DEVELOPMENT OF PROCESS-ORIENTED SOIL EROSION MODEL AND UNCERTAINTY ASSESSMENT OF MODEL OUTPUTS

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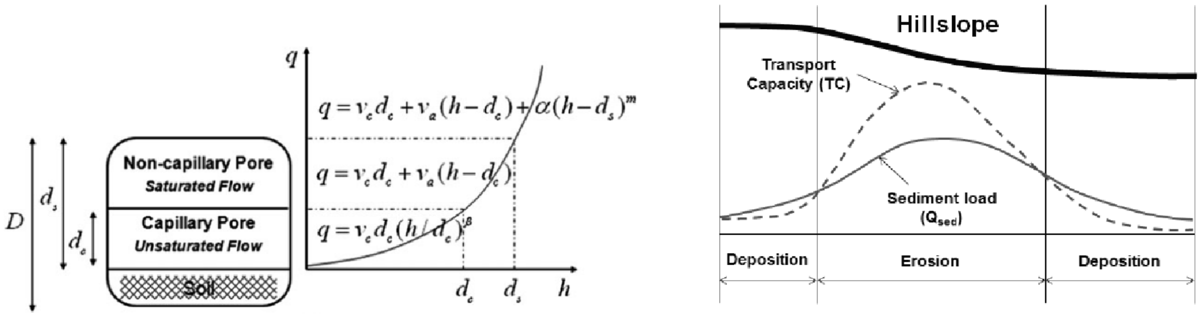
1. INTRODUCTION

In recent years, the rate of soil erosion exceeds the rate of soil formation over wide areas of Korea, resulting in the depletion of soil resources and productive potential. This disparity between erosion and soil-formation rates usually is the result of human activities. Especially, as haphazard land development and unauthorized farming increase in mountainous regions of Korea, soil depletion proceeds at faster rates and over wider areas. According to the National Soil Erosion Research report in Korea (Ministry of Environment, 2012), more than 30% of the land in Korea lead to an annual soil loss of 33 ton/ha, which corresponds to the 'severe' level of OECD soil erosion standards. In addition, about 20% of the land suffers from a serious soil loss problem exceeding 50 ton/hec·year. Computer models are good alternatives for soil erosion simulation at catchment scale; they take into account many of the complex interactions of soil erosion mechanisms in time and space. Commonly used soil erosion models developed in the last decades tend to shift in their methodology from empirical or conceptual approaches such as USLE family models in the 1970s to physics-based approaches in the present. In this study, we developed the process-oriented soil erosion model which consists of two basic modules: rainfall-runoff module and erosion-sediment yield module and then applied the model for soil erosion simulation due to typhoon events. Moreover, we assessed model uncertainties by coupling the model with particle-filtering method.

2. METHODOLOGIES

The rainfall–runoff transformation is based on the assumption that each hillslope element is covered with a permeable soil layer. This soil layer consists of a capillary layer and a non-capillary layer. In these conceptual soil layers, slow and quick flow are simulated as unsaturated Darcy flow and saturated Darcy flow, respectively, and surface flow occurs if water depth exceeds soil water capacity. The erosion-sediment yield module based on the unit stream power concept was linked with the rainfall-runoff module systemically to compute soil detachment, transport, and deposition processes. The algorithm of the erosion-sediment yield module is dependent on the comparison between transport capacity (TC) and sediment supply (Qsed); when surface runoff occurs in a grid cell and the TC of flow is larger than the Qsed from the upper grid cell, the sediment of TC – Qsed will be yielded (i.e., erosion). In contrast, if TC is smaller than Qsed from the upper grid cell, the sediment of Qsed - TC will be accumulated in a grid cell (i.e., deposition). The model with the two modules provides both catchment-aggregated responses, such as hydrographs and sedigraphs, and the spatial pattern of erosion and deposition within a modeling domain.



a) b)

***Figure 1**. Schematic diagrams of (a) rainfall-runoff and (b) erosion-sediment yield*

3. MODEL APPLICATION AND UNCERTAINTY ASSESSMENT

We applied the model to the Cheoncheon catchment, upstream of Yongdam dam in Korea for three flood events caused by large typhoons. Measured versus predicted values of runoff and sediment discharge, and soil redistribution (due to erosion and deposition) were plotted and discussed. In addition, the GIS technique was used to analyze the relationship between spatially distributed rainfall and erosion or deposition at each grid cell within the study site. Finally, we produced the most optimal time-varying parameter sets and uncertainty bounds of simulation of both discharge and sediment discharge at each time step of the study events. Figure 2 shows comparison of hydrograph and sedigraph data during the Rusa flood event and Figure 3 shows the spatial pattern of erosion and deposition within the study site. The proposed model properly simulated the hydrological responses (such as runoff and sediment load) of the study catchment, subject to spatially and temporally variable rainfall fields, generated by the Thiessen method. At the Cheoncheon outlet, which has hydrological measurement equipment, simulated peak discharge and time to peak discharge values were close to the observed values, although the simulated high concentration sediment loads were underestimated compared with actual observations. Finally, the particle-filter method generates the optimal parameters within feasible ranges as well as various parameters based on the calculated likelihood; consequently, it results in weight averaged computational outputs as well as simulation uncertainty bounds as shown in Figure 2.

