PROBLEMS

5. 1 Turbulent diffusion coefficient

Radon-222 is widely used as a tracer of vertical transport in the troposphere. It is emitted ubiquitously by soils and is removed from the atmosphere solely by radioactive decay (k = 2.1x10^{-6} s^{-1}). We consider in this problem a continental atmosphere where ^{222}Rn concentrations are horizontally uniform. Vertical transport is parameterized by a turbulent diffusion coefficient K_z.

1. Write a one-dimensional continuity equation (Eulerian form) for the ^{222}Rn concentration in the atmosphere as a function of altitude.

2. An analytical solution to the continuity equation can be obtained by assuming that K_z is independent of altitude, that ^{222}Rn is at steady state, and that the mixing ratio C of ^{222}Rn decreases exponentially with altitude:

$$C(z) = C(0)e^{-z/h}$$

Observations show that this exponential dependence on altitude, with a scale height h = 3 km, provides a reasonably good fit to average vertical profiles of ^{222}Rn concentrations. Show that under these conditions

$$K_z = \frac{kh}{\frac{1}{H} + \frac{1}{h}} = 1.3\text{x}10^5\ \text{cm}^2\text{s}^{-1}$$

where H is the scale height of the atmosphere.

3. The mean number density of ^{222}Rn measured in surface air over continents is $n(0)$ = 2 atoms cm^{-3}. Using the assumptions from question 2, calculate the emission flux of ^{222}Rn from the soil.

4. The mean residence time of water vapor in the atmosphere is 13 days (section 3.1.1). Using the same assumptions as in question 2, estimate a scale height for water vapor in the atmosphere.

[To know more: Liu, S.C., et al., Radon 222 and tropospheric vertical transport, *J. Geophys. Res.*, *89*, 7291-7297, 1984.]