Building a Water Balance Model

1. Set up a table in Excel or other spreadsheet program like this:

Location Name (LAT, LONG)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of Days	31	28	31	30	31	30	31	31	30	31	30	31
Daylight hours (hours)												
Mean Temperature (°C)												
Precipitation (mm/day)												
Heat Index (i)												
Potential Evapotranspiration (unadjusted) (mm/month)												
Potential Evapotranspiration (adjusted) (mm/month)												
Precipitation (mm/month)												
Extra Water/ Water needed (mm/month)												
Soil Storage (mm)												
AET (mm/month)												
Soil Recharge/ Soil Withdrawal (mm/month)												
Runoff (mm/month)												
Check												

For your given location, find the latitude and longitude to the nearest degree. Go to this site, and register so that you can download data:
http://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?+s01#s01
Enter in the latitude and longitude for your given location (look this up on Google) on the webpage, and then select the following fields and press submit.

Daylight Hours
Air Temperature at 10 m
Precipitation

Enter the data into your spreadsheet.

2. Calculate the heat index (*i*) for each month using the equation given on (page 122 of the text).

$$i = \left(\frac{T}{5}\right)^{1.514}$$

Where *T* is the mean monthly temperature in Celsius. If T<0, then i = 0. It will be easiest if you use a conditional here: =IF(*test, value if true, value if false*).

=IF(B4>0,*formula above*,0)

3. Sum the *i* values for the year (*I*) in the row where you calculated *i*, and enter in the column beyond December (column N, row 6). In the next column (column 0, row 6), calculate *a* (page 122 of the text).

$$a = 6.75 \times 10^{-7} I^3 - 7.71 \times 10^{-5} I^2 + 1.79 \times 10^{-2} I + 0.49$$

4. In row 7, calculate the monthly unadjusted PET using the equation 6.1 on page 122 of the text.

$$PET_{month,(unadjusted)}(\text{mm/month}) = 0 \quad for \ T_{month} < 0\ ℃$$

$$PET_{month,(unadjusted)}(\text{mm/month}) = 16 \times \left(\frac{10 \times T_{month}}{I}\right)^a \quad for\ 0\ ℃ < T_{month} < 26.5\ ℃$$

$$PET_{month,(unadjusted)}(\text{mm/month}) = -415.85 + 32.24 \times T_{month} - 0.43 \times T_{month}^2$$
$$for\ T_{month} \geq 26.5\ ℃$$

It will more convenient if you use a conditional statement here of the form:

=IF(B4<0,0,IF(B4<26.5,16*(10*B4/$N6)^$O6,-415.85+32.24*B4-0.43*B4^2))

5. In the next row (row 8), calculate the monthly adjusted PET using the formula on page 122 of the text. This makes adjustments for the length of the month and the length of the number of daylight hours per month. Round this value to the nearest 100th by nesting your function in the =ROUND(function, 2).

$$PET_{month,(adjusted)}(\text{mm/month}) = PET_{month,(unadjusted)} \times \frac{days_{month}}{30} \times \frac{daylight\ hours_{month}}{12}$$

6. In the next row (row 9), calculate the monthly precipitation by multiplying the mean daily precipitation with the number of days per month.

7. In the next row (row 10), calculate the Extra Water/Water Needed, the difference between Precipitation and adjusted PET. Think about this- what does a positive number mean? What does a negative number mean?

8. Now, in row 11, calculate the soil water storage, assuming a 100 mm maximum soil water storage. First, in column O, row 11, enter 100. This is the field capacity (you can experiment with this later). In column N, row 11, enter 50 (this is a temporary value you'll change shortly). Now, in cell B11, calculate the soil water.

Think of the soil as a tank that can hold a maximum of 100 mm of water, and cannot go below 0 mm. You need to calculate the amount of water that the soil is holding. First, use the 50 you placed in cell N11. This will be your temporary starting soil water. So for January, you add the "Extra Water/Water Needed" to the current storage (N11), and if this is larger than 100, then the rest runs off. If it is less than 0, then there is a shortage, and the soil water stays at zero.

