

5.6.12 Modelling Geomorphic Systems: Landscape Evolution

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Landscape evolution models (LEMs) present the geomorphologist with a means of investigating how landscapes evolve in response to external forcings, such as climate and tectonics, as well as internal process laws. LEMs typically incorporate a range of different geomorphic transport laws integrated in a way that simulates the evolution of a 3D terrain surface forward through time. The strengths of LEMs as research tools lie in their ability to rapidly test many different hypotheses of landscape evolution, to investigate the importance of particular processes by isolating them within a model, and to make quantitative predictions of geomorphic change within landscapes. LEMs can be applied to situations lasting from days to millions of years in real time, but reduce this to minutes or hours in model run-time. This chapter presents a brief introduction to the underlying principles of landscape evolution modelling, followed by an overview of the features of currently available, commonly-used models, and example applications from recent literature. Suggestions for dealing with common pitfalls in landscape evolution modelling, calibration, and confirming model predictions are also discussed.

KEYWORDS: numerical modelling, landscape evolution, fluvial, hillslope

Introduction

Landscape evolution models (LEMs) are quantitative tools used to simulate Earth surface processes and the evolution of the land surface. LEMs can be used to deduce whether hypotheses about landscape evolution are likely to be valid, by making quantitative predictions about their development. The earliest LEMs were conceptual and largely qualitative, such as the early pictorial landscape evolution diagrams by Gilbert (1880). Figure 1a. Gilbert's model contains many of the key components in a modern LEM. The background schematic depicts the effect of an uplift field alone on the landscape, and the foreground depicts the combined effects of uplift and erosion. Gilbert also recognised the important concept of boundary conditions in LEMs, stating that the base of the diagram represents a fixed sea-level in this case. These early models offered insight into the potential course of landscape evolution, and sowed the seeds

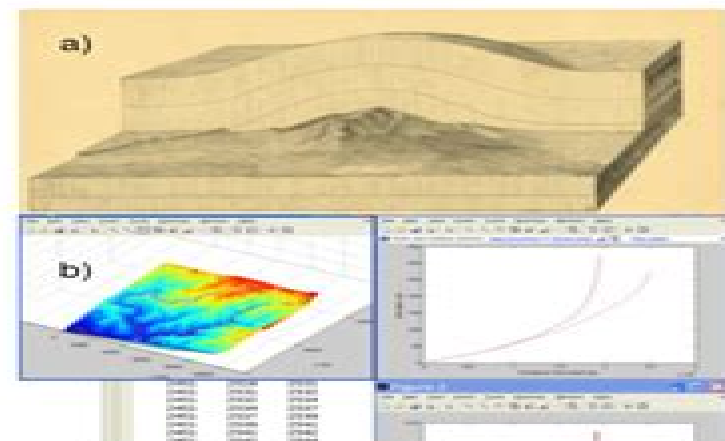


Figure 1. The evolution of LEMs. (a) The diagrammatic LEM of Gilbert (1880) compared to (b) a computer numerical model (CHILD, Tucker et al. 2001).

Modelling Geomorphological Systems

Russell S. Harmon, William W. Doe III



Modelling Geomorphological Systems:

Modelling Geomorphological Systems M. G. Anderson, 1988-07-04 Discusses a broad spectrum of topics in current modelling research in hillslope and river channel processes The book is designed to provide a coherent basis for understanding the potential range of modelling activity within hillslope and channel process investigations and to give readers an appreciation of the modelling challenges that still remain Topics cover research in specific areas of process study including equilibrium mathematical network and flow process models Also discussed are alternative modelling approaches within specific fields model validation and verification and the development of computer simulation as a significant and established element in geomorphological investigations *Encyclopedia of Geomorphology* Andrew Goudie, 2013-04-15 Volume editor is the leading authority in the field Alphabetically organized in two volumes c 700 comprehensively signed cross referenced and indexed entries Detailed bibliographies and suggestions for further reading follow most entries Fully illustrated over 300 plates and line drawings Written by an editorial team of over 270 experts from over thirty countries

