Comparison of Moving Average-Based, S Growth-Based, and AUF Rainfall-Induced Soil Erosion Area Models

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Keywords: Erosion experiment;S growth model; adaptive updating model; prediction model

Abstract: This paper gives the comparison of the moving average, S growth and adaptive updating forecasting(AUF) models based on the rainfall-induced soil erosion area experiment. The results show that (1) the average relative error of the moving average method is 5.7%–12.1%, while S growth model has an error of 3%–9.7%and average relative error of adaptive updating model is between 3.4%-9.6%. (2) the moving average method is easy to be constructed; the S growth model owns good physical meaning; (3) the AUF model is very reliable since it combines two models.

Introduction

Rainfall-induced soil erosion is widely recognized and modeled for the mechanism and prediction of soil erosion [1-4]. Especially, Nie et al[5] created an S-growth model for eroded soil area prediction based on a physical experiment. Following that, Fan et al[6] used a moving average model for rainfall induced soil eroded prediction. In our study, we develop an AUF model for rainfall-induced soil erosion prediction (the experimental data is from [5]). The comparison and discussion of three models are given. A flume is used to simulate the slope and the rainfall is offered by three nozzles (Fig. 1(a)). The slope angle of the soil layer is 34 degrees.One high-definition digital video camera (5 million pixels) isused to record the changes of the eroded soil area. Experimental schemes are in Table.1. (More details see [5]) The results of experiments are as shown in Fig. 1(b).

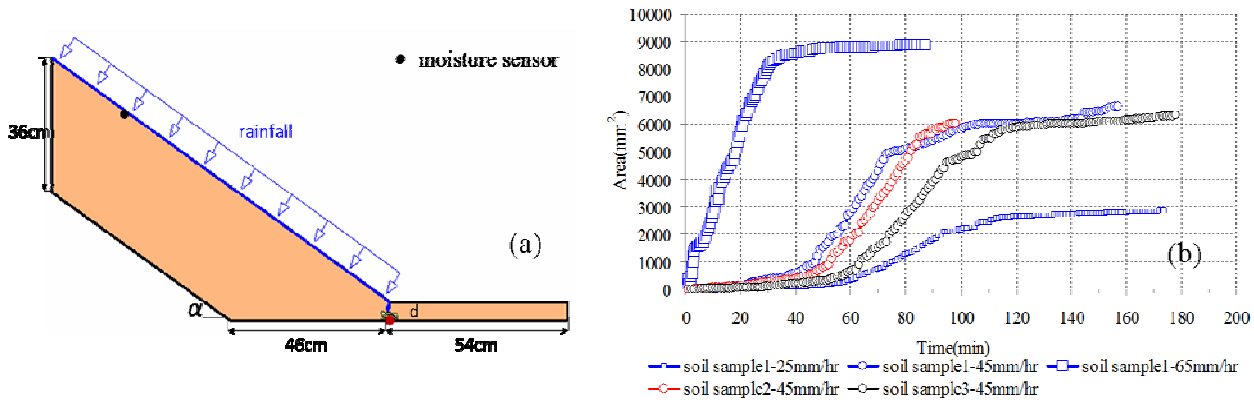

Fig. 1. (a)Geometry of the physical model (b) Results of soil eroded experiments.

Table.1 Experimental scheme

number	ratio of soil	rainfall intensity(mm/hr)
1	12% of clay, 88% of fine sand	25
2	12% of clay, 88% of fine sand	45
3	12% of clay, 88% of fine sand with 5% of coarse sand	45
4	12% of clay, 88% of fine sandwith 20% of coarse sand	45
5	12% of clay, 88% of fine sand	65

Three prediction models

(1) The moving average model[6] is as follows:

$$\hat{Y}_{t+1} = \frac{y_t + y_{t-1} + \cdots + y_{t-N+1}}{N} \tag{1}$$

where $y_t \ldots y_{t-N+1}$ are the erosion areas at time $t \ldots t\text{-}N+1$. $\hat{Y}_{t+1}$ is the predictionerosion area at time $t+1$.

(2) S growth-based model[5] is as follows:

$$S(\mathrm{x}) = \frac{S_m}{1 + \left(\frac{S_m}{S_0} - 1\right) * \exp * \left(-r\left(x - x_0\right)\right)} \tag{2}$$

where s(x) is the soil erosion area; s_0 is initial soil erosion areas; s_m is the most value of soil erosion; x_0 is the threshold of cumulative rainfall for the beginning of erosion; x is the cumulative rainfall; r is soil erosion rate.

(3) AUF model

$$s_i = \frac{S_{i-1} - S_{i-2}}{x_{i-1} - x_{i-2}}\left(x_i - x_{i-2}\right) + S_{i-2} \tag{3}$$

where x_i is the cumulative rainfall at time i and S_i is the corresponding erosion area.

