SSC 107 Soil Physics
Dec. 1, 1999
Due Dec. 8, 1999

Problem Set #7

1. The CO_2 vertical distribution in the crop root zone can be expressed as

$$C_g(z) = -\frac{\alpha}{2D_m} z^2 + \frac{\alpha L}{D_m} z + C_o$$

Where C_o is the CO_2 concentration at the soil surface, D_m is the apparent diffusion coefficient, z is the depth, L is the depth to an impermeable layer, and α is the CO_2 production rate and assumed to be constant over time and depth. Assume that the bulk-air diffusion coefficient D_g^a is 0.19 cm^2/sec, the total porosity is 0.45 cm^3/cm^3, the water content is 0.35 cm^3/cm^3 over the depth L of 600 mm. If the CO_2 concentration at the surface is 400 ppm, show how the consumption rate affects the CO_2 distribution in the root zone. List any assumptions you make.

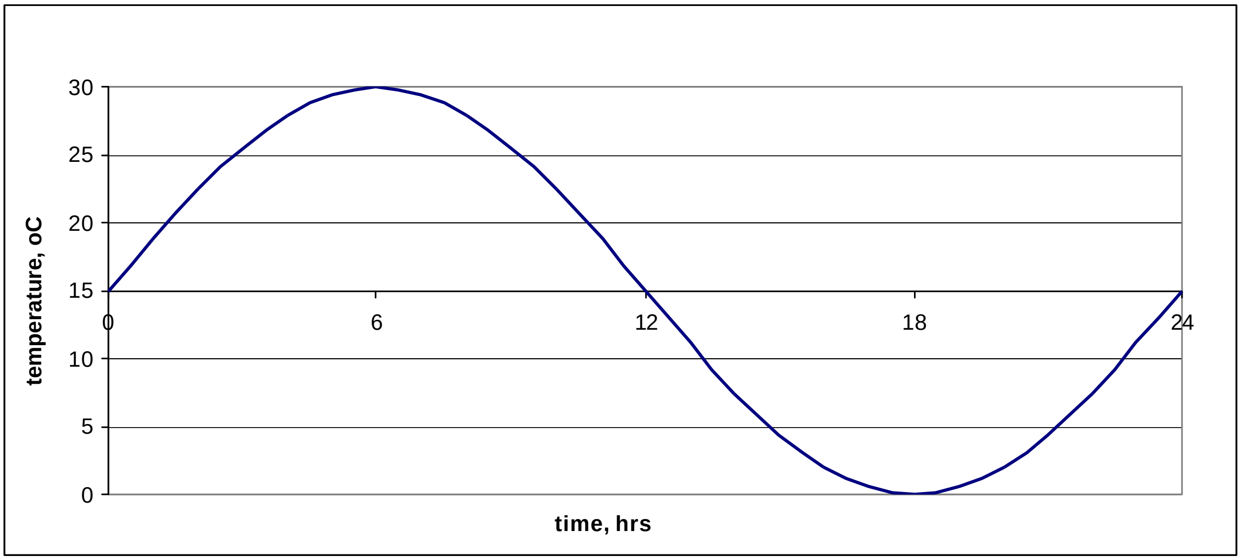
2. A soil has a volumetric water content of 0.3 cm^3/cm^3 and a bulk density of 1.4 g/cm^3.

   a. Calculate the volumetric heat capacity of the soil (heat required to raise the temperature of 1 cm^3 of wet soil by 1 ^oC.)
   b. Calculate the heat capacity of the soil on a mass basis.
   c. Calculate the thermal diffusivity if the thermal conductivity is 18 cal/cm hr ^oC.
   d. If this soil exists in a field, calculate the heat required to increase the temperature of a 15 cm deep soil, 2 hectare in area, by 5 ^oC.

3. The diagram below shows the temperature variation at the soil surface over a 24-hour period.

   a. Compute the angular frequency $\omega=2\pi/\tau$ with τ denoting time in hours for one complete temperature cycle.
   b. Compute the damping depth of the soil if the thermal diffusivity of the soil material is 10 cm^2/hr.
   c. Determine the amplitude of the wave (A_o) at the surface and calculate the amplitude of the temperature wave at the 15-cm depth.
   d. Compute the maximum temperature change at the 15-cm depth.
   e. Compute the time (in hours) at which the maximum temperature occurs at the 15-cm depth.

f. Sketch the temperature cycle for the 15 cm depth in the diagram, in relation to the surface temperature wave.



4. The saturated hydraulic conductivity values measured at random locations throughout a large field are given in the table below.

a. Determine the mean, standard deviation, and coefficient of variation,
b. Take the natural log of the data and determine the true mean, true standard deviation and the true coefficient of variation of the log transformed values,
c. Make a fractile diagram in order to evaluate if the hydraulic conductivity values are better described by a normal or a ln normal distribution.

Sample #	K(cm/day)
1	0.51
2	64
3	1.07
4	38.1
5	2.9
6	12.7
7	32.4
8	17
9	387
10	25.5
11	31.1
12	13.4
13	35.9
14	1.95
15	41.6