Integration of Computer Modeling and Field Observations in Geomorphology J.F. Shroder, M.P. Bishop, 2003-09-26 The integration of classic field gathered data with new computer models has allowed many new advances in geomorphology which the 31st Binghamton Millennium Symposium 2000 presents in this latest of the well known Binghamton book series the *Integration of Computer Modeling and Field Observations in Geomorphology* Conceptual models have been most commonly inferred from analyses of topography and investigator perspectives derived from fieldwork The main stumbling blocks to understanding surface processes their interactions temporal changes and resulting landforms are the difficulty of observation geological timescales involved spatial scale dependencies and the inability to attribute differences to either process or age Physically based computer models have thus become essential tools primarily because of their ability to explore spatial and temporal trends and to determine the sensitivity of physical inputs to change without the difficulties of identification and generalization associated with the complexity of field studies Thus the combination of both methods or the integration of field methods with computer modeling become a very powerful mechanism for robust understanding This new book presents topics on fluvial processes of overland and channelized flow in arid humid and periglacial areas of high and low relief as well as work on interlinked biogeographic and geomorphic fluctuations in alpine terrain and ground penetrating radar of coastal geomorphology Issues of long term evolution of drainage networks are addressed in natural systems as well as stream table environments and terrain analyses characterize surficial and subsurface geomorphic features by using GIS and remote sensing Botanical and biogeomorphologic controls of landforms are assessed along with issues of scientific visualization cartographic representation DEMs spatial analyses and scale dependencies

Recent Advances in the Modeling of Hydrologic Systems D.S Bowles, P. Enda O'Connell, 2012-12-06 Modeling of the rainfall runoff process is of both scientific and practical significance Many of the currently used mathematical models of

hydrologic systems were developed a generation ago. Much of the effort since then has focused on refining these models rather than on developing new models based on improved scientific understanding. In the past few years, however, a renewed effort has been made to improve both our fundamental understanding of hydrologic processes and to exploit technological advances in computing and remote sensing. It is against this background that the NATO Advanced Study Institute on Recent Advances in the Modeling of Hydrologic Systems was organized. The idea for holding a NATO ASI on this topic grew out of an informal discussion between one of the co-directors and Professor Francisco Nunes Correia at a previous NATO ASI held at Tucson, Arizona, in 1985. The Special Program Panel on Global Transport Mechanisms in the Geo Sciences of the NATO Scientific Affairs Division agreed to sponsor the ASI and an organizing committee was formed. The committee comprised the co-directors Professor David S. Bowles, U.S.A. and Professor P. Enda O. Connell, U.K. and Professor Francisco Nunes Correia, Portugal. Dr. Donn G. DeCoursey, U.S.A. and Professor Ezio Todini, Italy.

The SAGE Handbook of Geomorphology Kenneth J. Gregory, Andrew S. Goudie, 2011-06-22. Geomorphology is the study of the Earth's diverse physical land surface features and the dynamic processes that shape these features. Examining natural and anthropogenic processes, *The SAGE Handbook of Geomorphology* is a comprehensive exposition of the fundamentals of geomorphology that examines form, process, and applications of the discipline. Organized into five substantive sections, the Handbook is an overview of Foundations and Relevance, including the nature and scope of geomorphology, the origins and development of geomorphology, the role and character of theory in geomorphology, geomorphology and environmental management, and geomorphology and society. Techniques and Approaches, including observations and experiments, geomorphological mapping, the significance of models, process and form, dating surfaces and sediment, remote sensing in geomorphology, GIS in geomorphology, biogeomorphology, human activity, Process and Environment, including the evolution of regolith, weathering, fluids, flows, and fluxes, sediment transport and deposition, hill slopes, riverine environments, glacial geomorphology, periglacial environments, coastal environments, aeolian environments, tropical environments, karst and karst processes, Environmental Change, including landscape evolution and tectonics, interpreting quaternary environments, environmental change, disturbance, and responses to geomorphic systems, Conclusion, including challenges and perspectives, and a concluding review. The Handbook has contributions from 48 international authors and was initially organized by the International Association of Geomorphologists. This will be a much used and much cited reference for researchers in Geomorphology, Physical Geography, and the Environmental Sciences.

Tools in Fluvial Geomorphology G. Mathias Kondolf, Hervé Piégay, 2005-01-28. In recent years, there has been a marked increase in funding and employment in river restoration. *Methods in Fluvial Geomorphology* provides an integrated approach to the interdisciplinary nature of the subject and offers guidance for researchers and professionals on the tools available to answer questions on river management on every difference scale. Each chapter is organized to cover everything from general concepts to specific techniques. Topics covered include evolution of methods, guiding concepts,

a framework for deciding when to apply specific tools advantages and limitation of the tools sources of data equipment and supplies needed and a summary table Provides the professional with a useful handbook covering all tools used in fluvial geomorphology Also provides valuable information on the advantages and limitations of the tools All chapters include case studies to give examples of the applications of the tools discussed **Selected Water Resources Abstracts** ,1990

