

# **Interactive computer models for teaching dynamic geomorphological processes**

## **an example of web-based distance learning**

### **GIS/EM4**

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#### **Abstract**

A system for student instruction has been built based on the PCRaster dynamical modelling software. This system enables students to study geographical computer models without knowledge of the technical aspects of modelling. This demonstration focuses on the application of a geomorphological model as an interactive learning tool. The geomorphological model enables students to study the long-term effects of a certain slope process on slope profile form.

#### **Keywords**

Geomorphological modelling, Interactive dynamic modelling, GIS, Geomorphology

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## **Introduction**

In recent years there has been much work in the numerical modelling of landscapes, river behaviour, erosion and sedimentation based on observed sets of general principles and large data sets. This work has led to the creation of packages of computer models that enable a researcher to model the behaviour of observed parts of the earth's crust in reaction to a wide range of processes. The development of these packages has created a potential for using them as a teaching tool for students. Unfortunately, for many students these 'professional' numerical models go too far, for they only enable complex processes to be modelled at the price of many partial differential equations, a large computer system, a large data base, and a great deal of computer expertise (e.g. Smith et al 1997ab).

During the last two years a system for student instruction has been built at the Utrecht Centre for Environment and Landscape Dynamics. This system, based on the PCRaster Dynamic Modelling software (Wesseling et al 1996, Burrough 1998) enables students to work with geographical computer models without knowledge of the technical aspects of modelling (Burrough et al, 2000a). In this demonstration we focus on the application of a landform development model based on the principles of "SLOP3D" (Ahnert, 1976, 1987, 1996) as an interactive learning tool. It is demonstrated into the framework of the MUTATE programme (Burrough et al, 2000b).

# The geomorphological model

The theoretical geomorphological model enables students to study the long-term effects of a certain slope process on slope profile form. It is mainly based on the denudational mass balance. It is written as:

$$C = C' + (W + A - R) \Delta t$$

where:

C = Regolith thickness at time step t

C' = Regolith thickness at time step t-1

W = Weathering rate

A = Waste supply (from up slope)

R = Waste removal (down slope)

t = Time

The waste supply rate and waste removal rates are a function of the processes plastic flow and wash denudation. It is assumed that the model works at any spatial or temporal scale. By only varying the parameters of plastic flow, wash denudation and weathering rate it is possible to simulate different environmental and lithologic conditions, and thus different geomorphologic processes (Ahnert, 1987).

Ahnert has used the model in many ways for theoretical model experiments, such as slope profile development experiments (Ahnert, 1987), development of cuestas, inselberg landscapes and canyons (Ahnert, 1996) and development of gulleys and karst landforms (Ahnert, 1994). These experiments have generated a lot of insight in geomorphological processes and theoretical geomorphological modelling. However, until now, students were unable to visualise the results of these model experiments other than in "book format".

Our version of Ahnert's model enables researchers and especially students to interactively model the geomorphological processes on an average PC. Different parameters can be changed and the effects of these changes can be visualised in real time, in 1D or even 3D, illustrating how complex landscapes and landforms have come into being.

To obtain a teaching version of SLOP3D we have rebuilt Ahnert's original model in the PCRaster Dynamic Modelling software and have added a user interface. Two versions of the model were developed: a 2D-version and a 3D-version. The 2D-version shows the development of a single slope and is used to familiarise students with the model principles (figure 1a and figure 1b ). The 3D-version is used in a further teaching stage to analyse the development of total landscapes (figure 2). Schematic landscapes and real landscapes can be studied. The current modules include:

- The effects of geologic layers (formation of cuestas and mesas)
- The effects of tectonic uplift
- The formation of badlands
- The concepts of steady state and dynamic equilibrium of a landscape.

