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基于SCS-CN模型的紫色土坡地径流预测

Runoff estimation in hillslope cropland of purple soil based on SCS-CN model

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英文关键词:runoff optimization precipitation slope gradient soil conservation service-curve number (SCS-CN) model validation curve number initial abstraction ratio

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中文摘要:

地表径流是引起坡面土壤侵蚀的主要动力，对降雨径流进行有效的预测，是紫色土坡地水土保持的基础。SCS-CN模型中的径流曲线数CN和初损系数λ作为主要输入参数对径流模拟精度有重要影响，但在应用于紫色土坡耕地模拟时，却很少进行坡度的调整，而坡度是影响降雨产流的重要因子。该文利用紫色土不同坡度的径流小区，选取2013年的5场降雨产流的实测数据，旨在分析紫色土坡耕地降雨产流量与地表坡度的关系，对现有的基于坡度修正的SCS-CN模型进行适用性评价，并在考虑降雨量影响的基础上对初损系数进行修正。结果表明，次降雨下径流量随坡度的增大而增大，并出现径流影响的临界坡度；经坡度修正后的模型在小降雨事件下的模拟精度较好，但强降雨条件下预测值比实测值均偏大，初损系数λ=0.2适用于紫色土坡地小降雨产流模拟，在强降雨条件下，λ值越大，模型模拟效果越好，当λ=0.3时，修正的模型在紫色土坡地径流模拟效果最理想，此时，模拟值与实测值的平均相对误差为7.42%，模型效率系数达到0.99。而基于坡度调整后的CN值对应坡度6.5°～25°依次为78.23、78.45、78.77、79.11、79.47。该研究结果可为紫色土丘陵区降雨径流预测及水土保持提供参考。

英文摘要:

Abstract: Overland runoff is a main factor causing soil erosion ion hillslope, and runoff modeling is an effective way to predict soil erosion for conservation of the hillslope cropland of purple soil. The model of Soil Conservation Service-curve number (SCS-CN) is widely used for predicting direct runoff discharge based on measured rainfall, and also used as a runoff-estimating component of more complex watershed models. As a basic input parameter in the SCS-CN model, the curve number greatly affects the predictive value of runoff depth, and the initial abstraction ratio (λ) that was assumed to be o 0.2 in the original development of SCS-CN model. When applied in the hillslope areas, few attempts have been made to incorporate a slope gradient factor into the CN method although slope gradient exerts great influence on discharge of overland runoff according to relevant studies. In addition, the initial abstraction ratio is considered to be a constant in many applications, although lots of studies revealed that variations of the ratio exist in different conditions. In this study, the relationship between runoff and slope gradient was revealed by analyzing observed data of 5 rainfall-runoff events in 2013 from experimental plots with slopes varying from 6.5° to 25°. The existing approaches integrating slope gradient factor in the SCS-CN model were directly evaluated for simulating the rainfall-induced runoff in the hillslope cropland of purple soil. Meanwhile, the initial abstraction ratio was optimized considering the influence of rainfall volume. The Nash-Sutcliffe efficiency (E) and relative error (RE) were used in the simulation results evaluation. The results indicated that the observed discharge of runoff increased obviously with the increase of slope gradient in a rainfall event, and the runoff discharge achieved maximum at a critical slope. For our experimental conditions, the slope-modified SCS-CN method proposed by Williams overestimated the runoff depths with Nash-Sutcliffe efficiency (E) of 0.76. The initial abstraction ratio (λ) of 0.2 was applicable to estimate small rainfall-runoff events based on the equation proposed by Huang. For the large rainfall-runoff events, the slope-adjusted CN method put forward by Huang performed better with increasing initial abstraction ratio (λ). It appeared to be appropriate for overland runoff prediction in hillslope cropland of purple soil when the value of λ was equal to 0.3 in the case of large rainfall-runoff events, according to the values of Nash-Sutcliffe efficiency (E=0.99) and mean relative error (RE=7.42%). Runoff discharge observed and estimated by the modified model achieved relatively good agreement in each rainfall-runoff event with mean relative error of 7.58%, 7.93%, 8.92%, 5.98%, and 7.13%, respectively. The results also revealed that the validated curve numbers calculated from the equation developed by Huang were 78.23, 78.45, 78.77, 79.11, and 79.47 for each slope gradient from 6.5° to 25°, respectively. This study provides valuable information for rainfall-runoff estimation and soil and water conservation in the hilly area of purple soil.

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