Landscape Erosion and Evolution Modeling Russell S. Harmon, William W. Doe III, 2012-12-06 Landscapes are characterized by a wide variation both spatially and temporally of tolerance and response to natural processes and anthropogenic stress These tolerances and responses can be analyzed through individual landscape parameters such as soils vegetation water etc or holistically through ecosystem or watershed studies However such approaches are both time consuming and costly Soil erosion and landscape evolution modeling provide a simulation environment in which both the short and long term consequences of land use activities and alternative land use strategies can be compared and evaluated Such models provide the foundation for the development of land management decision support systems Landscape Erosion and Evolution Modeling is a state of the art interdisciplinary volume addressing the broad theme of soil erosion and landscape evolution modeling from different philosophical and technical approaches ranging from those developed from considerations of first principle soil water physics and mechanics to those developed empirically according to sets of behavioral or empirical rules deriving from field observations and measurements The validation and calibration of models through field studies is also included This volume will be essential reading for researchers in earth environmental and ecosystem sciences hydrology civil engineering forestry soil science agriculture and climate change studies In addition it will have direct relevance to the public and private land management communities *Introduction to Process Geomorphology* Vijay K. Sharma, 2010-04-21 Introduction to Process Geomorphology provides an integrative approach to the process dynamics and the origin of landforms by the contemporary processes involved in their evolution The author highlights the physical and chemical laws governing the activity of the earth surface processes in specific environmental stress conditions puts forward com Fundamentals of Geomorphology Richard Huggett, Emma Shuttleworth, 2022-12-22 This revised and updated edition continues to provide a comprehensive introduction to the subject exploring the world's landforms from a broad systems perspective It covers the basics of Earth surface forms and processes while reflecting on the latest developments in the field Fundamentals of Geomorphology begins with a consideration of the nature of geomorphology including its relation to society process and form history and geomorphic systems and moves on to discuss Structure structural landforms associated with plate tectonics and those associated with volcanoes and folds faults and joints Process and form landforms resulting from or influenced by the exogenic agencies of weathering running water flowing ice and meltwater ground ice and frost the wind and the sea landforms developed on limestone extraterrestrial landforms and landscape evolution a discussion of ancient landforms Fundamentals of Geomorphology provides a stimulating and innovative

perspective on the key topics and debates within the field of geomorphology Written in an accessible and lively manner it includes guides to further reading chapter summaries and an extensive glossary of key terms The book is also illustrated throughout with over 200 informative diagrams and attractive photographs all in colour It is supported by online resources for students and instructors Process Modelling and Landform Evolution Stefan Hergarten, Horst J.

Neugebauer, 2006-04-10 This book presents approaches to landscape modelling not only from geography but also from various related disciplines especially from applied mathematics computer science and geophysics New methods of terrain representation analysis and classification are presented as well as short and long term process models The intention of the book is not to give a complete overview of these broad and complex topics but to stimulate interdisciplinary cooperation and to encourage scientists to consider the ideas of related disciplines **Soil Erosion in Europe** John Boardman, Jean

Poesen, 2007-01-11 Provides a unique and comprehensive assessment of soil erosion throughout Europe an important aspect to control and manage if landscapes are to be sustained for the future Written in two parts Soil Erosion in Europe primarily focuses on current issues area specific soil erosion rates on and off site impacts government responses soil conservation measures and soil erosion risk maps The first part overviews the erosion processes and the problems encountered within each European country whilst the second section takes a cross cutting theme approach Based on an EU funded project that has been running for four years with erosion scientists from 19 countries Reviews contemporary erosion processes and rates on arable and rangeland in Europe Looks at current issues such as socio economic drivers controlling factors specific to the country and changes in land use *Applied Geomorphology* R. J. Allison, 2002-06-14

Erstmals wurden in diesem Buch praktische Beispiele geomorphologischer Daten aus der ganzen Welt zusammengetragen um zu zeigen wie sich mit Hilfe dieser Informationen präzise Vorschläge zur Landnutzung und zur Abschätzung von Katastrophenrisiken erarbeiten lassen Fallstudien zeigen wie sich Risiken erkennen lassen Experten kommentieren jeweils den neuesten Stand der Forschung Nicht zuletzt zeigt der Autor auch wann man einen Missbrauch der Umwelt mit geomorphologischen Mitteln korrigieren kann Geomorphology Mr. Rohit Manglik, 2024-05-24 Focuses on the formation and evolution of landforms through fluvial glacial and aeolian processes supported by models and field based case studies

