AT 621, Fall 2012

Homework #2

Due Wednesday, 12 September

Problem 1. *[stability and plume dispersion]*

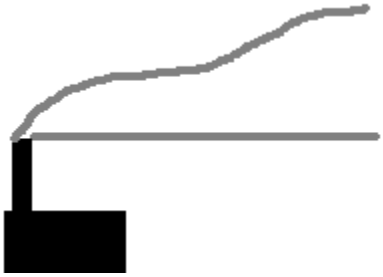
Draw an atmospheric temperature profile that would result in the stack plume dispersions shown below.

a)

b)

c)

d)



e)

Problem 2. *[atmospheric density / height relationships]*

(a) If a chemical species has a constant mixing ratio with height, what will its vertical profile in units of molecules cm^{-3} (or other concentration units) look like? Comment.

(b) If a species has a constant mixing ratio profile with height, what does that imply about its sources and sinks?

(c) If a species has a vertical mixing ratio profile that decreases with height, what does that imply about sources/ sinks? What if the profile increased with height?

Problem 3. *[characteristic times]*

(a) Using the data below, compute characteristic times for several processes that affect tropospheric species "A".

Reaction rate constant with OH· = 1.5×10^{-13} cm^3 $molecule^{-1}$ s^{-1}
Dry deposition velocity (apply to 1 km boundary layer) = 0.6 cm s^{-1}

(b) Compare these with characteristic times for exchange (see figure in your notes) and comment of the likely distribution of A in the atmosphere (trop. and strat.).

Problem 4. *[Simple species budget]*

Assume that the mass of methane in the atmosphere is represented by the variable M, and that methane has only one source, Q, (emissions of natural gas) and one sink, S (reaction with OH·).

(a) Sketch a simple representation of the budget of methane.

(b) Derive a differential equation that describes the time rate of change of M. (Note that S depends upon M.)

(c) Solve the differential equation for $M(t)$.

(d) At steady state ($t\rightarrow\infty$), what is the value of M?

(e) Using typical values of [OH·] and the reaction rate constant for methane with OH· in the troposphere, k = 6.3×10^{-15} cm^3 $molecule^{-1}$ s^{-1}, estimate the chemical lifetime of methane in the atmosphere. Given this lifetime, how would you expect methane concentrations to be distributed in the atmosphere (troposphere and stratosphere)?