So you'll need a nested conditional:
If the Soil Water from the previous month plus the Extra Water is larger than 100 mm, then the soil stays at 100 mm. If Soil Water from the previous month plus the Water needed is less than zero (in other

words, water needed is greater than what is in the soil), then the soil water goes to zero. Otherwise, the extra water simply recharges the soil and is available the next month.

In cell B11:
=IF(N11+B10>$O11,$O11,IF($N11+B10<0,0,$N11+B10))

Now, for February, we look at the soil water from January, and the extra water/water needed for February.

In cell C11:
=IF(B11+C10>$O11,$O11,IF(B11+C10<0,0,B11+C10))

March-December, D11-M11 are analogous to C11 (you can drag this formula across).

Once all the formulas are in for every month, and you know the ending value for December, you can adjust your starting soil water value in cell N11 to be equal to the December value (so it carries over). After you change it, the numbers in your row should change, including (possibly) a change in the December value. Keep changing the value in N11 to equal the new value in M11. It may take 2-4 times.

9. Actual Evapotranspiration (the next row) is limited by either energy available (PET) or the water available. You've calculated the adjusted PET above, so that is the energy limit. The water limit is the precipitation for the month plus the soil water from the previous month. Therefore, AET is the minimum of PET and the sum of the soil water from the previous month and precipitation.

In cell B12:
=MIN(B8,(B9+M11))

In cell C12:
=MIN(C8,(C9+B11))

March-December, D12-M12 are analogous to C12 (you can drag this formula across).

10. Soil water Recharge/Withdrawal (row 13) will keep track of the water going in or out of the soil. You have implicitly calculated this already; it is just a difference between the current soil water and in the soil water from the preceding month (from row 11). Calculate this for each month. Think about this- what does a positive number mean? What does a negative number mean?

11. Runoff (row 14) is the difference between precipitation and the sum of AET and soil water recharge/withdrawal.

12. As a check, make sure all the water is accounted for each month. Precipitation minus AET, recharge, and run off should equal zero for every month.

=B9-B12-B13-B14

Assignment 6

What to submit:

In a word processing document, answer the following questions for assignment 6 and assignment 7. You can put both assignments in the same file. After you have answered the questions, print the document as a .pdf and attach it to an email to geog345@gmail.com. In the subject line, type "Assignment 6&7" (without the quotes). For a pdf creator, go to www.cutepdf.com, download and install the free version. The cutepdf should then show up in your printer list.

This assignment must be submitted by **Thursday, October 23, 11:59** pm EST (i.e. before midnight). Late assignments will be deleted. Please only submit your completed assignment once.

1. Last Name, First Name

2. Type the honor code followed by your initials.
I pledge on my honor that I have not given or received any unauthorized assistance on this assignment. (Add your initials).

3. Copy the table you have created A1:O15 and paste it into your word document. Set the field capacity to 100 mm in O11. It may be easiest to paste special as an enhanced metafile.

4. Create a graph of Adjusted PET, AET, and Precipitation from your spreadsheet. Set the field capacity to 100 mm in O11. Make the precipitation line blue, the PET red, and the AET green. Make sure the lines are labeled correctly in the legend, and the x-axis contains the month names. Also make sure you have units on the y-axis label. Paste the graph below the table.

5. Create a graph of Soil Water Storage and Runoff from your spreadsheet. Set the field capacity to 100 mm in O11. Make the soil water line brown, and the runoff line purple. Make sure the lines are labeled correctly in the legend, and the x-axis contains the month names. Also make sure you have units on the y-axis label. Paste the graph below the table.

