Unit Hydrographs For Small Watersheds in Texas Using Particle-Tracking

Xin He
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204

Theodore G. Cleveland[1]
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204

Xing Fang
Department of Civil Engineering
Lamar University, Beaumont, Texas 77710-0024

David B. Thompson
Department of Civil and Environmental Engineering
Texas Tech University, Lubbock, Texas. 79409

The unit hydrograph is a well-documented method for predicting the runoff hydrograph of a watershed given an excess rainfall hyetograph. Watershed-specific unit hydrographs are parameterized by some conceptual time such as time to peak runoff or time of concentration. Estimation of time parameters when paired rainfall and runoff observations are available is reasonably straightforward. In the absence of paired observations, the parameters are estimated from regression equations that relate unit hydrograph behavior to watershed physical characteristics such as area, slope, and land use. This study performed an exploratory assessment of a particle-tracking (PT) method to estimate unit hydrograph timing parameters directly from a digital elevation model (DEM) instead of the regression approach.

The PT method was used to estimate the unit-hydrograph timing parameters of 135 selected small watersheds in Texas using a DEM of each watershed, and an assumed characteristic velocity to generate a watershed-specific unit-hydrograph. The study watersheds have drainage areas ranging from approximately 0.25 to 150 square miles, main channel lengths ranging from approximately 1 to 50 miles, and dimensionless main channel slopes between approximately 0.0002 and 0.02. The selected watersheds include coastal plains as well as inland hilly regions. Paired rainfall-runoff data for over 2,600 storms were compiled; these provide actual observations to test the performance of the PT model.

[1]corresponding author; 713 743-4280, cleveland@uh.edu

The unit hydrographs from the PT method were used to simulate response to historical storms. These responses are compared to the historical response and to unit hydrographs from conventional methods. The median prediction errors of the conventional and the PT unit hydrographs are approximately the same; the PT method has a 1.5 times larger inter-quartile range. The larger ranges are anticipated, as the PT method does not use actual rainfall or runoff data in generation of the unit-hydrograph. No attempt was made to optimize the characteristic velocity in the model to account for different flow conditions, yet the approach simulated episodic behavior at about the same order of magnitude as observed behavior in terms of peak discharge and timing. Because the results for conventional unit hydrographs and the PT unit hydrographs are nearly the same we conclude that for the small watersheds studied in this research, topography alone is a significant factor controlling runoff behavior and consequently the timing parameters common in all hydrologic models.

Key Words: digital terrain models, unit hydrograph, time to peak, time of concentration, rainfall-runoff