

Virtual landscapes, interactive models for learning about geographical change

GIS/EM4

Peter Burrough

Cees Wesseling

Raymond Sluiter

Derek Karssenberg

Kor de Jong

Marlous van der Meer

Abstract

Recent research in the modelling of dynamic spatial processes has demonstrated the ability to model a wide range of dynamic geographical processes in a simple, yet satisfactory way. These geographic models can be used for teaching and instruction, although it is technically too advanced for undergraduate students in the first or second year of geography or geology. We have built a system for student instruction that enables undergraduate students to study geographical computer models, without knowledge of the technical aspects of modelling. In this system the geographical models are available through an interface. Students can run the model and view the results as graphs, maps or animations. If required they can change the parameter values and run the model again. At present study modules have been developed for ecological, hydrological and geomorphological modelling.

Keywords

GIS, Environmental modelling, dynamic modelling, simulation, generic modelling language, 2D, visualisation, scripting

Introduction

Recent research in the modelling of dynamic spatial processes has demonstrated the ability to model a wide range of dynamic geographical processes in a simple, yet satisfactory way. These methods are all based on developments from Map Algebra and Cellular automata (Burrough 1998, Longley et al 1998, van Deursen 1995, Takeyama and Couclelis 1997, Wesseling et al 1996 etc.) and involve computations based on a regular tessellation of the landscape that can be rapidly updated. In contrast to many other kinds of models using finite elements, models can be quickly computed using finite difference methods of calculation instead of the more laborious finite element solution of partial differential equations. These methods provide an easy to use generic environment for teaching and instruction of dynamic spatial processes in areas as disparate as ecological modelling, geomorphological developments, urban processes and epidemiology. What is also emerging is the development of sets of specialised, high-level programming languages based on GIS and geostatistical concepts that make these kinds of models easy to develop and modify in a learning environment.

Modelling approaches

Because spatial processes in the environment and the surface of the earth in general are affected by many factors that are often incompletely surveyed or understood, effective interactive computer simulation of Virtual Landscapes requires that attention is focused on the most important factors. In essence, just as in Physics or Chemistry, one is taking a part of the real world and placing it in a laboratory environment. The main difference is that the environment is in a computer, though the distinction between laboratory bench and computer is also blurring in other areas of science (Casti 1997). Using the laboratory approach for teaching, however, means that the following conditions must be met:

- The models must have a sound physical base and be bias-free
- The models must be capable of being run on affordable computers
- The interaction with the student must be simple and straightforward.

During the last two years we at the Utrecht Centre for Environment and Landscape Dynamics have built such a system for student instruction. The project has been financed by the Faculty of Geographical Sciences, the Dutch Ministry of Education under the "Kwaliteit en Studeerbaarheid" stimulation programme, and internally. The key component of the Virtual Landscape modelling package is the PCRaster Dynamic Modelling software, which is used for coding all dynamic models (Wesseling et al 1996, Burrough 1998). Although we already teach students how to program in PCRaster, this specialist instruction is given only at the Masters or PhD level - the course is too advanced for undergraduates in the first or second year of geography or geology.

Teaching modules

Currently the Virtual Landscape models are written by specialist programmers working together with university lecturers. The lecturers supply theoretical and practical material, including maps, figures and photos or even video, and dictate the form and structure of the teaching modules. Ultimately the lecturers should be able to create the modules themselves once they have also acquired programming skills. The lecturer is also responsible for incorporating the modules in the lectures and practical classes. Modules are set up to deal with a limited set of concepts one at a time. Development in complexity and skills is taken care of by providing a series of modules of increasing difficulty and scope.

The student interface (an html or xml document) is so-designed that the context of a process being modelled is clear from text, figures and images (photos, maps, animations and videos). Questions to test understanding are provided in the document, and answers can be evaluated on line (see Burrough et al. 2000). When the student is ready, the model interface can be called up as a window with pre-defined boxes. The student may display and become familiar with the inputs and parameters used, but does not have to edit the model code which is protected from corruption. The student can run the model and view the results as graphs, maps or animations. If required, the student can change the parameter values and run the model again. Because all results are saved, the student can immediately see what the effect is of changing a single parameter, or of changing several parameters, and gain understanding accordingly.

