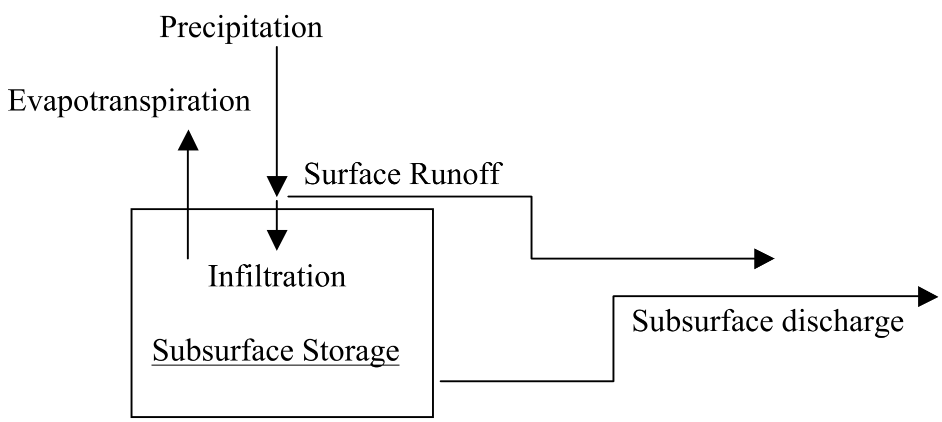
ERE445/645
HW#5
Due Thursday March 24, 2016

Part 2: Due by 5 pm on Thursday March 26th
This assignment builds on elements from the previous homework assignment. We will add a runoff component to the model from HW#4 for the West Branch of the Delaware River at Hale Eddy. Our model will employ Haith's continuous curve number model for runoff (discussed in class) and Hamon's temperature-based evapotranspiration model (from HW#4) to estimate streamflow discharge for 20 years of data (water years 1941 – 1960). The following diagram presents a schematic of this model.



Precipitation is partitioned into either surface runoff or infiltration. Infiltration enters the subsurface and is added to subsurface storage. Evapotranspiration comes from subsurface storage. A portion of subsurface storage is discharged to the stream. Streamflow is composed of surface runoff and subsurface discharge. Note that we will ignore snow and the division of subsurface storage into unsaturated and saturated zones in this model. Below each of the model components is discussed.

Estimating Surface Runoff and Infiltration
You are to use the SCS runoff model with Haith's smoothed curve number approach (discussed in lecture) to estimate the surface runoff, SR_t, on day t. The SCS runoff method is to employ an area-weighted curve number to estimate surface runoff. The table below contains various landcover classes across the watershed and the associated percent drainage areas. These values are based on a GIS analysis of the National Land Cover Dataset (NLCD) for our watershed. You are to estimate the curve number for each landcover class, and determine an area-weighted curve number (CN2) for the entire watershed to be employed in our analysis. Note that the soils vary across the site. Here we will assume a mix of 50% class B soils and 50% class C soils.

Land Cover Types for the West Branch of the Delaware River at Hale Eddy, NY Based on the 2006 National Land Cover Dataset and the 1 arc second Nation Elevation Dataset

Landcover Class	Value	Area (mi^2)	Percent
Open Water	11	5.7	0.96
Developed, Open Space	21	18.6	3.12
Developed, Low Intensity	22	2.2	0.37
Developed, Medium Intensity	23	0.5	0.08
Developed High Intensity	24	0.2	0.03
Barren Land (Rock/Sand/Clay)	31	3.7	0.63
Deciduous Forest	41	354.6	59.59
Evergreen Forest	42	21.9	3.68
Mixed Forest	43	47.6	8.00
Shrub/Scrub	52	4.1	0.69
Grassland/Herbaceous	71	5.8	0.97
Pasture/Hay	81	104.6	17.58
Cultivated Crops	82	18.8	3.16
Woody Wetlands	90	5.8	0.98
Emergent Herbaceous Wetlands	95	0.8	0.14
	Total Area:	**595**	

The surface runoff will then be calculated for each day based on the weighted curve number, the 5-day antecedent moisture condition (the sum of the precipitation on the 5 previous days), and the precipitation on the day. Note that if the precipitation is less than 0.2*S (S is a function of CN), then the surface runoff is equal to zero.

Subsurface Storage, Evapotranspiration, and Subsurface Discharge

This model accounts for subsurface storage using a mass balance approach:

$$SS_{t+1} = SS_t + I_t - ET_t - SD_t$$

Where:

SS_t = Subsurface storage at beginning of day t

I_t = Infiltration on day t

ET_t = Evapotranspiration on day t

SD_t = Subsurface discharge on day t

The infiltration is estimated as the quantity of precipitation (P_t) that is not surface runoff (SR_t):

$$I_t = P_t - SR_t$$

I_t includes interception, depression storage, and infiltrated waters. In Homework 5, Hamon's method was employed to estimate the potential evapotranspiration (ET_t):

$$ET_t \quad = \quad 0.021\, N^2\, e_{st}/(T + 273) \qquad \text{if } T > 0$$

$ET_t \quad = \quad 0 \qquad\qquad\qquad\qquad \text{if } T \leq 0$

where ET_t = potential evapotranspiration (cm/day)
N = number of hours of daylight on day t
e_{st} = saturated water vapor pressue (mb) on day t
T = mean air temperature (°C) on day t

We will assume that as long as enough subsurface storage is available at the beginning of day t, evapotranspiration is equal to ET_t. If $SS_t < ET_t$, then $ET_t = SS_t$.

The subsurface discharge on day t (SD_t) will be calculated using a linear reservoir model, where discharge is linear function of the subsurface storage at the beginning of day t (SS_t):

$$SD_t = (1 - K_b)(SS_t - ET_t)$$

where K_b is the baseflow recession constant.

Streamflow

The final estimated streamflow (Q_t) on day t is estimated as a combination of surface runoff and subsurface discharge:

$$Q_t = SR_t + SD_t$$

Assignment

Using the model described above with a daily time step, you are to determine the daily streamflow for the 1941-1960 water years. You are to use the temperature and precipitation data you employed in HW#5. Assume that the initial 5-day antecedent moisture is zero, the baseflow recession contact (K_b) equals 0.9, and the initial subsurface storage (SS_0) for this model equals zero

a) Determine the Bias and Nash Sutcliffe Efficiency (NSE) for annual average daily streamflow and monthly average streamflows. Report these values.
b) Manually adjust the CN2 value to maximize the NSE of monthly average streamflows. Report the original and new CN2 values, as well as the new Bias and NSE for both annual average daily streamflow and monthly average streamflows
c) A scatter plot containing the predicted (from parts a) and b)) and observed (from HW1) annual average daily streamflow versus water year.
d) A scatter plot of the predicted (from parts a) and b)) and observed (from HW3) average daily streamflow for each month averaged across the 20 years (the month should be on the x-axis).
e) Make a line plot with day on the x-axis and lines for observed daily streamflow and the predicted daily streamflow for parts a) and b) for the 1960 water year.