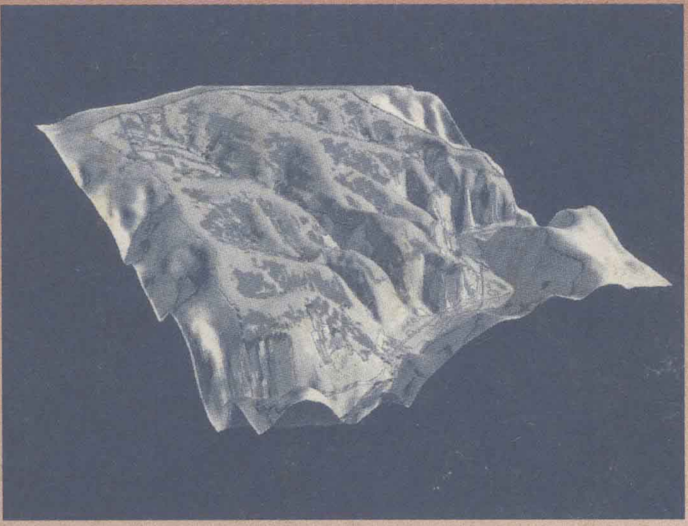
Jürgen Schmidt (Ed.)

Soil Erosion



Application of Physically Based Models

Springer

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Application of Physically Based Models

With 119 Figures and 85 Tables

Springer

Editor

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Preface

Soil erosion at the present extent is mainly a result of human activities and not a product of natural processes. Without human impact, the earth's soil surface would be almost completely covered by permanent vegetation with the exception of extreme climatic environments, such as deserts, polar or high mountainous areas. The main natural hazards which may cause erosion under natural conditions would be natural fires, storms, volcanic eruptions, or meteorite impacts. Since such hazards would have only local and temporary effects on the vegetation cover, one can assume that – especially in the regions of temperate climate – the amount of soil loss as a result of natural processes would be negligible.

The use of soils by man – in particular for agriculture – constrains to remove the natural vegetation cover and to replace it by crops. Thus, the protection of the soils from the direct impact of wind and water is, at least, temporarily suspended. Accelerated erosion caused by water and wind is the inevitable consequence.

Erosion leads to the irreversible degradation of soils and to the loss of their ecological and economic functions. Once the soil has been lost, it cannot be compensated by natural soil restoration within reasonable time periods. In addition, erosion usually causes further off-site damages by depositing the transported material on adjacent sites. Moreover, eroded sediments and sediment-bound chemicals may enter the surface water system, resulting in long-term eutrophication and toxification.

Erosion is usually regarded as a slow and almost imperceptible process which occurs in a large number of isolated erosion events. In fact many difficulties are associated with the monitoring and surveying of erosion processes. In most cases direct measurements of soil loss are limited to small experimental plots on which the relevant hydraulic conditions of erosion cannot be completely reproduced. For the same reasons, plot measurements cannot be directly transferred to natural slopes and watersheds without taking the differing hydraulic conditions into account.

Nevertheless, the first mathematical approach to describe soil erosion by water, the UNIVERSAL SOIL LOSS EQUATION (USLE) by Wischmeier and Smith (1965), was derived by correlating the amount of soil loss gained from experimental plots with various topographic, climate, soil, and land use parameters. More recently developed soil erosion models mainly use physically based approaches which allow adequate representation and quantitative estimation of erosion (soil detachment and transport) and deposition. Such models and their practical application are the main subject of this book.

Table 0.1 provides an overview of the various soil erosion models which are described in this book. The models are sorted by the year of their first publication. The

Table 0.1. Overview of the soil erosion models described in this book

Name	Author	Chapter
AGNPS	Young et al. (1987)	3
SMODERP	Holy et al. (1989)	8
WEPP	Lane and Nearing (1989)	1, 11
EUROSEM/KINEROS	Morgan et al. (1992); Woolhiser et al. (1990)	10, 11, 13
EROSION 2D/3D	Schmidt (1991); von Werner (1995)	5, 6, 7, 9, 11
PEPP-HILLFLOW	Schramm (1994); Bronstert (1994)	4, 12
LISEM	De Roo et al. (1996)	2

table shows that the first physically based soil erosion models were developed about 15 years ago. This book was particularly motivated by the fact that, in the meantime, the results of numerous practical applications of these models have become available.

This book is divided into three parts. It mainly focuses on the papers in Part I in which nine different examples for practical model applications are described. Part II consists of three papers that deal with the validation of physically based soil erosion models. Finally, the two papers in Part III provide information on current developments of recent modelling approaches.

References

Bronstert A (1994) Modellierung der Abflußbildung und der Bodenwasserdynamik von Hängen. Mitt Inst Hydrologie und Wasserwirtschaft, Univ Karlsruhe, H 45

De Roo APJ, Wesseling CG, Ritsema CJ (1996) LISEM: a single event physically-based hydrologic and soil erosion model for drainage basins. Hydrological Processes, Part I:1107-1117, Part II:1119-1126

Holy M, Váška J, Vrána K (1989) SMODERP – Simulation Model for Determination of Surface Runoff and Prediction of Erosion Processes. User's Guide. Faculty of Civil Engineering CTU Prague, pp 24

Lane LJ, Nearing MA (eds) (1989) USDA – Water erosion prediction project: hillslope profile model documentation. NSERL Report 2 (USDA-ARS National Soil Erosion Laboratory), West Lafayette, Indiana, USA

Morgan RPC, Quinton JN, Rickson RJ (1992) EUROSEM documentation manual, Version 1. Silsoe College, Silsoe

Schmidt J (1991) A mathematical model to simulate rainfall erosion. In: Bork HR, De Ploey J, Schick AP (eds) Erosion, transport and deposition processes – theories and models. Catena, Supplement 19:101-109

Schramm M (1994) Ein Erosionsmodell mit zeitlich und räumlich veränderlicher Rillengeometrie. Mitt Inst Wasserbau und Kulturtechnik, Univ Karlsruhe, H 190

Werner M von (1995) GIS-orientierte Methoden der digitalen Reliefanalyse zur Modellierung von Bodenerosion in kleinen Einzugsgebieten. PhD thesis, Department of Geography, Berlin Free University

Wischmeier WH, Smith DD (1965) Predicting rainfall-erosion losses from cropland east of the Rocky Mountains. Agr Handbook 282 (USDA), Washington DC

Woolhiser DA, Smith RE, Goddrich DC (1990) KINEROS, a kinematic runoff and erosion model, documentation and user manual. US Department of Agriculture – Agricultural Research Service 77, Washington DC

Young RA, Onstad CA, Bosch DD, Anderson WP (1987) AGNPS, Agricultural Non-Point-Source Pollution Model – a watershed analysis tool. United States Department of Agriculture, Conservation Research Report, 35-80

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