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Incorporating Seasonal Rainfall Intensity and Soil Properties into a Daily Runoff Model

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Assessment of runoff resulting from rainfall not infiltrating into soil is critically important in evaluating the water balance of soils as well as the contribution of surface water to reservoirs, rivers and streams. Runoff is influenced by the amount and intensity of rainfall in addition to the soil and landscape properties. The most lacking of these factors is information on the variability of rainfall intensity over space and time. Thus, simulation of runoff over large areas and long times depends on use of widely recorded daily rainfall. A mass curve approach developed by the USDA Soil Conservation Service has been the primary simulation approach used in soil water balance models developed for use in large areas and long times. We developed an alternative empirical approach using a physically based infiltration equation with using 30 year records of hourly rainfall recorded for numerous sites in the United States. This approach is intended to simulate only the Hortonian flow resulting from near surface soil properties, thus it does not account for saturated flow resulting from runoff caused by subsurface properties or the presence of a water table. Runoff from these latter causes can best be simulated in combination with other daily incrementing models. A range of surface saturated hydraulic conductivity values (Ksat) corresponding to those found in most agricultural soils resulted in hourly runoff estimates. The hourly values were summed to obtain a single daily value. These aggregated results were then used to find empirical functions that were somewhat uniform over space and time. Rainfall amount, Ksat, and maximum daily air temperature (Tmax) were the most influential variables needed to simulate the temporal and spatial variations in daily runoff values estimated from the physical approach. The simplest and most robust model found was a mass balance approach using a linear model between daily rainfall and runoff with an offset rainfall amount in which no runoff occurs. The offset values were first determined using regression techniques and were strongly influenced by Ksat and to a lesser extent by Tmax. Slopes (increment of runoff per unit of rainfall above the offset value) were then determined, and they, too were functions of Ksat and Tmax. The spatial variations in the slopes corresponded rather closely to the reported spatial variations in 10-year 5-minute rainfall intensities for the 48 contiguous U. S. states. Root mean square errors were usually in the range of +-1.0 mm/day for Ksat values between 1 and 3 cm/day, with the error increasing to 2 to 4 mm/day for Ksat values between 15 and 36 cm/day. We believe these empirical procedures add accuracy to soil water balance models when coupled when used with surface ponding capacity and known landscape features.