In the last lecture, we showed these results of a full calculation of radiative equilibrium using a one dimensional model in which the concentrations of all the important radiatively active gases have been specified. This graph shows temperature as a function of altitude on the right hand axis or pressure on the left hand axis.

The temperature of the surface itself is about 333 degrees Kelvin, decreasing very rapidly with height to about 190 degrees Kelvin at around 10 kilometers altitude. Then increasing above that into the model stratosphere. Now, this solution has problems when one compares it to average vertical temperature profiles in the real world.

It's much too hot at and near the surface. The average global surface temperature is closer to about 288 degrees Kelvin. It's too cold at and near the tropopause. Actual tropopause temperatures are closer to 200 degrees Kelvin or a little bit warmer. And consequently, the lapse rate of temperature in the troposphere is much larger than we observe. On the other hand, the temperature in the model stratosphere is pretty close to observations.

So why do we have problems with the radiative equilibrium solution in the troposphere? Why is it not so very close to what we observe ? Well, it turns out there's a missing ingredient and that's convection. Convection is another mode of heat transfer in the atmosphere. It's very important and it will be the subject of the next few lectures.

There are several reasons why convection is important. In the troposphere it's just as important as radiation in transporting enthalpy vertically. But it also controls the distribution of the most important greenhouse gas in the atmosphere, water vapor. And also indirectly controls the distribution of clouds. These together are the two most important constituents in radiative transfer.

So the real problem of radiation and convection together is a strongly two way problem, as we'll see in a minute. Radiation is what drives convection in the atmosphere ultimately. But the convection determines the distribution of the most important gases and condensed matter for determining the radiative transfer itself. So it's a very interesting two way problem.

Now, most of you are familiar with the concept of convection. This little cartoon illustrates what happens if you were to take a pan of say water, and heat it in the center of the bottom of the pan. Water, which is heated, is slightly less dense than cooler water. And that less dense air will accelerate upward, or water in this case, driving these convective cells.

So the warm fluid rises near the center of the pan. When it gets to the surface, it begins to cool off. And that cool water descends near the edges of the pan. That in a nutshell is convection.

We can ask under what circumstances will the atmosphere convect? Is it sufficient simply to heat it from below? As we know, radiation heats not just the surface of the atmosphere but the gas itself. When is the column of gas unstable to convection? When will convection actually arise?