At present, study modules have been written for the following processes and more are planned:

- Dispersion of plants and animals
- Land degradation in Mediterranean landscapes
- Development of landforms over geological time as a function of climate, rock type and tectonics

(Sluiter et al, 2000).

- Development of sedimentary landforms such as alluvial fans and deltas, also under influence of confining processes, secondary transportation and local uplift
- Study of gully and rill erosion on bare soils
- Rainfall-runoff characteristics of small and large river basins

Each module is a study course in itself for which credits can be obtained. Modules can be run locally using a CD-ROM source disk on standard PCs with at least a 200 MHz processor, 200 Mbytes free disk space and 32 Mbytes memory under control of Microsoft Internet Explorer 4 or better. The modules can also be provided on the net through the MUTATE GIS and Environmental Modelling Distance Learning initiative (see Burrough et al. 2000 and <http://mutate.chiron.pt>).

References used

Burrough PA. 1998. Dynamic Modelling and GIS, Chapter 9, In: Longley P. et al, Editors. Geocomputation: a Primer. Wiley, p. 165-192.

Burrough PA., da Costa JR., Haurie A., Fedra K., Salvemini M., Hauska H. 2000 MUTATE: a web-based distance learning programme for environmental modelling with GIS. (Banff 2000 - submitted).

Casti 1997 Would-be worlds. Wiley

Longley PA., Brooks, SM., McDonnel R., Macmillan B. 1998. Geocomputation: a Primer. Wiley

Sluiter R., van Steijn H., Karssenber D., Burrough PA., Wesseling C., de Jong K. 2000. Interactive computer models for teaching dynamic geomorphological processes. (Banff 2000 - submitted).

Takeyama, T. & Couclelis, H. 1997 Map Dynamics: integrating cellular automata and GIS through GEO-Algebra, In: International Journal of Geographical Information Science, 11, p. 73-92

Van Deursen W. 1995. Geographical Information Systems and Dynamic models. Ph.D. Thesis, Utrecht University, NGS Publication 190, 198 pp.

Wesseling CG., Karssenber D., Burrough PA., Van Deursen W. 1996. Integrating dynamic environmental models in GIS: the development of a Dynamic Modelling language. Transactions in GIS Vol 1: 40-48, 1996.

Authors

Peter Burrough, Director

Utrecht Centre for Environment and Landscape Dynamics, Faculty of Geographical Sciences, Utrecht University

P.O. Box 80115, 3508 TC, Utrecht, The Netherlands.

Email: p.burrough@geog.uu.nl Tel: +31-30-253-2766, Fax: +31-30-253-1145

Cees Wesseling, Environmental software engineer

Harpstraat 29, 3513 XA, Utrecht, The Netherlands

Email cees@pcraster.nl Tel: +31-30-2380124, Fax +31-30-2380125

Raymond Sluiter, Researcher

Utrecht Centre for Environment and Landscape Dynamics, Faculty of Geographical Sciences,
Utrecht University
P.O. Box 80115, 3508 TC, Utrecht, The Netherlands.
Email: r.sluiten@geog.uu.nl Tel: +31-30-253-4050, Fax: +31-30-253-1145

Derek Karssen, Lecturer

Utrecht Centre for Environment and Landscape Dynamics, Faculty of Geographical Sciences,
Utrecht University
P.O. Box 80115, 3508 TC, Utrecht, The Netherlands.
Email: d.karssen@geog.uu.nl Tel: +31-30-253-2768, Fax: +31-30-253-1145

Kor de Jong, Software engineer

Utrecht Centre for Environment and Landscape Dynamics, Faculty of Geographical Sciences,
Utrecht University
P.O. Box 80115, 3508 TC, Utrecht, The Netherlands.
Email: k.dejong@geog.uu.nl Tel: +31-30-253-2768, Fax: +31-30-253-1145

Marlous van der Meer, Researcher

Utrecht Centre for Environment and Landscape Dynamics, Faculty of Geographical Sciences,
Utrecht University
P.O. Box 80115, 3508 TC, Utrecht, The Netherlands.
Email: m.vandermeer@geog.uu.nl Tel: +31-30-253-2768, Fax: +31-30-253-1145