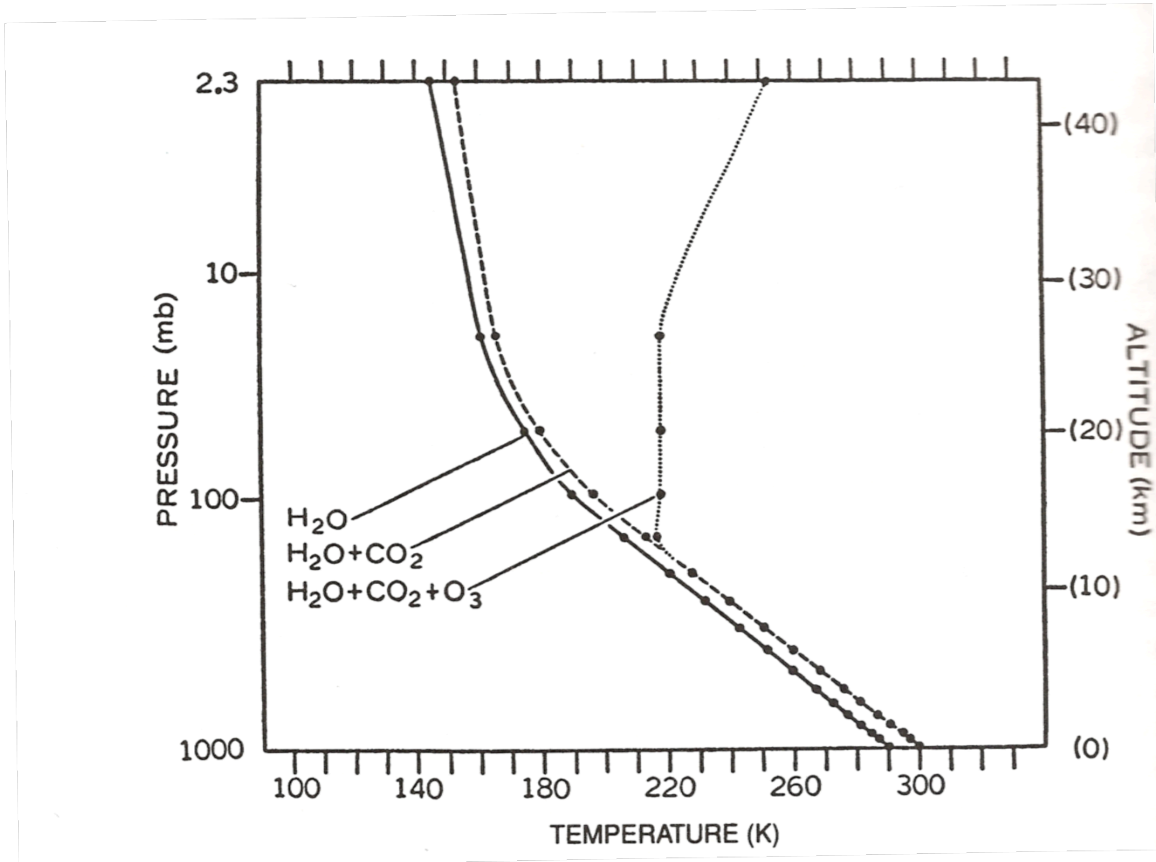


Figure 7.14 Comparison of results from a purely radiative equilibrium model of the atmosphere (solid line) with results from models in which the lapse rate of temperature was constrained not to exceed the dry adiabatic limit (dotted line) or a lapse rate of 6.5°C km^{-1} (dashed line). Source: Manabe and Strickler 1964.

[From McElroy, 2002]

