

PROJECT THREE: CONVECTION AND ATMOSPHERIC THERMODYNAMICS

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In this project we will investigate the nature of convection in the lower troposphere, which is the mechanism responsible for transporting heat from terrestrial radiation vertically upward to the upper troposphere where water vapor concentration and thus infrared absorption is much lower, allowing it to be emitted to outer space.

To carry out this investigation, we will use observed temperature profiles from radiosonde soundings to study the onset of convection in the lower atmosphere.

1 Stability to dry processes

Plotting the given temperature profile for standard atmospheric conditions at the mid-latitudes on a skew $T \log P$ graph, we can answer the given questions.

1. The tropopause can be identified as the region where an abrupt change in the lapse rate occurs. By inspection, we see this happens somewhere between 300 hPa to 200 hPa with the reference temperature profile indicating that it occurs at around 225 hPa.
2. We see that dry air is unstable only up to the lifted condensation level and then becomes stable, but moist air is unstable all the way up to 525 hPa at which point it becomes stable.
3. The mixing ratio at 1000 hPa is 9.5 g kg^{-1} , and at 500 hPa it is just above 1.5 g kg^{-1} indicating drier conditions as expected.
4. If the surface cools radiatively during the night, the air just needs to cool by 2°C for it to reach the same temperature as the dew point and for fog to form.
5. If the air is heated the following day and rises adiabatically, condensation will occur above the lifted condensation level (LCL) which occurs where a lifted air parcel reaches 100% relative humidity. For our temperature profile, this happens around

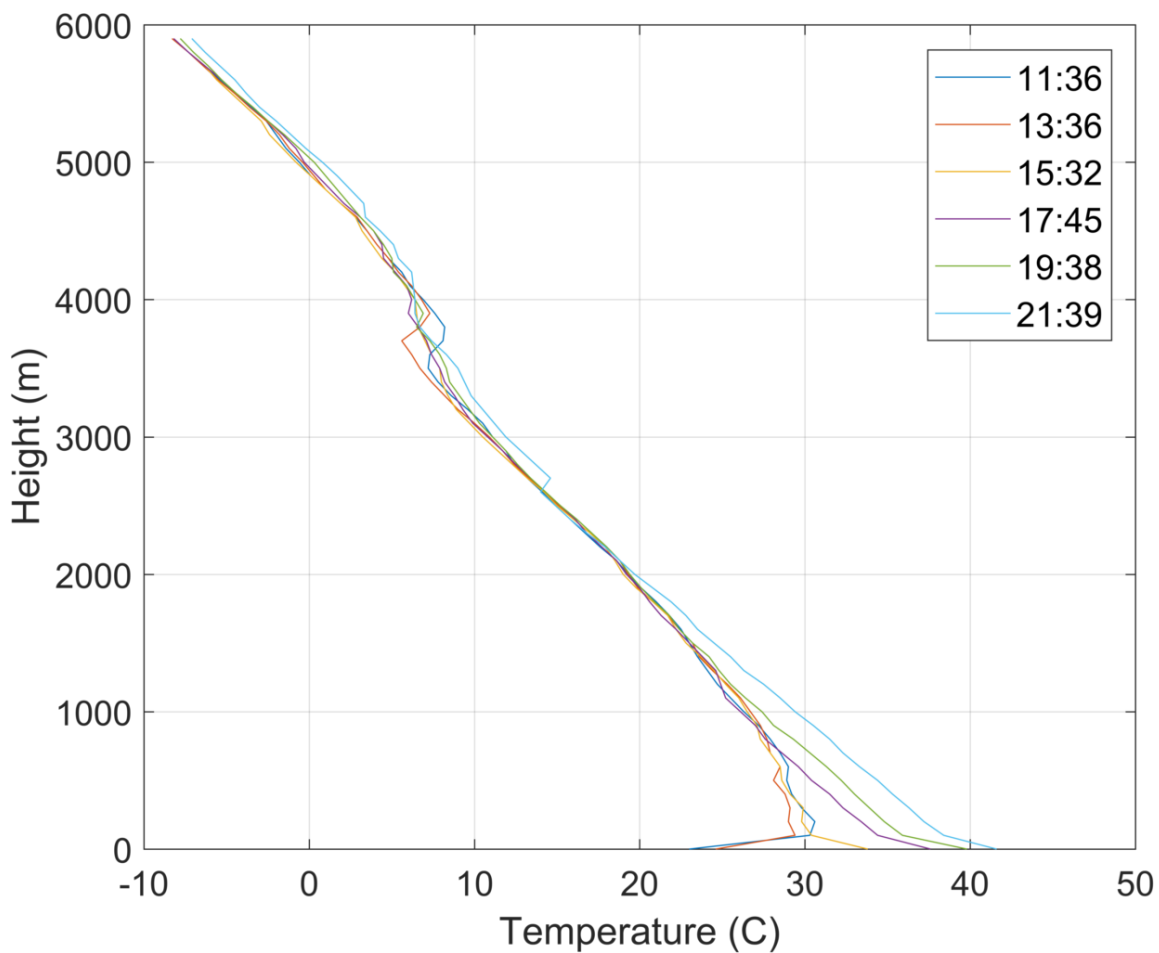


Figure 1: Temperature profile over Yuma, AZ.

