Robert Nelson - ATS761 HW2

12.4. The more concentrated precipitation scenario will likely result in 20% of the soil quickly becoming saturated and thus generating more catchment runoff than the evenly distributed precipitation scenario.

12.6 (required to complete 12.7). R = 11.07 mm (see code)

12.7.
a) R = 6.85 mm (drier soil can absorb more moisture and thus less runoff)
b) R = 41.66 mm (slower absorption means more runoff)
c) R = 21.53 mm (greater spatial variability in infiltration capacity means more areas with low infiltration capacity and thus more runoff)

12.8. An area with a larger topographic index (10.0 vs. 6.5) is more likely to produce runoff because:
- Smaller β: shallower slope means an increased chance of saturation
- Larger upslope area (A) means more upslope area contributing and thus more water available
- Smaller contour length (c) results in a higher flow rate and thus a greater likelihood of runoff

12.9. Via eq. 12.19, a watershed is saturated when z <= 0, thus (via simple algebra) when ln(a/tan(β)) is equal to or less than λ+ f*z_bar.

12.10. Using eq. 12.19, we get z-z_bar values of -2.3 m and 1.0 m for topographic indices of 15 and 5, respectively. As the local water table for the area with a topographic index of 15 is 2.3 meters above the average depth to water table, that area is more likely to saturate and produce runoff during a storm.

13.1. Using eq. 13.1, we find dT/dt = 0.16 degC/hr for the first soil and 0.12 degC/hr for the second soil. Thus, the first soil warms faster despite the second soil having a greater input of net radiation.

13.4. Using eq. 13.5 gives an annual evaporation of 63.3 cm for the first site and 54.5 cm for the second site. Thus, the second site would have more runoff, as less water would have evaporated.

13.5. R_n (120 W/m^2) is considerably less than λP (227.22 W/m^2), thus soil water is plentiful and evaporation is limited by the net radiation.

13.7. Using eq. 13.18 gives a latent heat flux (λE) of 348.5 W/m^2 for part (a) and 462.3 W/m^2 for part (b).

13.8. Using eq. 13.20 gives a surface temperature (T_s) of 26.11 degC for part (a) and 23.65 degC for part (b). The more latent heat release, the cooler the surface temperature and vice versa. Specifically, latent heat is a function of the vapor pressure deficit, which is a function of the relative humidity.

14.1. Using the first part of eq. 14.8 gives a sensible heat flux of 231.2 W/m^2.

14.2. Using equation 14.16 to initially solve for u* using u(25m) then proceeding to use u* to find u(2m) gives a u(2m) of 2.95 m/s. To find the momentum flux I used eq. 14.12 with du/dz at 2m to be ~11.2 s^{-1}. Maybe I should use the average height, but the question kind of implies that they want the momentum flux at 2m, which gives a τ of 8.9 kg/ms^2.

14.4. Using eqs. 14.26, 14.27, and 14.33 (see code) results in r_{aH} values of:

r_{aH}(forest, neutral) = 17.4 s/m
r_{aH}(forest, unstable) = 6.6 s/m
r_{aH}(forest, stable) = 60.5 s/m
r_{aH}(grass, neutral) = 80.1 s/m
r_{aH}(grass, unstable) = 54.2 s/m
r_{aH}(grass, stable) = 157.7 s/m

The aerodynamic resistances for grass are higher than for forest because the roughness length for a forest is larger. Additionally, an unstable atmosphere results in lower aerodynamic resistances while a stable atmosphere inhibits mixing and has higher aerodynamic resistances.

14.5. Using the equation for H in 14.32 (see code for previous problem) gives θ_s values of:

θ_s (forest, neutral) = 295.8 K
θ_s (forest, unstable) = 294.1 K
θ_s (forest, stable) = 302.3 K
θ_s (grass, neutral) = 305.3 K
θ_s (grass, unstable) = 301.4 K
θ_s (grass, stable) = 317.0 K

Grass generally has a higher surface temperature than forest. Additionally, the surface temperature is higher when the atmosphere is stable. This is because less heat is being transferred away from the surface via turbulence. For example, an unstable atmosphere mixes the air near the surface and efficiently transfers surface heat to the atmosphere.