Problem 3 Watershed Hidrology

Emilio Aguilar

2022-09-27

1 - Penman Potential Evapotranspiration

1.1 Data

```
Tavg_Aug2 <- 18.6 #Celsius
Tma_Aug2  <- 24.4 #Celsius
Tmin_Aug2 <- 12.8 #Celsius
Tavg_Aug1 <- 15.0 #Celsius
Tavg_Aug3 <- 20.6 #Celsius
VPD = 1.0927 #kPa
U2 = 1.83 #ms1
Rn = 10.63 #MJ m-2 day-1
H = 213.4 #m
lat = 41 #N
```

1.2 What is your calculated G?

G is the ground heat flux messured in MJ m^{-1} day^{-1}

$$G = 4.2 * (T\ i + 1 - T\ i - 1)/Deltat$$

```
#Select Variables
Tbefore <- Tavg_Aug1
Tafter <- Tavg_Aug3
time <- 3 - 1

#Solution
G <- 4.2 * ((Tbefore - Tafter)/time)

print(paste("The ground heat flux is",G,"MJ m-1 day-1"), quote = FALSE)
```

```
## [1] The ground heat flux is -11.76 MJ m-1 day-1
```

1.3 What is your calculated Lambda?

Lambda is the latent heat of vaporization in MJ kg^{-1}, where T is average temperature (I assumed of the 3 days)

$$Lambda = 2.501 - 2361 * 10^{-3} * T$$

```
#Data
AvgT <- mean(c(Tavg_Aug1,Tavg_Aug2,Tavg_Aug3))

#Solution
Lambda <- round(2.501 - 2361* 10^{-3} * AvgT,2)

print(paste("The latent heat of vaporization is",Lambda,"MJ kg-1"), quote = FALSE)
```

```
## [1] The latent heat of vaporization is -40.15 MJ kg-1
```

1.3 What is your calculated P?

P is atmospheric pressure measure in kPA, H is the elevation above sea level in meters.

$$P = 101.3 - 0.01055H$$

```
#Data
H <- H #elevation above sea level

#Solution
P <- round(101.3 - 0.01055 * H,2)

print(paste("The atmospheric pressure is",P,"Kpa"), quote=FALSE)
```

```
## [1] The atmospheric pressure is 99.05 Kpa
```

1.4 What is your calculated Gamma?

Gamma is the pyschrometric constant measured in kPa C^{-1}, cp is the specific heat of water at constant pressure (0.001013 kJ kg-1 oC-1) and P is atmospheric pressure

$$Gamma = C\ p * P/0.622 * Lambda$$

```
#Data
CP <- 0.001013 #kg-1 oC-1

#Solution
Gamma <- round(CP * P / 0.622 * Lambda,2)

print(paste("The pyschrometric constant is",Gamma,"kPa C-1"), quote = FALSE)
```

```
## [1] The pyschrometric constant is -6.48 kPa C-1
```

1.5 What is your calculated Delta?

Delta is the slope of the saturation vapor pressure - temperature curve, mesured in kPa C^{-1}

$$Delta = 0.200(0.00738T + 0.8072)^7 - 0.00116$$

```
#Data
#AvgT

#Solution
Delta= round(0.200 * (0.00738*AvgT + 0.8072)^7 - 0.00116,2)

print(paste("The slope of curve is",Delta,"kPa C-1"), quote=FALSE)
```

```
## [1] The slope of curve is 0.13 kPa C-1
```

1.6 What is your calculated PET?

PET is potential evapotranspiration in mm day^-1

```
#Solution
#First Part of the equation

PET_1 <- Delta / (Delta + Gamma) * (Rn - G)
PET_2 <- Gamma/ (Delta + Gamma) * 6.43 * (1 + 0.53 * U2) * VPD

PET <- round((PET_1 + PET_2) / Lambda,2)

print(paste("The potential evapotranspiration is",PET,"mm per day"), quote=FALSE)
```

```
## [1] The potential evapotranspiration is -0.34 mm per day
```

2 - The Evaporation Pan

2.1 Data

2.2 Solution

Evaporation is computed as the difference between observed levels, adjusted for any measured precipitation (or other added water).

If the level on day 1 was measured at 7.8 in and the level on day two was measured at 7.6 in, and precipitation on day 2 was 0.1 in, what was the evaporation from the pan?

```
day1 <- 7.8 #inches
day2 <- 7.6 #inches
Preciptiation <- 0.1 #inches

EV <- day1 - day2 + Preciptiation
```

```
## [1] The evaporation from the pan was 0.3 inches
```

3 - Budyko Curve

a) How is the Penman-Monteith Equation related to the Budyko curve? Why would we would be interested in examining watersheds in the context of the Budyko curve?

The PET equation is used to draw the x axis in the Budyko Curve. Budyko curves makes us understand if the events in a watershed are natural occurring or if there is a climate-change element in them.

b) If we have a watershed on the Georgia coast with a large amount of precipitation and warm average temperatures over the curse of the year, where we would expect it to plot along the curve? Use the data just below to mark and label a point on the Budyko curve below. Remember the water balance equation: p = et + q. GA: Ave Temp(deg C)= 19.6 Precipitation(mm)=1,288 Q(mm)=312 PET(mm)=1121

```
Avg_Temp <- 19.6 #Celsius
Prep_GA <- 1288 #mm
Q_GA <- 312 #mm
PET_GA <- 1121 #mm

#Metric of energy available
Energy_GA <- PET_GA/Prep_GA

#ET
ET_GA <- - Q_GA + Prep_GA
AET_GA <- ET_GA/Prep_GA
```

```
## [1] The AET is 0.76
```

```
## [1] The Energy Available is 0.87
```

What about a watershed in the Colorado Rocky Mountains with a cold climate and significant precipitation at a elevation? Use the data just below to mark and label a point on the Budyko curve below. CO: Ave Temp(deg C)=-1.6 Precipitation(mm)= 973 Q(mm)= 803 PET(mm)=229

```
Avg_Temp_CO <- -1.6 #Celsius
Prep_CO <- 973 #mm
Q_CO <- 803 #mm
PET_CO <- 229 #mm

#Metric of energy availabloe
Energy_CO <- PET_CO/Prep_CO

#ET
ET_CO <- - Q_CO + Prep_CO
AET_P <- ET_CO/Prep_CO
```

```
## [1] The AET is 0.17
```

```
## [1] The Energy Available is 0.24
```

c.) Based on where these two watersheds plot on the Budyko what does it tell us about which factors are limiting ET in the system (explain both the Georgia cost and Colorado points)?

In the plot in Georgia, there is a lot radiation available to use and also a lot of water, evepotraspiration is limited by energy . Meanwhile, at the Colorado ecosystem, the ET is also greatly limited by energy but it also limted by water.