Impact of H_2O, CO_2, and O_3 on the Temperature Profile

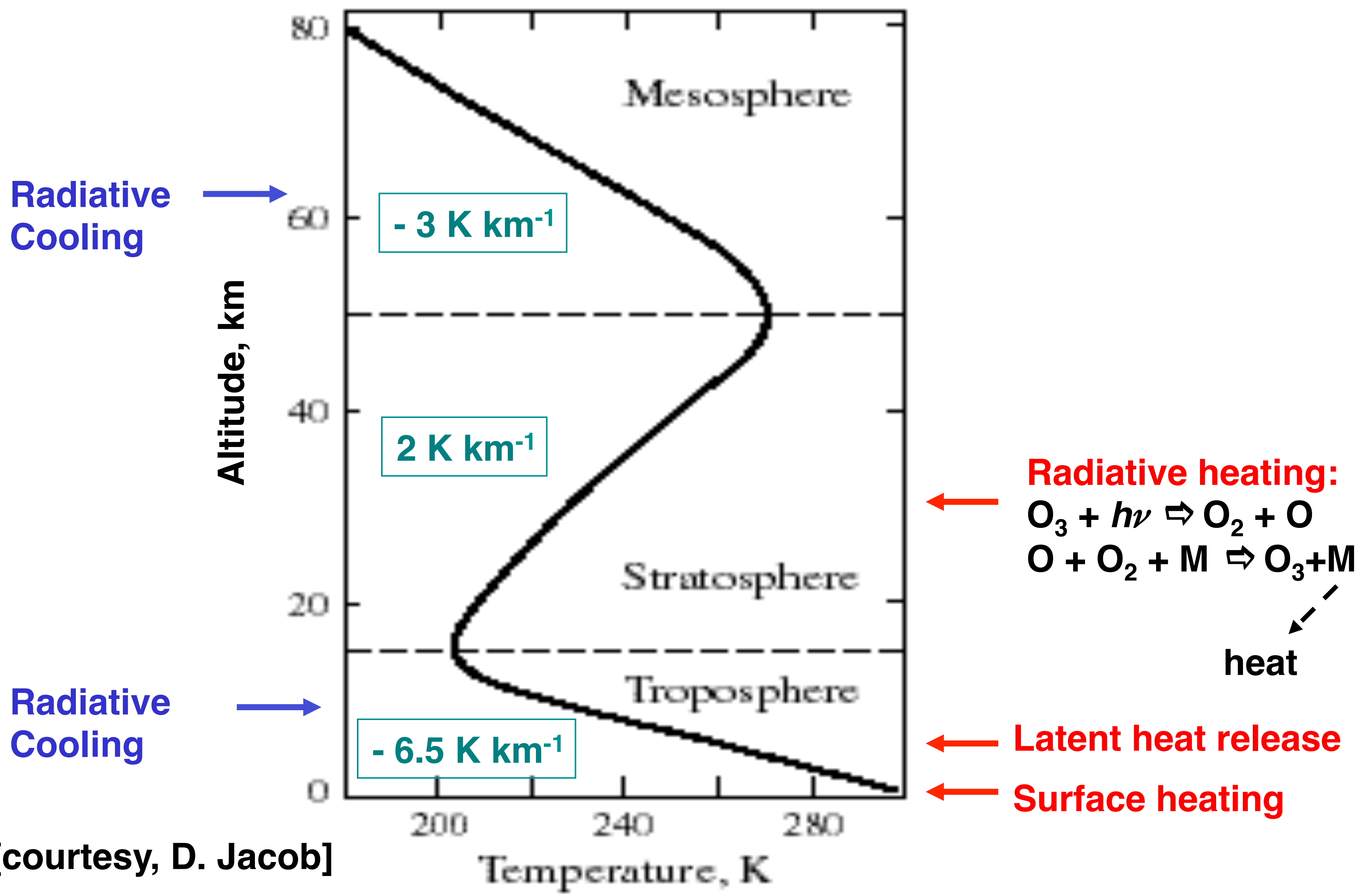


Calculations assumed a lapse rate of 6.5 K/km

[From Hartmann, 1994]