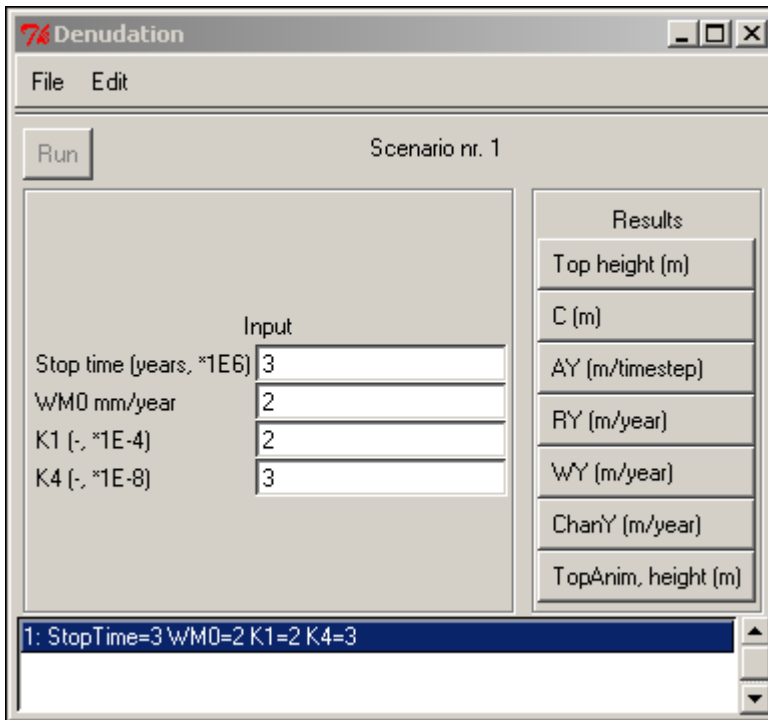


Figure 1a - 2D model version, the model interface with input and output options.

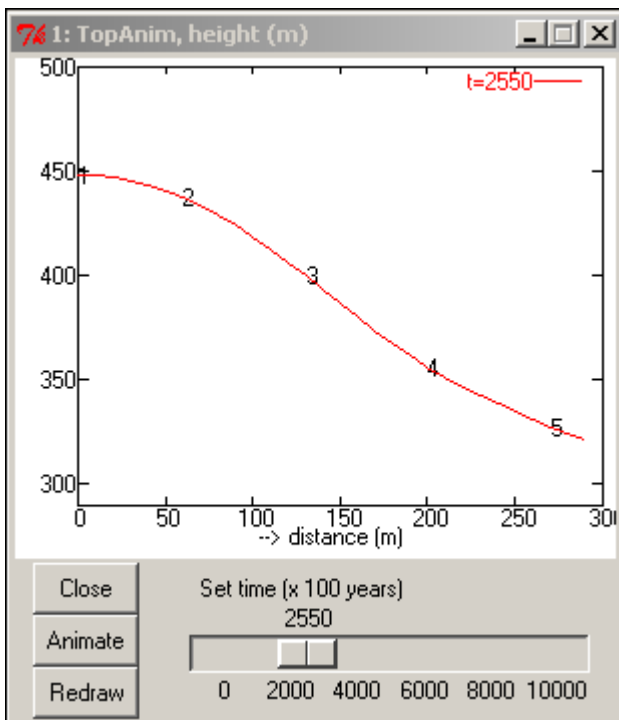


Figure 1b - 2D model version, the animated output of the development of a slope.

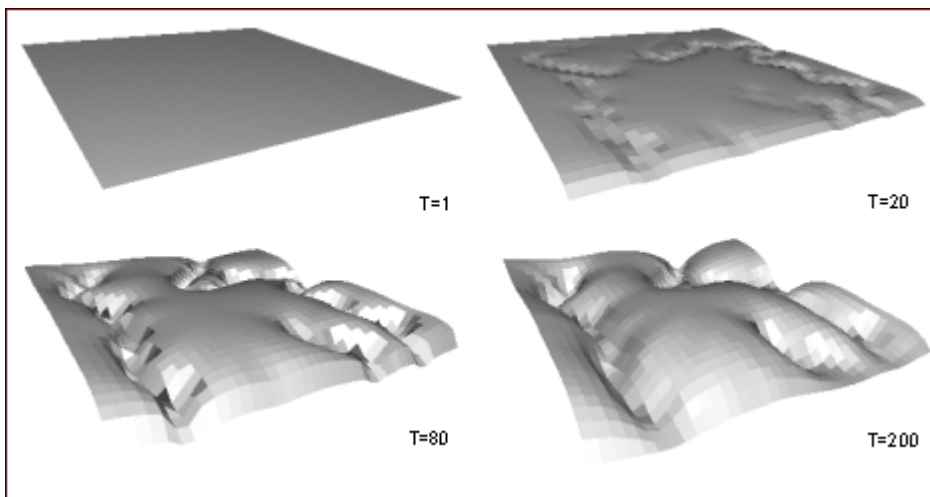


Figure 2 - 3D model version, schematic landscape. Initial situation and after 20, 80 and 200 time steps.

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