TR-7

Streamflow Forecasting Based on Statistical Applications and Measurements Made with Rain Gage and Weather Radar

M. D. Hudlow

- Full Text

Techniques for streamflow forecasting are developed and tested for the Little Washita River in Oklahoma. The basic input for streamflow forecasts is rainfall. the rainfall amounts may be obtained from several sources; however, this study is concerned with the possibility of utilizing weather radar and probabilistic simulation to obtain the rainfall input. Also, the feasibility of a radar, raingage combination is examined.

It is shown that quantitative estimates of runoff can be made from measurements taken with weather radar. In addition, accurate estimates of lag time can be made from radar observations. For a storm which is unevenly distributed over the watershed, it is demonstrated that a better estimation of lag time may be made from radar measurements than from measurements obtained from a sparse rain-gage network (1 gage/110 mi2).

A technique for hydrograph synthesis which utllizes the Pearson type III function is developed. The use of the Pearson function for hydrograph synthesis constitutes a valuable tool for streamflow forecasting. Since this method of hydrograph synthesis is adaptable to the digital computer, the "time factor," which is so important for river forecasts, can be shortened.

A stochastic model (which incorporates a sixth-order Markov chain) for rainfall-runoff simulation is developed. Monte Carlo techniques are coupled with the stochastic model to yield frequency histograms of hydrograph-peak discharges and corresponding lag times. A model such as the one developed in this study could be coupled with radar observations to provide a probabilistic forecast of streamflow-shortly after rainfall commencement.

Introduction

Hydraulic structures such as dams can prevent or reduce damages caused by flooding. However, lack of suitable dam sites and/or economic constraints make the control of floods impractical in many instances. In such cases river forecasts provide an alternative means of reducing both flood damage and loss of life. If a flood forecast is issued in sufficient time to allow people, animals, and property to be evacuated, countless lives and dollars may be saved. The Office of Hydrology, Weather Bureau, Environmental Science Services Administration is the agency responsible for issuing such forecasts. Up-to-date forecasts are maintained for more than 16OO points on our nation's rivers.

The Bureau's forecasts are needed not only when floods threaten but are used daily by many major industries. The forecast provides streamflow information needed for such activities as shipping, production of hydroelectric power, crop irrigation, reservoir operation, manufacturing, and fish and wildlife management. In addition, river forecasts can provide indispensable knowledge for pollution control. The greatest war on water pollution in history is under way in our nation. From a knowledge of the volumetric flow of a stream, discharge of municipal and industrial wastes can be regulated to keep stream pollution within safe limits.

Because of the importance of the "time factor," the most efficient techniques for the preparation and dissemination of forecasts must be utilized o The weather radar's capabilities of spatial and temporal coverage and its speed of data collection represent enormous possibilities for hydrologic work.

Conclusions

It is realized that some of the procedures proposed in this study (particularly the stochastic technique for the simulation of rainfall-runoff) will require further testing with additional storms before their real value can be assessed. Nevertheless, the potential usefulness of the proposed procedures has been demonstrated. The following conclusions may be inferred from this study:

1. Quantitative estimates of runoff can be made from measurements taken with weather radar. In the derivation of procedures for operational forecasting, great effort should be placed in the development of the runoff-prediction equation (Eq. 11 in this study) If the amounts of runoff and the spatial distribution of the rainfall excess are estimated accurately, satisfactory streamflow forecasts can be made.
2. Accurate estimates of lag time can be made from radar observations. The radar is superior to a sparse rain-gage network (1 gage/110 mi2) for depicting the areal distribution of rainfall; this is especially true for storms which are unevenly distributed over the watershed.
3. A radar, rain-gage combination represents a potentially useful arrangement for rainfall measurements if a storm produces appreciable depths of precipitation over the entire basin. Adjustment of radar-derived measurements to conform to rain-gage observations may present difficulties if the precipitation is of a showery type.
4. Hydrograph synthesis with the Pearson type III function constitutes a valuable tool for streamflow forecasting. Since this method of hydrograph synthesis is adaptable to the digital computer, the "time factor" for analysis is very short. Although some of the modern techniques for runoff routing might prove profitable for certain watersheds, the technique for hydrograph synthesis with the Pearson type III function should constitute a valid approach for most basins since temporal and spatial variations in rainfall are considered in the scheme.
5. A stochastic model, such as the one developed in this study, offers great possibilities as a probabilistic forecasting tool. The sixth-order Markov chain appears to reproduce adequately the rainfall process for Ninnekah, Oklahoma. A stochastic model coupled with radar measurements will make possible a probabilistic

forecast of streamflow shortly after rainfall commencement.

Texas Water Resources Institute

1500 Research Parkway A110
2260 TAMU
College Station, TX 77843-2260

Phone: 979.845.1851
Fax: 979.845.0662
Email: twri@tamu.edu

TWRI and the Texas A&M Institute of Renewable Natural Resources are working together to foster and communicate research and educational outreach programs focused on water and natural resources science and management issues in Texas and beyond.