

Problem Set # 4

1. An factory smoke stack releases intense small spherical patch of dust particles of total mass 54 kg in an isotropic turbulent atmosphere characterized by a zero mean wind field. If the density (concentration) of the dust particles at the center of the patch (location of release point) after 5 minutes is found to be $\rho = 2 \frac{kg}{m^3}$, what is the turbulent diffusivity. If these particles are known to be hazardous at concentrations greater than $\rho = .5 \frac{kg}{m^3}$ levels how far from the plume should you be at 5 minutes release time. How far after 1 minute release time? When is it safe to be at the center of the plume?
2. Suppose you release 1000 oceanic Lagrangian surface floats in a field of two dimensional turbulent eddies. You use a satellite tracking system and observe that these eddies have an rms velocity field of $\langle (u')^2 \rangle^{\frac{1}{2}} = 10 \frac{cm}{sec}$ and a decorrelation time 10 days. (a) Using random walk theory estimate the turbulent diffusivity. (b) After 50 days what do you expect the density of these floats to be (numbers/ km) at the center of the release point? How far have 68% of the floats gone ? (c) How long is it practical to be able to track these floats within 50 km of their release point. (d) If you wanted to track these floats for a longer time what would you have to do initially?
3. Homework: A patch of dye initially 5 m vertically by 100 m horizontally is located in a constant vertical velocity shear of $\frac{du}{dz} = \alpha = .01 sec^{-1}$ Microstructure turbulence measurements in this region suggest a vertical diffusivity of

$$k_z = 10^{-4} \frac{m^2}{sec}$$

How far does the patch disperse horizontally and vertically in 1 second, 1 minute, 1 hour, 1 day? When does shear dispersion effects become more important than the laminar stretching effects in determining horizontal structure.?