6. Define in two sentences or less:
   a.) Potential Evapotranspiration
   b.) Actual Evapotranspiration
   c.) Soil Storage
   d.) Field Capacity
   e.)Soil Water Recharge/Soil Water Withdrawal
   f.) Runoff

7. How does the graph change if you vary the field capacity in increments from 0 to 1000 mm?

8. Repeat questions 3-5 for College Park, MD (All you should have to change are the numbers on rows 3,4, and 5).

Assignment 7

This assignment must be submitted by **Thursday, October 23, 11:59** pm EST (i.e. before midnight). Late assignments will be deleted. Please only submit your completed assignment once.

1. For your given location, what is the Köppen climate classification/subclassification (see color plate 8.1)? Describe the criteria specifics of this classification and why your location belongs in this classification.

2. For your given location, what is the Trewartha climate classification/subclassification (see http://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification)? Describe the criteria specifics of this classification and why your location belongs in this classification.

3. Calculate the moisture index (MI) for your location, using the spreadsheet you created in Assignment 6 and using the formula on page 177. For months where the AET is less than precipitation, the surplus (S) is the difference between AET and precipitation. For months where AET is greater than precipitation, the deficit (D) is the difference between PET and AET. It is probably easiest to do this on two separate rows, one for S, one for D and use the conditionals =IF(B12<B9,B9-B12,0) and =IF(B12>=B9,B8-B12,0)

Sum all the surpluses , deficits and PET for the year. Use a field capacity of 100 mm.

MI = 100*(S-D)/PET

Calculate the Thronthwaite dryness index (DI) and humidity index (HI) for your location (note these are annual sums of D, S, and PET).

DI = 100*D/PET
HI = 100*S/PET

Estimate the thermal efficiency index by summing the PET for the year and converting it to cm.

Calculate the Summer Thermal Efficiency Concentration for your location =Summer PET/Annual PET, where summer is June, July, and August in the northern hemisphere and December, January, and February in the southern hemisphere.

a.) What is the MI for your location?
b.) What is the DI for your location?
c.) What is the HI for your location?
d.) What is the Thermal Efficiency Index for your location?
e.) What is the Summer Thermal Efficiency Concentration for your location?
f.) Based on your results what is Thornthwaite moisture and temperature divisions and subdivisions (see tables 8.6-8.8)?

4. Calculate the Potential Evapotranspiration Ratio for your location, the mean annual PET over the mean annual precipitation.

5. Which Holdridge Life Zone is best represented by your location (see Figure 8.5)?

6. What is the dominant air mass for your location (see figure 8.7)?

7. Repeat questions 1-6 for College Park, MD.

Assignment 8

This assignment must be submitted by **Tuesday, October 28, 11:59** pm EST (i.e. before midnight). Late assignments will be deleted. Please only submit your completed assignment once.

With your group , prepare a 15-20 minute presentation that discusses the climate of your group's region. In your presentation, be sure to include:

1. A title slide that contains the region name and all the group members' first and last names
2. A map of the location of all the individuals water balance analyses.
3. All of the individuals' water balance graphs (PET, AET, and Precipitation).
4. Variation of climate classifications across the region.
5. Unique climate features (e.g., mountain ranges, ocean currents, etc.) of the region (see Chapters 9 and 10)
6. Paleo-historic climates of the region
7. Any other interesting or relevant climate information about your region.

Submit one ppt file for the group to geog345@gmail.com.

The group will present the PowerPoint in class on 10/30, 11/4, 11/6. The group will be assessed on content and delivery of the presentation.

Individually, submit an email to geog345@gmail.com
1. Last name, First name
2. Rates your effort (0 =lowest, 10=highest)
3. Rate the average effort you feel that the other members in the group put forth.
For example, if you feel like you did all the work and the rest of the group did absolutely nothing, you give yourself a 10, and the rest of the group a 0. On the other hand, if you worked just as hard as everyone else, and you all worked pretty hard, then give everyone a 9.
4. This is also the place where you can let me know of anyone who totally shirked their responsibilities or who went above and beyond the call of duty.
(The scores will not affect the assignment grade except in cases where the group proved to be dysfunctional.)