

Homework 1

The first two problems are “back of the envelope” calculations to estimate the effects of mixing, ventilation, and chemical sources and sinks. The third problem needs a little thinking in geometry of the Sun relative to the roof.

1. Ventilation of a building (10 points)

A pollutant cloud containing SO_2 at a concentration of $C \mu\text{g m}^{-3}$ engulfs a building for t_1 minutes after which it lifts off and is replaced by clean air. The air in the building is recycling every T minutes and any incoming pollutant is well mixed throughout the building of volume V_b . Use the principle of mass conservation to derive an expression of SO_2 concentrations in the building, C_b and schematically plot C_b vs t .

2. Long-range transport of acidity (10 points)

A cluster of coal-fired power plants in Ohio emits sulfur dioxide (SO_2) continuously to the atmosphere. The pollution plume is advected to the northeast with a constant wind speed $U = 5 \text{ m s}^{-1}$. We assume no dilution of the plume during transport. Let $[\text{SO}_2]_0$ be the concentration of SO_2 in the fresh plume at the point of emission; SO_2 in the plume has a lifetime of 2 days against oxidation to sulfuric acid (H_2SO_4), and H_2SO_4 has a lifetime of 5 days against wet deposition. We view both of these sinks as first-order processes ($k_1 = 0.5 \text{ day}^{-1}$, $k_2 = 0.2 \text{ day}^{-1}$). Calculate and plot the concentrations of SO_2 and H_2SO_4 as a function of the distance x downwind of the power plant cluster. At what distance downwind is the H_2SO_4 concentration highest? Look up a map and see where this acid rain is falling.

3. Building a solar panel (10 points)

If you were to construct a solar-heated home in Atlanta for maximum heating in the coldest part of the year (say, around winter solstice), at what angle would you construct the roof (the size of which is fixed) so that it absorbs the maximum solar flux of the day.