Fundamentals of Geomorphology Richard John Huggett, 2011-03-15 This extensively revised restructured and updated edition continues to present an engaging and comprehensive introduction to the subject exploring the world's landforms from a broad systems perspective It covers the basics of Earth surface forms and processes while reflecting on the latest developments in the field Fundamentals of Geomorphology begins with a consideration of the nature of geomorphology process and form history and geomorphic systems and moves on to discuss structure structural landforms associated with plate tectonics and those associated with volcanoes impact craters and folds faults and joints process and form landforms resulting from or influenced by the exogenic agencies of weathering running water flowing ice and meltwater ground ice and frost the wind and the sea landforms

developed on limestone and landscape evolution a discussion of ancient landforms including palaeosurfaces stagnant landscape features and evolutionary aspects of landscape change This third edition has been fully updated to include a clearer initial explanation of the nature of geomorphology of land surface process and form and of land surface change over different timescales The text has been restructured to incorporate information on geomorphic materials and processes at more suitable points in the book Finally historical geomorphology has been integrated throughout the text to reflect the importance of history in all aspects of geomorphology Fundamentals of Geomorphology provides a stimulating and innovative perspective on the key topics and debates within the field of geomorphology Written in an accessible and lively manner it includes guides to further reading chapter summaries and an extensive glossary of key terms The book is also illustrated throughout with over 200 informative diagrams and attractive photographs all in colour

Modelling Soil Erosion by Water John Boardman, David Favis-Mortlock, 2013-06-29 TO THE MODEL EVALUATION 1 MODELLING SOIL EROSION BY WATER 1 2 John Boardman and David Favis Mortlock 1 School of Geography and Environmental Change Unit Mansfield Road University of Oxford Oxford OX1 3TB UK 2 Environmental Change Unit University of Oxford 5 South Parks Road Oxford OX1 3UB UK Introduction This volume is the Proceedings of the NATO Advanced Research Workshop Global Change Modelling Soil Erosion by Water which was held on 14th September 1995 at the University of Oxford UK The meeting was also one of a series organised by the IGBP 1 GCTE Soil Erosion Network which is a component of GCTE's Land Degradation Task 3 3 2 Ingram et al 1996 Valentin this volume One aim of the GCTE Soil Erosion Network is to evaluate the suitability of existing soil erosion models for predicting the possible impacts of global change upon soil erosion Due to the wide range of erosion models currently in use or under development it was decided to evaluate models in the following sequence Favis Mortlock et al 1996 field scale water erosion models catchment scale water erosion models wind erosion models models with a landscape scale and larger focus As part of this strategy the first stage of the GCTE validation of field scale erosion models was carried out at the Oxford NATO ARW I A list of Acronyms forms Appendix A

Monitoring and Modelling Dynamic Environments Alan P. Dykes, Mark Mulligan, John Wainwright, 2015-07-17 The Times Obituaries 4 August 2008 reported that John Thornes was one of the most eminent and influential physical geographers of his generation John's keen interest in understanding landform processes and evolution was furthered through a variety of methods and informed across a range of disciplinary boundaries In particular he pushed for better integration of monitoring theoretical and simulation modelling field and laboratory experimentation and remote sensing techniques Although dominated by an interest in the Mediterranean region and problems of land degradation his research activities ranged across a number of time scales and with other environmental perspectives This collection of papers reflects this wide range of John's interests through the recent work of scientists and professionals most strongly influenced by his rigorous training or leadership The thematic focus of the book which runs through all of the main contributions is the integration of different methodologies and the application of this

approach to improved understanding of natural systems and the development of appropriate strategies for environmental and resource management Short overviews of John s contributions to geomorphological research are also presented to provide context for the origins of this book

Mathematical Morphology in Geomorphology and GISci Behara Seshadri Daya Sagar,2016-04-19 Mathematical Morphology in Geomorphology and GISci presents a multitude of mathematical morphological approaches for processing and analyzing digital images in quantitative geomorphology and geographic information science GISci Covering many interdisciplinary applications the book explains how to use mathematical morphology not only to perform

Global Geomorphology Michael A. Summerfield,2014-05-12 The plate tectonics revolution in the earth sciences has provided a valuable new framework for understanding long term landform development This innovative text provides a comprehensive introduction to the subject of global geomorphology with the emphasis placed on large scale processes and phenomena Integrating global tectonics into the study of landforms and incorporating planetary geomorphology as a major component the author discusses the impact of climatic change and the role of catastrophic events on landform genesis and includes a comprehensive study of surface geomorphic processes

Environmental Modelling John Wainwright,Mark Mulligan,2005-04-08 Simulation models are increasingly used to investigate processes and solve practical problems in a wide variety of disciplines eg climatology ecology hydrology geomorphology engineering Environmental Modelling A Practical Approach addresses the development testing and application of such models which apply across traditional boundaries and demonstrate how interactions across these boundaries can be beneficial Provides a general overview of methods and approaches as well as focusing on key subject areas written by leading practitioners in the field Assesses the advantages and disadvantages of different models used and provides case studies supported with data output tutorial exercises and links to the model and or model applications via the book s website Covers major developments in the field eg the use of GIS and remote sensing techniques and scaling issues As associated website contains colour images as well as links to www resources

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