950 hPa (540 m) where the moist adiabat from the dew point crosses the dry adiabat from the surface temperature.

6. Condensation can continue happening until around 525 hPa at which point the atmosphere becomes stable and convection stops.

2 Dry convection

Figure 1 shows a temperature profile over Yuma, AZ while figure 2 shows the corresponding potential temperature profile for approximate 2-hour intervals from 11:36 to 21:39 that day.

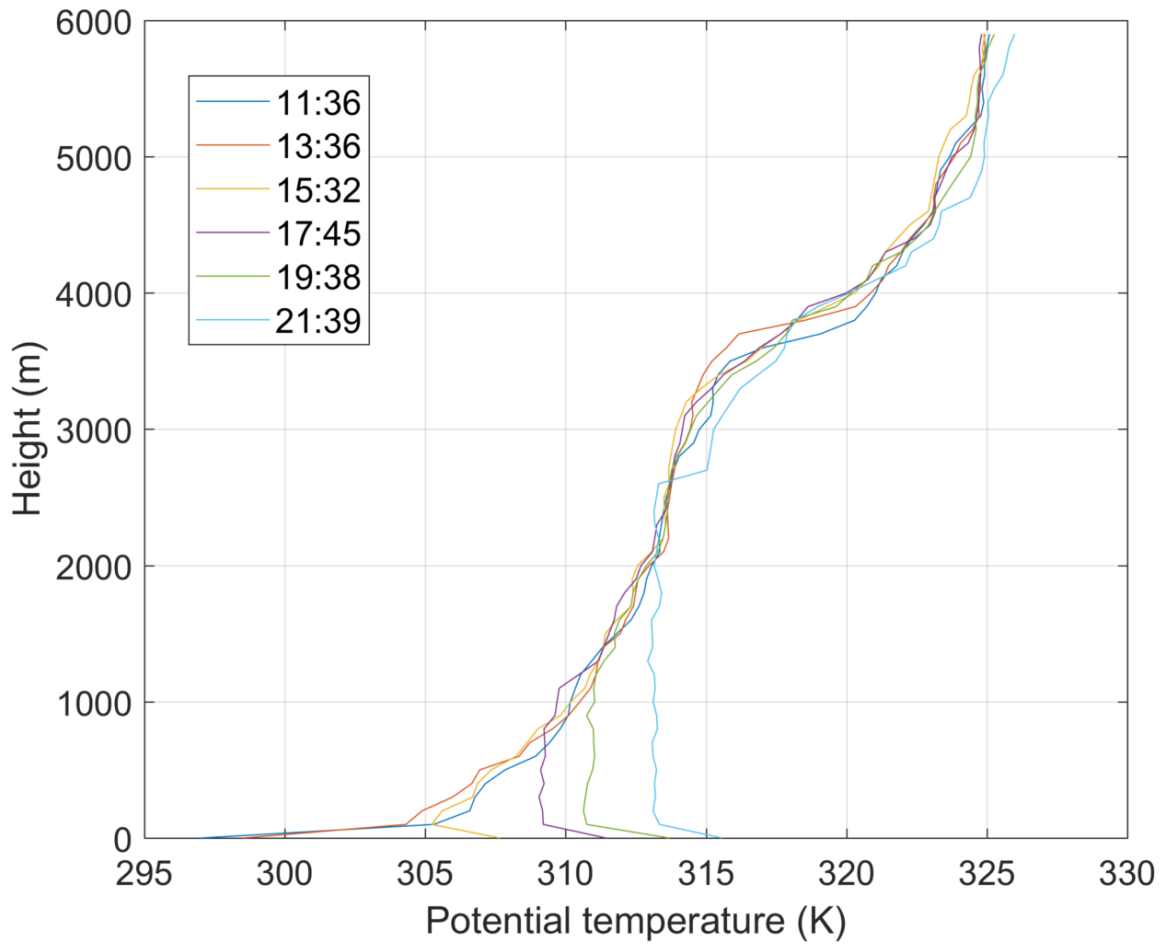


Figure 2: Potential temperature $\theta(T) = T \left(\frac{p_0}{p} \right)^{R/c_p}$ profile over Yuma, AZ.

We see the surface temperature drop during the day and stabilize a bit during the night.

3 Moist convection