Unit 2 ATM401, ATM601 and CHEM601

Instructions: Only the tasks at your class level and those for all students are mandatory for you. Once you are done with the tasks, scan them in and save each problem solution as one PDF file with your name, unit and problem number indicated. If, for example, I would submit my solution of problem 1, the name of the PDF-file would be *Nicole-Mölders-unit-2-problem-1.pdf*.

Application, analysis, and evaluation

1. **All students:** In Lectures in Meteorology, we learned about vertical temperature gradients. Obviously, they can be used to determine the temperature at a different height, when the temperature is known at the surface or at any arbitrary alitude in the troposphere as

   $$T_2 = T_1 \pm \gamma \cdot \Delta z$$

   Where Δz is the distance from the height at which the temperature T_1 is known and the height at which we want to calculate the temperature T_2. In the case that there is no temperature inversion, temperature decreases when $z_2 > z_1$ and we have to use a negative sign for the vertical temperature gradient γ. The opposite is true, when $z_2 < z_1$ or when we are dealing with an inversion.

   On a day without an inversion, a power plant releases hot dry air with a temperature of 20^oC. The temperature gradient in the plue is that of dry air $.098^oC/100m$. To what height will the plume ascend if the ambient air temperature varies with height according to (a) $T(z) = (-10 - 6z)^oC$ and (b) $T(z) = (-10 + z)^oC$ where z is in km. Comment on your results.
   Hint: Determine the vertical temperature gradient first and think about what/where your reference temperature T_1 is. State the assumption you have to make, and justify it.

2. **ATM601, CHEM601:** Derive the height dependency of argon for an isotherm atmosphere in the absence of sinks and sources. By which factor does the concentration of the gas decrease with increasing height? How would the height dependency look like for a homogeneous atmosphere? Discuss the vertical structure of the atmosphere in terms of what we learned about the mean vertical profiles of temperature, pressure, and composition in chapter 1 and in this unit.
   Hint: Think about what Dalton's Law means in terms of the pressure decrease with height in the homosphere.

3. **All students:** In 1962, CO_2 had a mean concentration of about 318 ppm at Mauna Loa. In August 2015, the mean concentration was 398.82 ppm. Calculate the individual gas constant for 1962 and 2015 for a dry atmosphere. Which assumptions do you have to make to solve this task? Next calculate the individual gas constant of moist air for an air mass containing 1% and 4% water vaporfor an air pressure $p = 1000hPa$ and air temperature $T = 15^oC$. Discuss whether

you have to ”update” the individual gas constant of dry air when you do climate simulations assuming increasing CO_2 at such a rate.