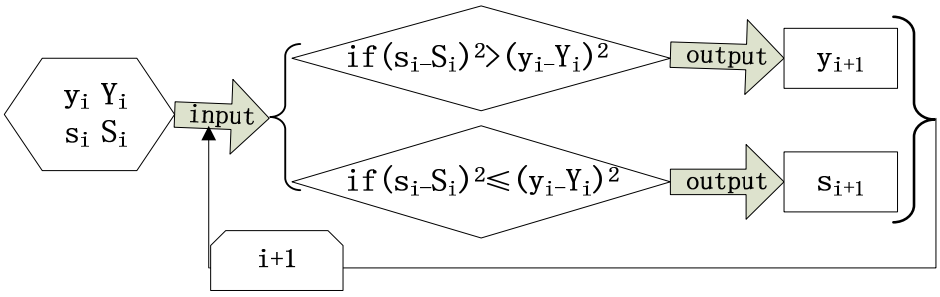

Fig. 2.Adaptive update forecast idea

In Fig.2, the s_i is prediction of soil erosion area of linear model at time i and S_i is the corresponding observation value. y_i is prediction of soil erosion area of moving average model at time $i$and Y_i is the corresponding observation value. The AUF will choose the more accurate prediction of two methods as the final output.

Comparison of three models prediction

Fig. 3 shows the results of sample 1 from three models prediction. Table 2 gives the error analysis of all the experiments.

Table2 the average difference of three models prediction

Sample	Average of different value for soil erosion(mm^2)		
	Moving average model	S growth model	AUF model
1 -25mm/hr	25.00	11.99	12.32
2 -45mm/hr	58.47	26.07	24.49
3-45mm/hr	53.96	25.39	33.69
4 -45mm/hr	53.96	25.88	24.23
5 -65mm/hr	93.78	40.72	30.91

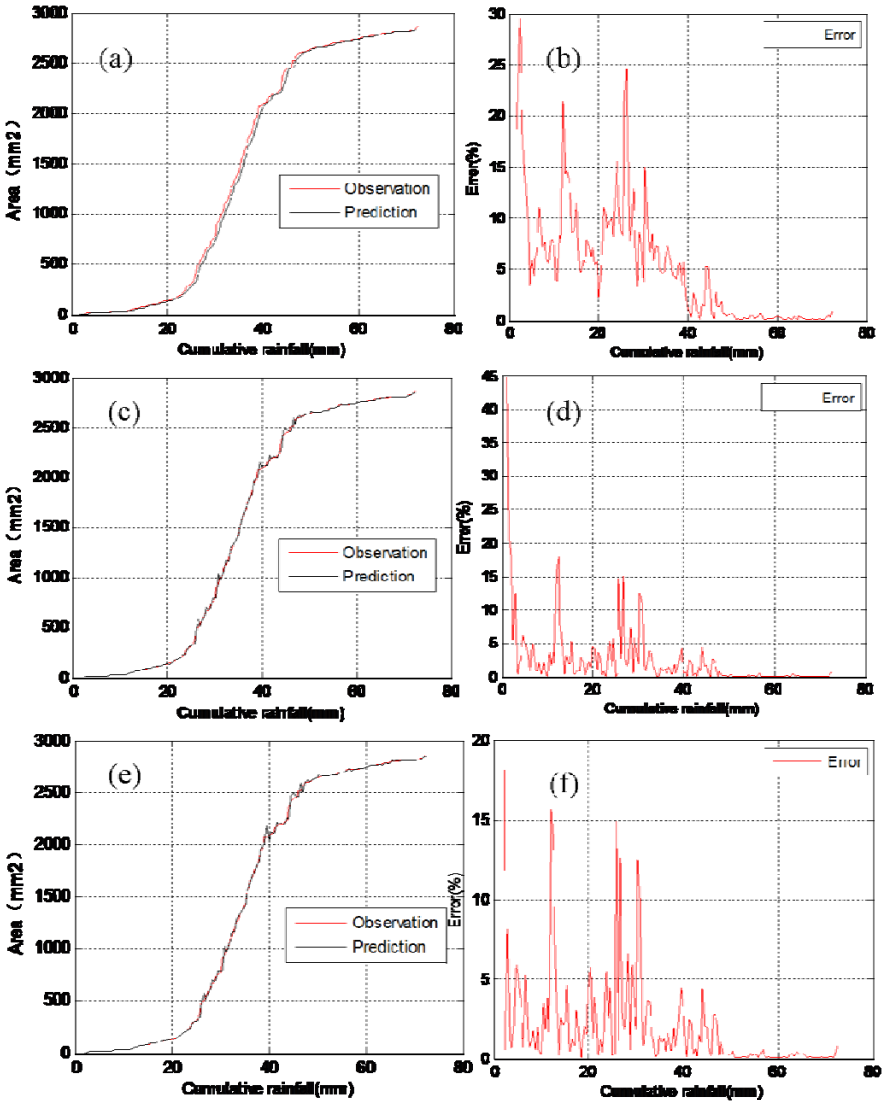

Fig. 3(a)prediction and observation of moving average model (b) error of moving average model (c)prediction and observation of S growth model (d) error of S growth model (e) prediction and observation of AUF model (f) error of AUF model

Conclusions

In this study, three models for rainfall induced soil erosion are compared based on the same experimental data. Prediction of moving average model has a relatively bigger error but the model construction is very simple. The S-growth model can predict the soil erosion area very well unfortunately it is complex. The AUF model has a more reliable structure because it involves combining of two models which means at least one model can work in case the failure of the other one.

Acknowledgements

This work was financially supported by the State Key Laboratory of Geo-hazard Prevention and Geo-environmentProtection(SKLGP2013K007).

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