University of British Columbia, Vancouver GEOB 300 - Microscale Weather and Climate Knox February 2, 2023

Study Questions - Lecture 10

- 1. The specific heat of water is $c_p = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$. Calculate the heat capacity C of water.
- 2. Calculate the heat capacity C of a dry mineral soil with a porosity of 55%. Use values from the table in Lecture 10, Slide 8.
- 3. Calculate the heat capacity C for the same soil if it is completely saturated.
- 4. Calculate the heat capacity C of a partly saturated soil with P = 50%, $\theta_a = 0.30$ and an organic to mineral ratio of 1.5. Again, use the table in Lecture 10, Slide 8.
- 5. If you increase the soil volumetric water content θ_w of any soil by 0.1, how does the heat capacity C of the soil change?
- 6. Assume we have a soil with $C = 2 \,\mathrm{MJ}\,\mathrm{m}^{-3}\,\mathrm{K}^{-1}$ and we measure a soil heat flux density Q_G of $+100 \,\mathrm{W}\,\mathrm{m}^{-2}$ all going to the first 10 cm of the soil, how fast would the layer 0-10 cm heat up?
- 7. Write Fourier's law and explain it briefly.
- 8. In a dry and uniform mineral soil with a porosity of 55%, we measure soil temperatures T_1 at 2 cm and T_2 at 6 cm. $T_1 = 20^{\circ}\text{C}$, $T_2 = 18.5^{\circ}\text{C}$. Calculate the soil heat flux density Q_G assuming a thermal conductivity of $k = 0.27 \,\text{W}\,\text{m}^{-1}\,\text{K}^{-1}$.
- 9. At 5 cm depth we measure a soil heat flux density $Q_G=20\,\mathrm{W\,m^{-2}}$ and simultaneously a temperature gradient of -0.5 $\mathrm{K\,cm^{-1}}$. Calculate the thermal conductivity k.
- 10. For a soil with a specific heat $c_p=1.8~{\rm kJ~kg^{-1}~K^{-1}}$, a density $\rho=1.4~{\rm Mg~m^{-3}}$, and a thermal conductivity $k=0.4~{\rm W~m^{-1}~K^{-1}}$, calculate the thermal diffusivity κ .

- 11. Calculate the thermal admittance μ for the same soil.
- 12. Assume we know a soil's dry <u>mass</u> fraction of organic material ($f_o = 25\%$), and its bulk density ($\rho_s = 1.4 \,\mathrm{Mg}\,\mathrm{m}^{-3}$). What is the mass of organic (M_o) and mineral material (M_m) contained in one cubic metre of this soil?
- 13. Using the values of specific heat for organic (c_o) and mineral (c_m) given in the table of Lecture 10, slide 8, calculate the composite heat capacity (C_s) for the dry soil in Question 12.