University of Colorado
Department of Civil, Environmental and Architectural Engineering
CVEN 5333 Physical Hydrology & Hydroclimatology
Homework #1
Due September 8th, 2022
Topics: Mass Balance, Residence time, persistence/variability measures, Flow Duration Curve, Reservoir sizing,

Mass Balance

1. Bras Chapter 1 Problem 5
2. Bras Chapter 1 Problem 6
3. *Mass Balance Equation applied to an Event*
   Chow book – Problem 2.3.2

Assume the initial storage in the basin to be 0.
(i) What percent of precipitation appeared as streamflow during this 8 hour period?
(ii) What was the maximum storage in the basin?
(iii) Plot the time distribution of incremental precipitation, streamflow, change in storage and cumulative storage

Reservoir Sizing and Firm Yield

4. Monthly naturalized flow at Lees Ferry, AZ, the key location on the Colorado River through which over 80% of the flow in the entire river passes, can be obtained from the class page or http://civil.colorado.edu/~balajir/r-session-files/LeesFerry-monflows-1906-2016.txt
   The units are in acre-feet, you can divide by 10^6 to convert them in Million Acre-Feet (MAF) the commonly used unit by water managers on this river.

You are to design a reservoir at this location, to this end, develop a storage-yield curve using the "sequent peak" algorithm. Refer to Loucks et al., (2005), chapter 11, pages 343-347 (http://hdl.handle.net/1813/2804) for additional discussion and perspective on this approach.

- Assume a reservoir starts full, with storage depletion $K_t = 0$. Then the depletion of storage at each time step is:
  $$K_t = K_{t-1} + Q_t - I_t$$
  If K_t from this equation is negative it means inflow was larger than release plus available unfilled storage capacity so the reservoir fills up in that time step and the excess water is released as spill, and K_t reset to 0
- It is common to specify release Q_t as a constant fraction of the overall mean inflow
  $$Q_t = y * I_{avg}$$
  where y is a fraction between 0 and 1, and I_{avg} is the average of the (89 x 12 = 1068) monthly inflows.
- For a given series of inflows the maximum of all K_t is the storage, S, required to sustain the specified releases or yield fraction.
- A storage-yield curve is constructed by calculating S for a series of yield fractions, e.g. y = 0.1, 0.2, ... 0.9, 0.95 and plotting ($y * I_{avg}$) versus S.

[Make sure that I and Q are in volume units and not in flow units. Which means you will have to convert the monthly mean flow (I) to volume by multiplying it by the number of days in the month].

5. Computer the storage - 'firm yield' (or optimal yield) curve. For each storage from problem 4, compute the optimal yield and thus, select the 'design' storage – compare it with the present storage on the river (which is ~60MAF).
   Repeat the same using flows from 1985 ~ 2016.

6. Dingman 3-8 (*Residence Time*)

Streamflow and watershed Characteristics

7. Obtain a series of streamflow data for a river of interest from the USGS (e.g. http://water.usgs.gov/, follow the link to surface water) that has data through water year (Oct – Sep) 2012 and in some cases through 2013. Daily data for 20 years or more is ideal. Prepare a time series plot of the data you downloaded – time vs flow. The USGS has developed a tool dataRetrieval for retrieval of data directly into R that simplifies data retrieval and analysis (if you know R), if not you can work with other packages that you are familiar with – Excel, Matlab etc. I strongly encourage you to learn R and use this problem as opportunity. dataRetrieval https://github.com/USGS-R/dataRetrieval/
For this selected daily flow series that you plotted in the question above compute the average annual flow, peak flow and annual seven day minimum flow. Plot your results similar to figure 2.6 in Dingman.

8. Using the daily flow series from above, make the necessary computation and produce a Flow Duration Curve (FDC). Monthly mean flow defined as average of daily flows within each month (e.g., average of daily flows in Jan 2012). The mean of the monthly streamflow is defined as the average of monthly mean flow across all years (e.g. average of all monthly average flow of Jan). Plot a graph of mean monthly flow (12 months – Jan, Feb, .. Dec on the X-axis and their mean monthly flow on the Y-axis). This provides an indication of the seasonality associated with the hydrologic cycle at this location.

9. For the gauge location selected in problem 7 delineate the contributing area (i.e., the River Basin) - using *Streamstats* obtain the basin characteristics (area, average slope, etc.)