ANALYSIS OF METEOROLOGICAL DATA
FOR THE UPPER COLORADO RIVER BASIN

A Progress Report

by

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OBJECTIVES

The objectives of the study at Colorado State University have been two-fold.

1. To obtain frequency distributions of pertinent meteorological parameters to provide climatological data in more useable form than is presently available. This involves use of computer facilities and includes the necessary steps to put back-weather records into format suitable for such computer analyses.
2. To suggest ways for utilizing such "refined" climatological data in problems related to stream flow.

PROCEDURE

The first step in the study was to select stations having suitable length and quality of record and to place the data from the stations on punch cards for the period of record available prior to 1948. After 1948 the data have been placed in IBM form as a matter of routine by the U.S. Weather Bureau. Thirty (30) stations were selected, 19 of them in Colorado, 5 in Utah, 5 in Wyoming and 1 in New Mexico.

The second step in the study was to punch back weather records data into IBM cards. The total number of cards that resulted from the study was about 608,000. This included about 140,000 cards that were obtained from the Weather Bureau and from the States of Utah and Wyoming.

The third step was to reduce the data by preparation of storm total cards. In this process precipitation from individual days was combined into a storm total for consecutive days with precipitation greater than a trace. By using this process the quantity of cards to be handled was reduced from about 608,000 to about 60,000 separate cards.

Listings of the data from individual cards and for the storm totals were made as a part of the checking process. In addition, listings were made of the last storm card from each year. This step gave a summary of the precipitation amount and the number of storms within that particular water year.

After the storm total cards were prepared the information was transferred to tape for entry into the IBM 1620 computer. The computer was used to obtain the probability of occurrence of various precipitation amounts during the water year.

RESULTS

The results of these frequency analyses are partially illustrated by the following list of figures which will appear in the final report:

Figure	Title
1	Stations and inclusive dates for meteorological data used in this study.
2	Mean, standard deviation, and coefficient of variation of annual precipitation (in inches) during a water year.
3	Mean, standard deviation, and coefficient of variation of the number of storms received during a water year. See accompanying text for definition of a storm period.
4	Mean, standard deviation, and coefficient of variation of "Annual precipitation (in inches) contributing to runoff" during a water year, determined by making certain reductions in observed precipitation for assumed evapo-transpiration losses. See accompanying text for details.
5	Mean, standard deviation, and coefficient of variation of the "Number of storms contributing to runoff" during a water year, determined by making certain reductions in observed precipitation amounts for assumed evapo-transpiration losses. See accompanying text for details.
6	Average percentage, standard deviation and coefficient of variation of the number of storm periods giving 25 per cent of annual rainfall for the water year.
7	Average percentage, standard deviation and coefficient of variation of the number of storm periods giving 50 percent of annual rainfall for the water year.
8	Average percentage, standard deviation and coefficient of variation of the number of storm periods giving 75 per cent of annual rainfall for the water year.
9	Mean date, standard deviation in days, and coefficient of variation of acquiring 5 inches of precipitation during a water year. Number in parenthesis indicates the fraction of total years of record in which 5 inches or more of precipitation was received. Dates are not shown for stations for which less than half the total years of record exceeded 5 inches of precipitation.
10	Repeat figure 9, using 10 inches.

11 Repeat figure 9, using 15 inches.

12 Repeat figure 9, using 20 inches.

13 Repeat figure 9, using 25 inches.

14 Probability of receiving more than 5 inches of precipitation during the water year after 1 January, 1 March and 1 May.

15 Repeat figure 14, using 10 inches.

16 Repeat figure 14, using 15 inches.

17 Repeat figure 14, using 20 inches.

18 Mean, standard deviation and coefficient of variation of the amount of precipitation (in inches) received from storms beginning in October.

19 Repeat figure 18, for November.

20 Repeat figure 18, for December.

21 January . . . .

22 February . . .

23 March . . . . .

24 April . . . . .

25 May . . . . .

26 June . . . . .

27 July . . . . .

28 August . . . .

29 Repeat figure 18, for September.

30 Mean, median, mean plus one standard deviation, and extremes of amounts of precipitation (in inches) received from storms beginning in various months of the water year.

