Air Pollution Physics and Chemistry EAS 6790
Fall 2010

Home Work Assignment No. 1, Air Pollution Meteorology Part 2 of 2

1. The following observations of mean winds and temperatures were made at night from the 200-m mast at Cabauw in the Netherlands (0.7 m below sea level):

Height (m)	Wind Speed (m/s)	Wind Dir (deg. from N)	Temperature (°C)
10	3.1	80	14.67
20	3.9	84	14.81
40	5.9	90	15.17
80	9.1	98	16.33
120	11.1	112	18.73
160	10.6	122	19.71
200	9.8	127	19.77

a. Plot the wind speed, wind direction, and potential temperature profiles, note the atm. stability (e.g., neutral, stable, or unstable).
b. Calculate and plot the component velocity profiles, with the x-axis along the near-surface wind.

2. The following wind profile observations were made on a short grass surface, under near-neutral conditions, during the Wangara Experiment:

z (m):	0.5	1	2	4	8	16
u(bar) (m/s)	4.08	4.51	5.04	5.52	5.97	6.48

Using a graphical procedure, determine the roughness length and the friction velocity.

3. Role of molecular diffusion in atmospheric transport

The molecular diffusion coefficient *D* of air increases with altitude as the mean free path between molecular collisions increases. One can show that *D* various inversely with pressure:

$$D = D_0 P_0/P$$

Where P_0 is the pressure at sea level and $D_0 = 0.2$ cm^2 s^{-1} is the molecular diffusion coefficient at sea level.

a. Calculate the average time required for a molecule to travel 1 m by molecular diffusion at sea level, at 10 km altitude, and at 100 km altitude.

b. At what altitude does molecular diffusion become more important than turbulent diffusion as a mechanism for atmospheric transport? Assume a turbulent coefficient $K_z = 1 \times 10^5$ cm^2 s^{-1} independent of altitude.

4. Plume Dispersion

The effective stack height of an electric generating station is 300 m and the unit emits 2,800 g/s of SO_2 when coal containing 2.3% sulfur is used as fuel. Assuming no SO_2 reacts:

a. Find the maximum ground level concentration of SO_2 at a distance of 10.0 km downwind when the stability class is D, corresponding to nighttime conditions with partial cloudiness. Include the effect of reflection at the ground. The wind speed is 8.5 m/s.

b. Find the maximum ground level concentration 10.0 km downwind when the stability class is A, corresponding to strong convective conditions and when an elevated inversion is present at a height of 600 m. The wind speed is now 1.95 m/s. At this downwind distance there is perfect mixing in the vertical, $0 < z < 600$ m, and turbulent transport occurs in the crosswind direction. (Hint: this problem is equivalent to diffusion from a vertical line source between ground and inversion level).

5. Plume Dispersion

A long highway running in a north-south direction has a traffic volume (TV) of 1000 vehicles/hr traveling in both directions (average of 500 each way). The CO emission factor (EF) for traffic is estimated to be 60 g/vehicle-mile. The line source emission strength is then given by:

$$Q_l = 0.174 \text{ (EF) (TV)} = 10{,}440\ \mu\text{g/m/s}$$

Calculate the ground level CO concentration 1 km east of the highway if the wind speed is 5 m/s from the west when the sky is overcast. Neglect inversion effects. Include the effect of reflection at ground level.