Vertical Structure of the Atmosphere

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Contents

Notice:

If you have a laptop or tablet that you can bring to class and connect to the internet, I recommend you do so today so you can work along with me in using the online models.

Reading:

Required Reading (everyone):

- Understanding the Forecast, Ch. 5.

Reading Notes:

The key thing in this chapter is understanding why the troposphere gets colder as you go higher, and how this phenomenon (described by the term **lapse rate**), contributes to the greenhouse effect.

First, the chapter starts by defining a **skin layer**, which is an important concept, and connects it to the greenhouse effect.

Next, it moves on to describe how air pressure varies with altitude. I find the discussion on pp. 46–49 more confusing than it needs to be. Don't get bogged down in the details of *why* the equation at the bottom of p. 48 is true. Just understand *what* that equation tells you:

$$P(z) = 1 \text{ atm} \cdot e^{-z/8 \text{ km}}$$

You might find it easier and more intuitive to work with another way to write the same equation:

$$P(z) = 1 \text{ atm} \cdot 2^{-z/5.5 \text{ km}}$$

If we think of it this way, it's intuitive that every 5.5 km you go up in the atmosphere, the pressure drops by half: at 5.5 km, it's 50% what it is at sea level. At 11.0 km it's 25%; at 16.5 km it's 12.5%, and so on.

Third, we learn why air cools off as it rises through the atmosphere. It's because it expands as the pressure surrounding it drops. Similarly, as air descends to lower altitudes, it compresses and gets hotter.

Fourth, we learn about latent heat from water evaporating and condensing. Latent heat is responsible for a large fraction of the heat transport around the atmosphere. Latent heat is also very important because it affects lapse rate. How does the lapse rate in **saturated** air (i.e., air with 100% relative humidity) differ from the lapse rate in **unsaturated** air

(with relative humidity < 100)? Why? (Hint: the relavant material appears in the section on **moist convection**, not the section on latent heat.)

Fifth, we learn about convection: as you heat air it tends to rise and this moves heat around the atmosphere. The key concept regarding convection is **stability** vs. **instability**. Unstable air undergoes convection (as the troposphere does), whereas stable air does not, and instead remains **stratified**, as the stratosphere does.

Sixth (and finally), we put everything together to see the connection between lapse rates and the greenhouse effect. The key result is that adding greenhouse gases raises the height of the "skin" and this added height, together with the lapse rate, tells us how much the surface temperature will warm up. The book summarizes these five points concisely on p. 55.