Zoe Maisel
BEE 6740: Week 9 Assignment
Forcing Hydrologic Models with Climate Projections: GCM

Purpose:
General Circulation Models, GCMs, are used to predict climate variability over time to understand how climate change will impact earth systems. Hydrologic modeling for future cases must take into account climate change as carbon and water fluxes change. Multiple models exist to predict future precipitation and air temperature; using those models to understand future snowmelt, soil water storage, flooding and evapotranspiration is key to sustainable planning.

Methods:
Five climate datasets were acquired from NEX-GDDP (https://nex.nasa.gov/nex/projects/1356/). Ithaca was extracted and data was converted to csv format. The five datasets were: ACCESS1-0, bcc-csm1-1, BNU-ESM, CanESM2G, and GDFL-ESM2G. The analysis spanned years 2015 to 2100.

First, annual total precipitation and average annual air temperature projections were plotted, which are shown in Figure 1. From this data visualization, it is clear that data from ACCESS1-0 is an outlier and different from the four other projections. ACCESS1-0 was included in analysis to show the impact that the outlier has on analysis, but other analysis might remove ACCESS1-0 from consideration.

Next, the “SnowMelt” and “Lumped_VSA_model” functions from the “EcoHydRology” package were used with default parameters and GCM forcing data. Soil Water, Groundwater Storage, and Discharge for both ACCESS1-0 and GFDL-ESM2G-rcp85, as shown in Figures 2 and 3.

Ensemble hydrologic forecasts with all GCM/ESM meteorological projections were made. All climate models were considered equally as good, using arithmetic mean ensemble averages. The ensemble averages were used for four projections to simulate projections of: maximum annual SWE accumulation, total number of days per year with soil moisture below 180 mm, peak annual discharge, and annual ratio of annual ET to annual precipitation. Each of the five models was run to determine the mean ensemble. The four projections are plotted in Figure 4.

Conclusion:
Precipitation data stays about the same over the forecasted period, but air temperature is clearly projected to increase. ACCESS is shown as the open circle, and as mentioned above, appears to be an outlier.

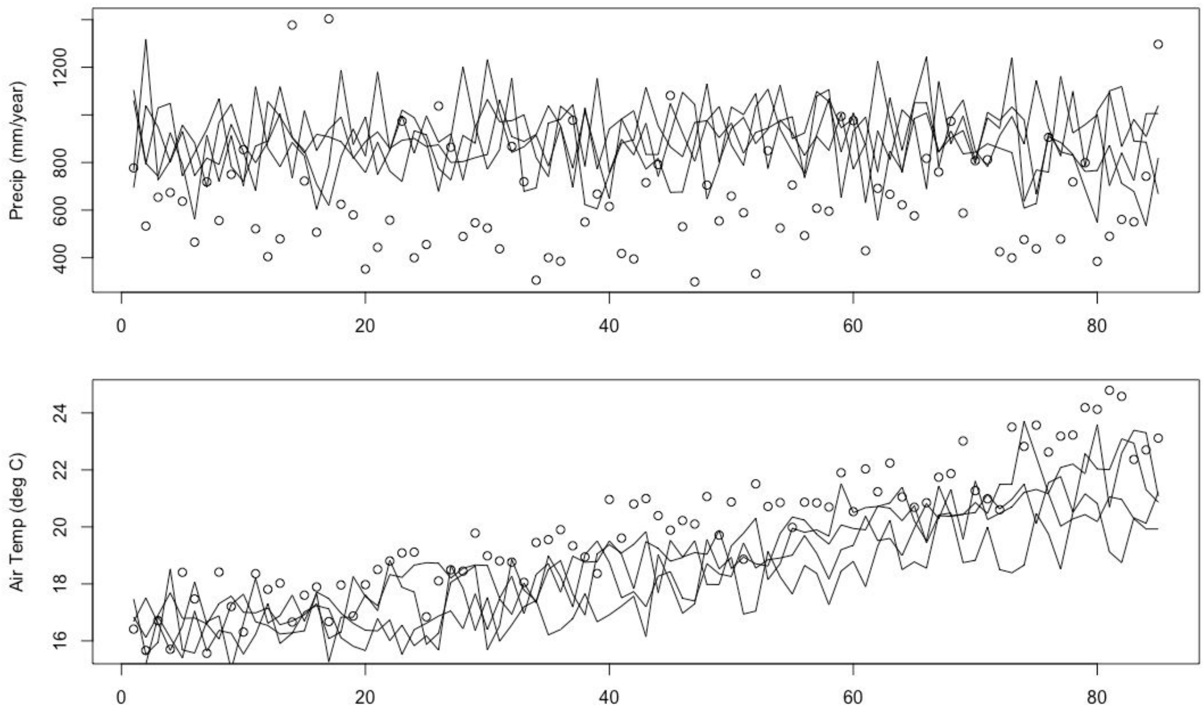

Figure 1: Five model projections for precipitation and air temperature for 2015 - 2100.

