

Homework No. 2: Precipitation and Interception (due 21 February 2009)

I. Precipitation

1. One of the things that hydrologists commonly do is to estimate the probability of different events. I won't have you go through the full exercise of calculating and plotting data, and then determining its normality, but some of the steps are relatively easy and can still provide some insights. If you want to take this further, you can. Assume you have a site where the sequence of annual precipitation has been measured as:

1987	1197
1988	1036
1989	1155
1990	1250
1991	1436
1992	993
1993	1036
1994	1197
1995	1783
1996	1074
1997	1282
1998	1351
1999	1231
2000	1422
2001	1904
2002	1296
2003	1010
2004	857
2005	1231
2006	1303
2007	1581

(a) Calculate the mean, standard deviation, and skew. (b1) Rank these data from largest to smallest, and calculate the probability of each value using the standard plotting position formula of $p=m/(n+1)$, where p is the probability, m is the rank, and n is the number of years with data. Remember that m and n are integers, so adjust your significant figures accordingly. (b2) Calculate the return period for each data point, using $T=1/p$. Attach a spreadsheet listing the data from parts b1 and b2. (c) Your next step would normally be to plot the data on normal probability paper to see if the data plot as a straight line, indicating that they are normally distributed. If not, you would try some transformations to see if they can be transformed to approximate a normal distribution. If they can't be transformed, you can then try plotting them using a three parameter distribution, with the mean, standard deviation, and skew being estimated from your data or a regional study where more data can be analysed. Note that it is very difficult to determine the "best" probability distribution for a given set of data when there are only a few years of data (e.g., <20).

2. Once you have determined the probability or recurrence interval of a given event, you can then calculate the probability within any specified time period. For example, what is the probability of a 20-year storm event occurring: (a) next year? (b) in the next 5 years? (c) in the next 20 years? (d) Explain why the probability in (c) is or is not equal to 1.0. (For reference, the probability of an event occurring in any given year is $1-(1-p)$, and the probability of a given event occurring in the next n years is $1-(1-p)^n$.)

II. Interception

3. From a process point of view, people often divide interception into an initial storage component and a continuing evaporation component. The idea is that the storage of water in the canopy must first be satisfied before throughfall occurs; once the canopy is wet evaporation proceeds at a relatively constant rate over time (although this rate can vary considerably within storms according to the wind, temperature, and relative humidity). For forests the canopy storage has been estimated to range from 0.5 to 9 mm, and the evaporation rate to range from 10-30% of the total rain or snow fall (Zinke, 1967). However, for ease of calculation hydrologists typically use a simple model in the form of:

$$I = a + b (P_g - a)$$

where I is the interception, a is the storage coefficient, b is the interception rate, and P_g is the gross precipitation for a given storm. (a) Use this formula to calculate the absolute and percent interception for a storm with 15 mm and 105 mm of precipitation, respectively. Assume a relatively dense, closed-canopy forest with a storage capacity of 4 mm and a continuing interception rate of 15%.

III. For Thought (These questions are intended to stimulate additional thinking and any answers will be reviewed, but they are not required and points are not being added or subtracted for “good” or “bad” answers, respectively.)

4. Given your answer to #3, do you think you would need to account for this potential loss when estimating the amount of water that is likely to become runoff?

5. The interactions between hydrology and ecology is now defined as a new field called “ecohydrology”. As one example of ecohydrology, many trees and shrubs in the drier areas of California have smooth bark, such as madrone (*Arbutus menziesii*) and manzanita (*Arctostaphylos spp.*). Can you think of an evolutionary advantage, hydrologically-speaking, to smooth bark vs. rough bark? Although we will talk about this later, you might also want to think about how the soil conditions might vary between the base of a tree or shrub as compared to the interspaces between plants.