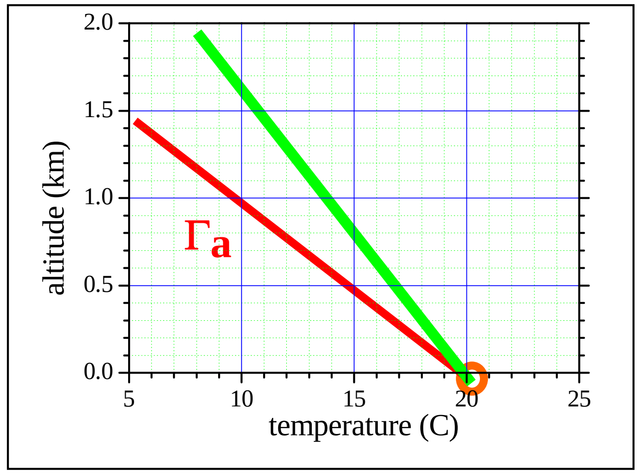
Atmospheric Stability

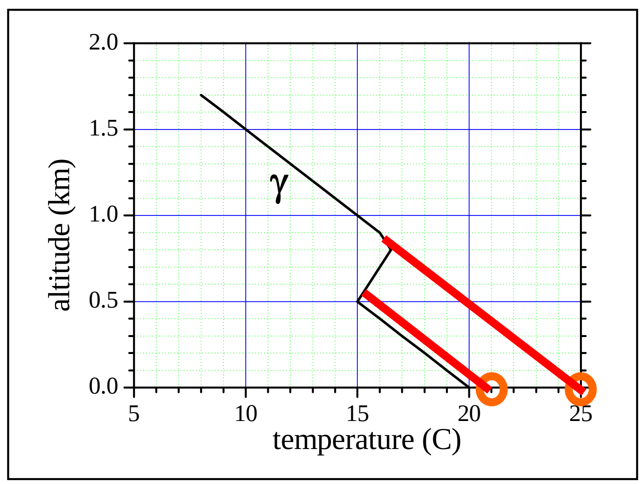


1. Draw the temperature curve that a balloon with a temperature of 20°C at the ground will follow if we lift it to 1.5 km altitude for two cases:

a) Assuming that the air is dry (without condensation) , what is its temperature?

b) Assuming that the air contains water vapor (with condensation) , what is its temperature?

(hint: the "curve" is a straight line
note: dry adiabatic lapse rate Γ_a= 10°C/km;
wet adiabatic lapse rate, Γ_w= 6°C/km)



2. By drawing the temperature curves describe what will happen to dry pollution plumes that we release with a temperature of 21°C and 25°C at the ground. The curve in the graph describes the environmental lapse rate. Describe in words the behavior of these pollution plumes.

*** The 21°C pollution plume will rise and cool at the dry adiabatic lapse rate until its temperature is the same as surrounding air. That altitude is ~0.6 km (15.5°C). This is an inversion layer and the parcel will stay there.**

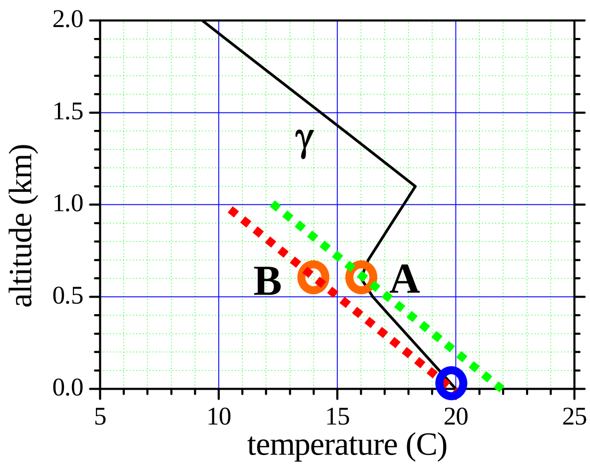
*** The 25°C plume will rise adiabatically until 0.9 km where it temperature will be equal to the surrounding air. This part of the profile is neutral and the air parcel will stay at that altitude, with a temperature of 16°C.**

3. Using the environmental lapse rate on the graph answer the following question.

a) Calculate the lapse rates for each part of the curve. For each layer state whether the air is stable/neutral/unstable with respect to the dry adiabatic lapse rate.

b) If we push the dry air parcel "A" sitting at 0.6 km altitude with a temperature of 16°C up or down is it going to sink, rise, or remain at this altitude? Why?

c) Now let's cool off the dry air parcel sitting at 0.6 km by 2°C, down to 14°C. If we push this air parcel "B" up or down, what will happen? Why?



a) Lapse rates for each part of the curve are determined by looking at the rate of decrease of temperature with increasing height.

<u>0-0.6 km altitude:</u> The temperature decreases by 4°C over 0.6 km altitude, so the lapse rate is Γ = 4°C/0.6km = 6.6°C/km <10°C/km. The air is stable.

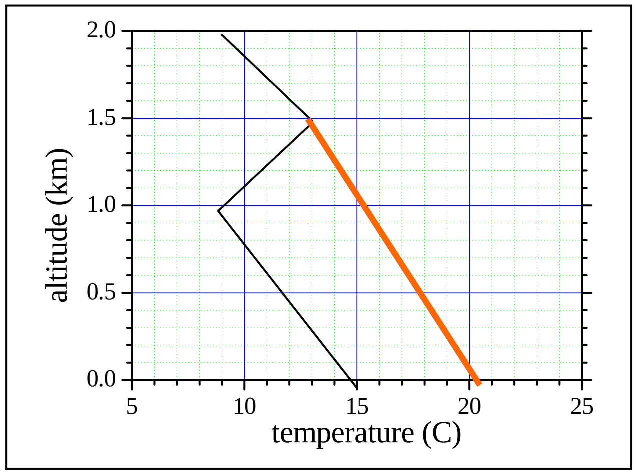
<u>0.6-1.1 km altitude:</u> The temperature <u>increases</u> by 2.25°C over 0.5 km altitude, so the lapse rate is Γ = -2.25°C/0.5km = -4.5°C/km <10°C/km. The air is stable.

<u>1.1-2 km altitude:</u> The temperature decreases by 5°C over 0.5 km altitude, so the lapse rate is Γ = 5°C/0.5km = 10°C/km =Γa. The air is neutral.

b) Air parcel A will remain at 0.6km altitude. If we push it up it will cool at a rate of 10C/km, and will be colder than surrounding air, it will thus sink back to its initial position. If we push it down it will cool less rapidly than the surrounding air (it will be warmer), so it will go back up.

c) Air parcel B will sink to the surface. If we push the air parcel down, it will be colder and denser than surrounding air, it will thus keep sinking following the dry adiabatic lapse rate (red dashed line) until it reaches the surface. If we push the air parcel up, it will still be colder than surrounding air and will thus sink.

4. The temperature at the top of the inversion is 13°C. What is the minimum temperature a parcel must have at the surface to rise past the inversion if it rises at the wet adiabatic lapse rate (Γ_w) of 5°C/km?



Since the top of the inversion is at 1.5 km and the saturated adiabatic lapse rate is 5°C/km, the parcel would have cooled by 7.5°C by the time that it reached the inversion top. Since the inversion is at 13°C, at the surface the parcel would need to be at 20.5°C.