31 Frequency distribution of precipitation amounts received for the entire water year, and for storms beginning in January and July.

The above list of figures describes the types of data which will be available in the final report. These data will be presented in map form for the Upper Colorado River Basin.

APPLICATION OF RESULTS

Results of the previous frequency analyses can be applied to any specific problem in which the probability of precipitation for various periods is desired. An example was presented showing how the probability of occurrence of precipitation at successively later periods within the water year could be used in making a probability forecast of the amount of runoff. In this example, the April through July runoff on the Gunnison River, below Gunnison Tunnel, the runoff was assumed to be linearily correlated with precipitation amounts from three separate stations in the Gunnison River Basin. Procedure for the study was to assume that the runoff

$$Y = B_0 + B_1X_L + B_2X_M + B_3X_H$$

where

Y = the April to July runoff in the Gunnison River Basin,

B_0, B_1, B_2, B_3 = constants,

X_L = precipitation from the lowest level station,

X_M = the precipitation from the middle level station, and

X_H = precipitation from the high level stations.

This procedure was repeated for five estimates of evapo-transpiration, one of the five estimates being that no amounts of precipitation were lost by evapo-transpiration. The other four evapo-transpiration estimates were for successively smaller evapo-transpiration losses through the winter time and with higher elevation stations.

Precipitation periods included combinations of months accumulated through the water year. For example, one period was October alone. The second period was October plus November. The third period was October plus November plus December, and so on through October through July. A new series of precipitation periods was considered beginning with November alone, then November plus December, then November plus December plus January and so on through July. The beginning of the precipitation periods used was October, November, December and January. This makes a total of 34 separate precipitation periods.

The various combinations of stations possible with these stations were used. These combinations were the low, middle and high level stations separately. All combinations of the low, middle and high stations were used for a total of seven station combinations. The total number of combinations used for this linear correlation problem were five (5) evaporation transpiration estimates, 34 precipitation periods, and seven station combinations. A total of 1190 separate individual correlations that were computed. A print-out from the 1620 computer gave the values of the constants

$$B_0, B_1, B_2, B_3$$

The standard error of estimates of the individual constants,

Y = standard error of estimate

R = the correlation coefficient.

Results from this study may be summarized as follows:

1. Individual correlation coefficients rarely exceeded 0.60, hence, this is probably not a useable method for estimating runoff in the Gunnison River. This is not surprising, however, since runoff is a function not of rainfall alone but also of ground-water flow, temperature, wind and other hydrologic parameters.
2. The correlation coefficients plotted as a function of precipitation period indicate the significance of
   a. Late fall large storm. This lends support to the hypothesis that a large rainfall amount in September or October, is highly significant in producing above-normal runoffs in the following spring, so that the correlation of October precipitation alone with the following springs runoff gives a significant degree of correlation.
   b. There is a maximum value of the correlation coefficient for the precipitation period extending through April which decreases between May and July.
3. Values of the amounts of evapo-transpiration can be deduced from this process. The study on the Gunnison River indicates that the correct amount of evapo-transpiration for the period being considered was probably slightly less than that estimated in this study from the runoff from the Gunnison.

4. While values of the correlation coefficient less than .6 indicate that a degree of correlation that is probably unacceptable for practical use, it is believed that as the area involved becomes smaller this process should be applicable and give useable results for prediction of seasonal runoff.

DIRECTION OF FUTURE WORK

The work done at Colorado State University should be of value in studies designed to improve the short range (1 to 12 months) prediction of flows in the Upper Colorado River and its tributaries. Further work of the type illustrated for the Gunnison River should improve the forecasting accuracy for such short-term studies.

SUMMARY

Climatological data from the Upper Colorado River Basin have been prepared in a format suitable for computer analyses and frequency combinations of a generalized nature have been prepared for thirty (30) stations within the Upper Colorado River Basin. These data will be available in the form of maps of the Upper Colorado River Basin above Lee's Ferry. Application of these data to a specific problem of seasonal runoff in the Gunnison River begins to give some insight into the physical processes involved in seasonal runoff, including the significance of major storms in the fall of the year, the importance of the April precipitation in the seasonal runoff period, and permits deducing correct values of evapo-transpiration.