Because the data for ACCESS are considered outliers, the projections are likely unsuitable for Ithaca, NY analysis. One projection that appears to be most unlikely is the projection for SWE, as shown in Figure 2. It would be expected that SWE might change in magnitude or duration, but the ACCESS projection shows some short periods of very high accumulation which appear and disappear quickly. It would be expected that a seasonal variability would occur, but not with the same pattern that is shown in ACCESS. The projection for SWE by GFDL in Figure 3 is more expected. Additionally, the GFDL projection shows smoother soil water curve projections and discharge events following the SWE melt.

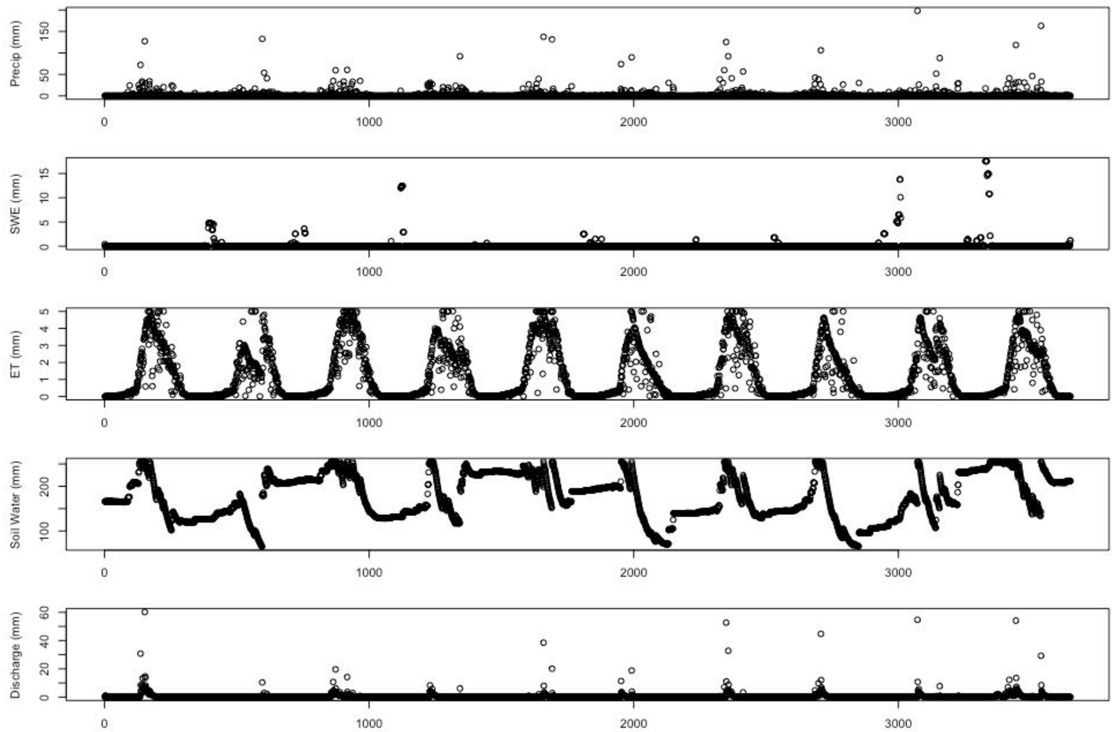

Figure 2: ACCESS projections for multiple hydrologic values of importance over the projected time frame.