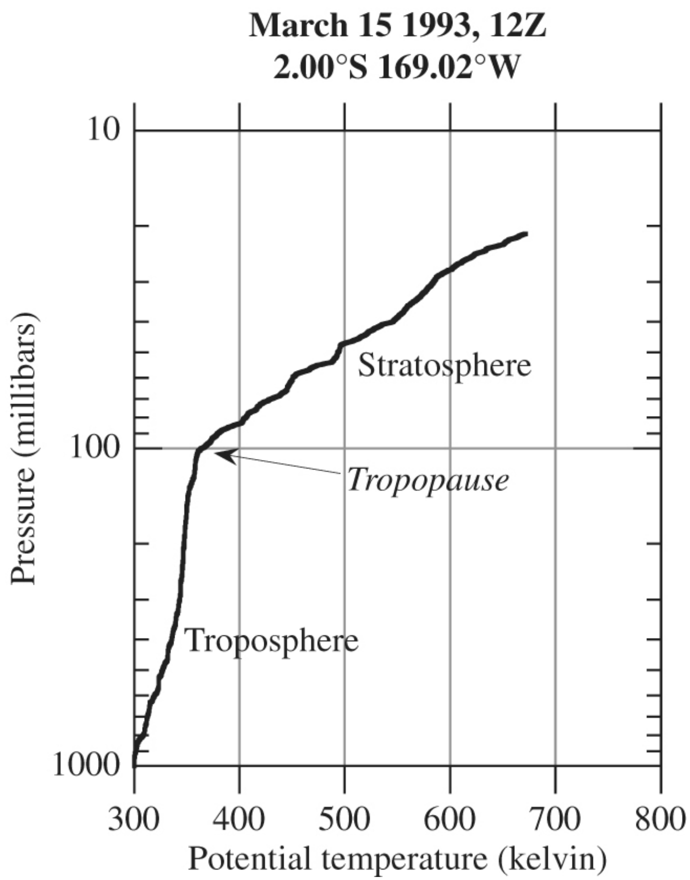
Vertical Profile of Temperature

Mean values for 30°N, March



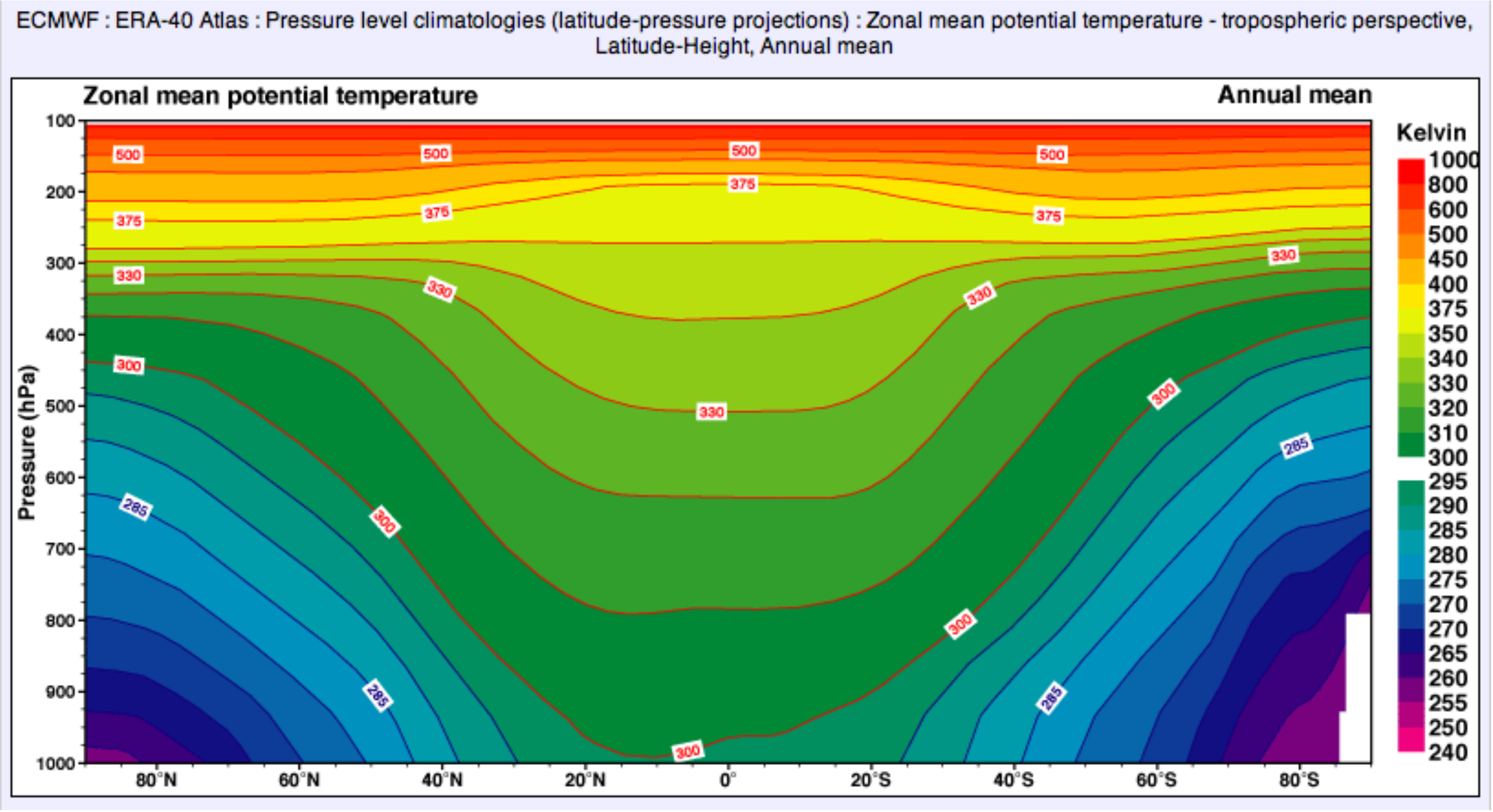
[courtesy, D. Jacob]

Potential Temperature



[From Pierrehumbert, 2010]

Potential Temperature



[From http://www.ecmwf.int/research/era/ERA-40_Atlas/docs/index.html]