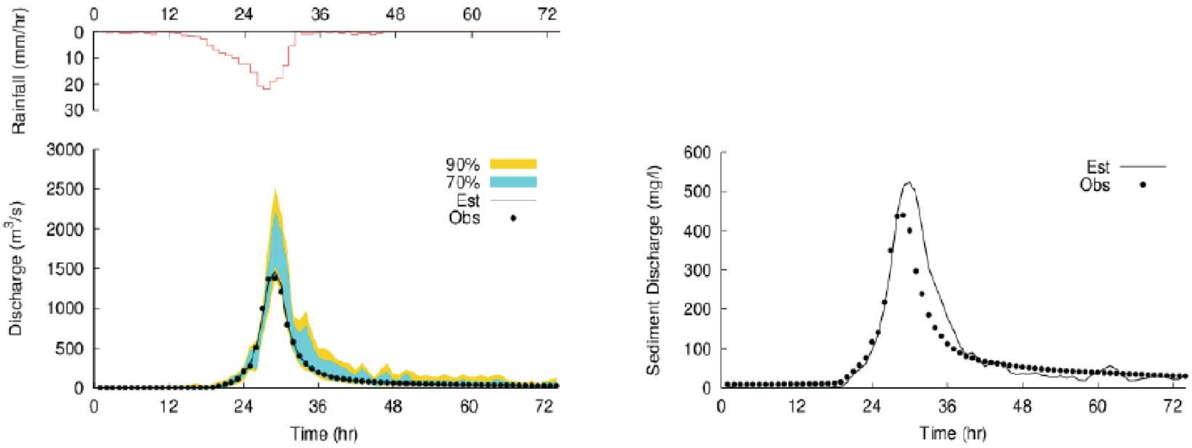


***Figure 2.** Comparison of hydrograph and sedigraph data with uncertainty bounds during the Rusa flood event*

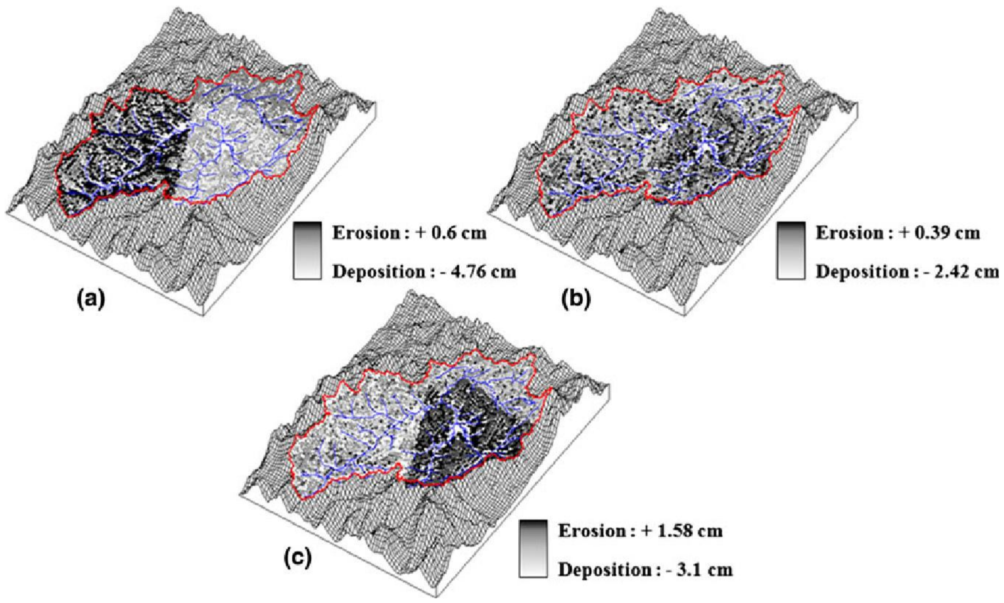


Figure 3. *Soil erosion and deposition in the Cheoncheon catchment for the three events: a Rusa (2002); b Maemi (2003); c Nari (2007)*

4. REFERENCES

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