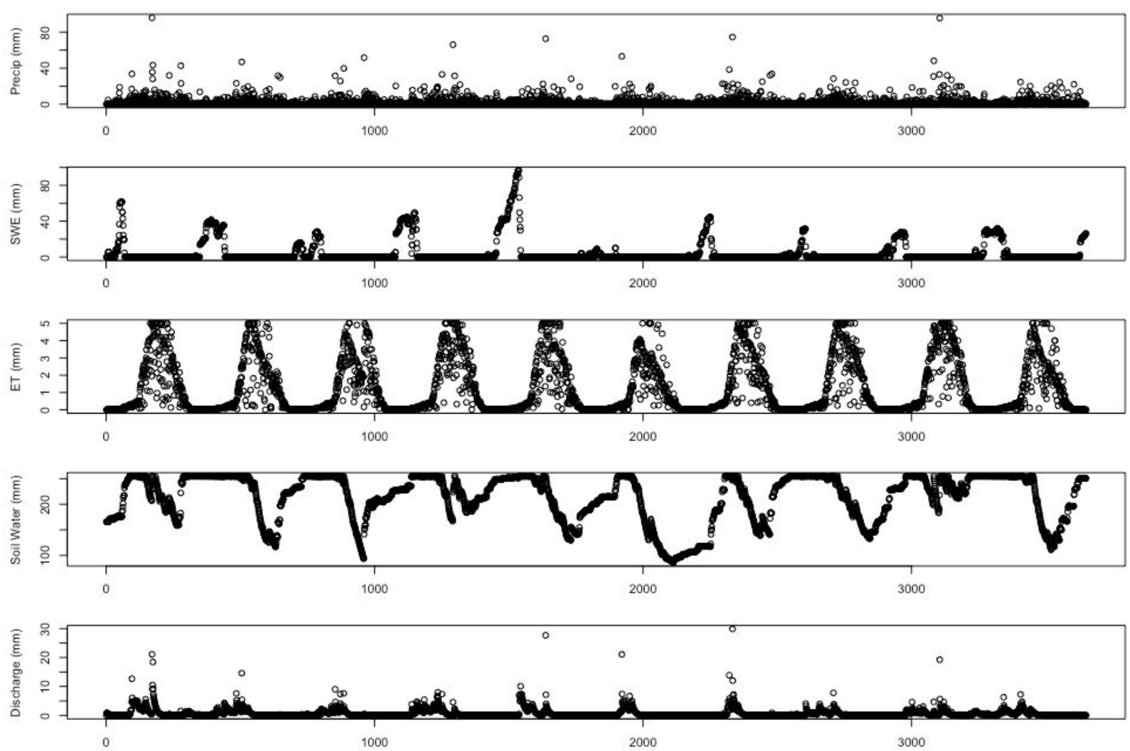

Figure 3: GFDL projections for multiple hydrologic values of importance over the projected time frame.

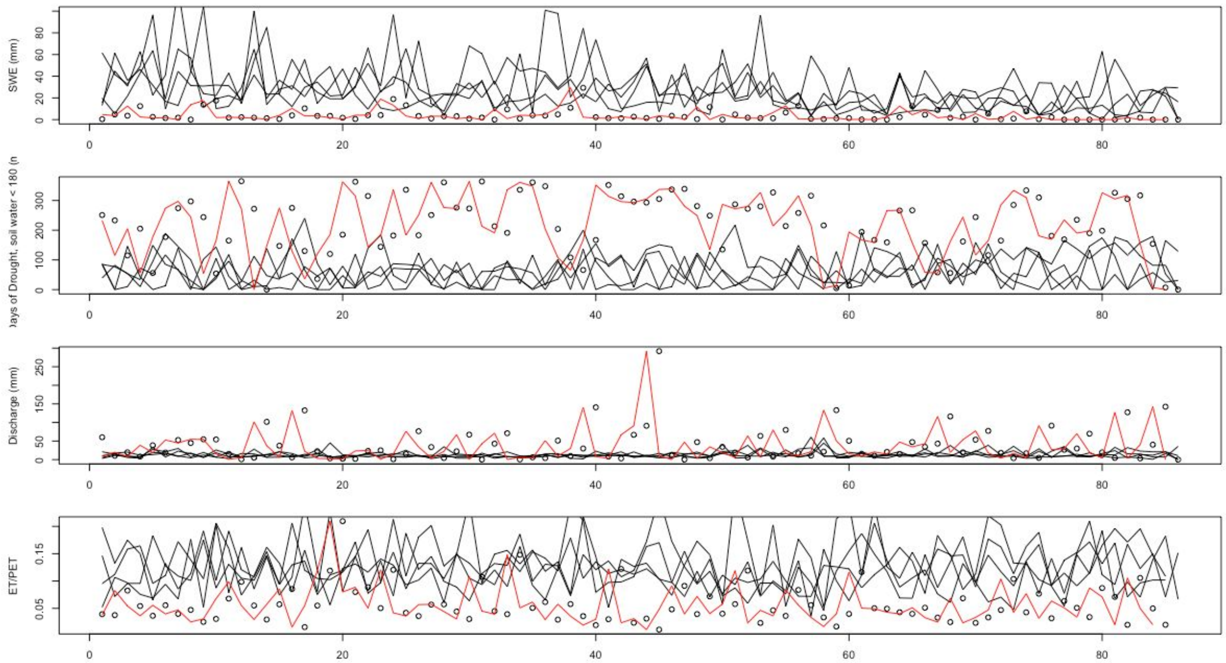

Figure 4: Ensemble averages, shown in red, for the five GCM models to predict SWE, days of drought, runoff, and ET/PET.

Figure 4 shows interested trends in data. Firstly, the ensemble average is clearly impacted by the ACCESS outlier because all models were considered equally in the mean ensemble. The models suggest that SWE decreases over time, days of drought might be more variable with a larger data spread, and discharge and ET/PET seem about consistent. It is expected that increased air temperature leads to increased snowmelt and decreased SWE. Number of days of drought would likely be impacted by the change in SWE. Discharge would be impacted by intensity of snowmelt, impervious surface, and overall soil water storage. ET/PET would be impacted by increased air temperature which might lead to more evaporation, while changes in plant populations might impact transpiration.

The model projections assumed no change in land use, assumed that plant population remained the same, assumed that land use and population stays the same, and that more precipitation falls during the winter and leaves as runoff. The models used were calibrated to historical conditions which means that they might not be applicable to future cases. It would be important to tune parameters to different conditions to see how well they perform.