METR 130 (Spring 2011): Take-Home Assignment for Final Exam
Due Date: May 20, 2011 (Friday)

Calculate the downwind air pollution concentration of sulfur dioxide (SO_2) emitted from a coal combustion power plant. The process for doing this involves three basic steps:

1) Calculation of the SO_2 emission rate from the plant (in grams per second)
2) Calculation of the SO_2 concentration downwind (in micrograms per m^3, ppm, or ppb, as appropriate for 'step 3').
3) Comparison of calculated concentrations from 'step 2' to relevant national ambient air quality standards (NAAQS) for SO_2.

For 'step 1', the emissions are calculated according to the following information about the plant:

- Power plant energy output capacity of 500 MW (megawatts)
- Power plant thermal efficiency of 30% (meaning 30% of the energy fed into the plant in the form of coal gets transferred to electricity generation).
- Energy content of coal equal to 27 MJ/kg (Megajoules per kg of coal; this quantity is called the "higher heating value" of coal)
- An SO_2 "emission factor" for uncontrolled emissions taken from Table 1.1.3 of http://www.epa.gov/ttnchie1/ap42/ch01/final/c01s01.pdf. Find a ballpark value among the different choices, assume all emission is in the form of SO_2, and assume a sulfur content of the coal equal to 1% (i.e. S = 1, see table).
- An emission control efficiency for a wet limestone scrubber, taken from Table 1.1.1. Use a value on the low end of the efficiency range given in the table in order to be "conservative" in your emission estimation, i.e. to not underestimate emissions.

For 'step 2', utilize the program SCREEN3 to calculate downwind concentrations. This can be downloaded as free software from http://www.weblakes.com/download/freeware.html (SCREEN View). Assume the following in running the model …

- A "point source"
- "rural" dispersion coefficients
- Receptor height off ground (meters) = 0
- Stack height = 80 meters
- Stack diameter and exit velocity each set to zero.
- Stack temperature equal to ambient temperature = 293 K
- Emission rate equal to your answer in 'step 1'
- Simple, flat terrain
- Automated Distances; set a minimum distance of 10 m and a maximum of 5000 m.
- Full Meteorology (All Stability Classes and Wind Speeds)

Plot the calculated maximum concentration as a function of downwind distance (the program has a utility that does this). Also, print out the output file and note the meteorological conditions (wind speed and stability classes) that produced the maximum concentrations at various downwind distances. Comment on this … i.e. why is it that these meteorological conditions caused the maximums at these distances? Are these day or nighttime conditions? Cloudy or clear-sky? Windy or light winds?

For 'step 3', compare your calculated concentrations against the 1-hour NAAQS for SO_2 (see table of NAAQS posted at http://www.epa.gov/air/criteria.html). Are there any exceedances? If so, at what distances downwind? Be sure to convert your concentrations from micrograms per m^3 to ppb in order to compare to standards. Infer the multiplication factor to make this conversion from the other entries in the NAAQS table.