



Virtual Landscapes

Interactive computer models for teaching dynamical processes

an example of web-based distance learning

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Introduction

Virtual land is based on the PCRaster dynamical modelling software.

This system enables you to study geographical computer models without knowledge of the technical aspects of modelling.

This presentation focuses on the application of a geomorphological model as an interactive learning tool, one of the modules of Virtualland.

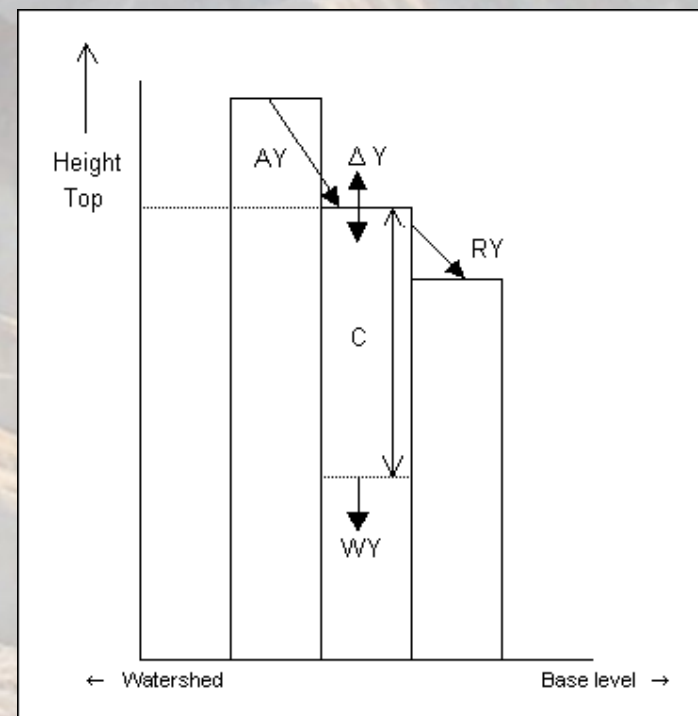
Theory

The interactive model is based on the principles of SLOP3D (Ahnert, 1996). The model core is the denudational mass balance:

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

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



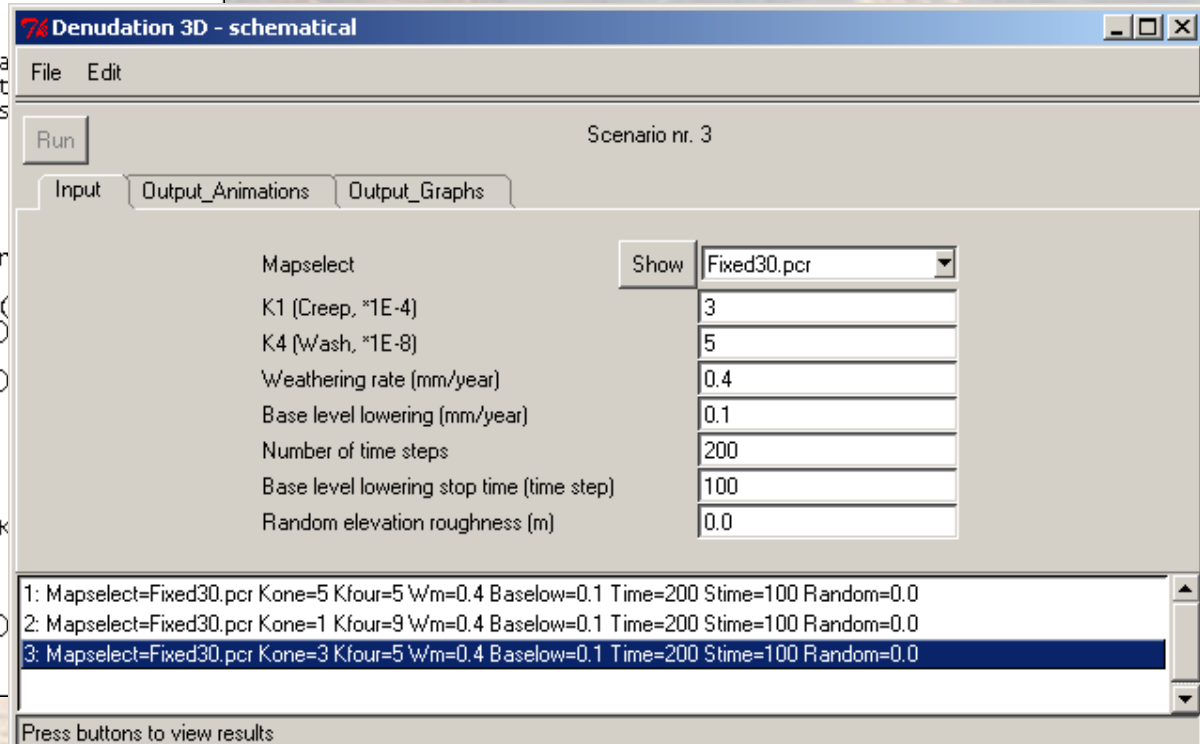
Model implementation

The model is programmed in PCRaster Dynamic Modelling software. The model code cannot be edited but is available through an interface:

```
# MECHANICAL WEATHERING #
WM = T * WM0 * exp(-Kseven * C);
wtot=WM;
EBmin=mapminimum(EB);
wtot=if(EB-wtot lt (EBmin-Baselow),Ba
C=if(Edges,if(time() ge stopTime,C+wt
wtot=if(Edges and wtot lt Baselow,Bas
EB=EB-wtot;

# PLASTIC FLOW #
Sst=(Top-downstream(Ldd,Top))/downstr
Up=accuflux(Ldd,cellarea());
Streams=if(Up gt streamlimit,boolean(
S=max(0,cover(if(Sst gt 90,0,Sst),1))
Sas=sin(atan(S));
Rp=max(T * Kone * (C * Sas - Ktwo),0)
report Rp=min(Rp,5);
C=max(0,C-Rp+upstream(Ldd,Rp));

# WASH DENUDATION #
RwFracN=T*Kfour*(Up**Kfive)*((Sas)**K
RwFrac=min(1,RwFracN);
report Rw=max(RwFrac*C,0.00001);
report LogRw=log10(Rw);
C=if(Edges,if(time() ge stopTime,0,0)
C=if(Streams and C gt 3,3,C);
report C=min(C,10);
```



Denudation 3D - schematical

File Edit

Run Scenario nr. 3

Input Output_Animations Output_Graphs

Mapselect	Show
K1 (Creep, *1E-4)	Fixed30.pcr
K4 (Wash, *1E-8)	3
Weathering rate (mm/year)	5
Base level lowering (mm/year)	0.4
Number of time steps	0.1
Base level lowering stop time (time step)	200
Random elevation roughness (m)	100
	0.0

1: Mapselect=Fixed30.pcr Kone=5 Kfour=5 Wm=0.4 Baselow=0.1 Time=200 Stime=100 Random=0.0
 2: Mapselect=Fixed30.pcr Kone=1 Kfour=9 Wm=0.4 Baselow=0.1 Time=200 Stime=100 Random=0.0
 3: Mapselect=Fixed30.pcr Kone=3 Kfour=5 Wm=0.4 Baselow=0.1 Time=200 Stime=100 Random=0.0

Press buttons to view results

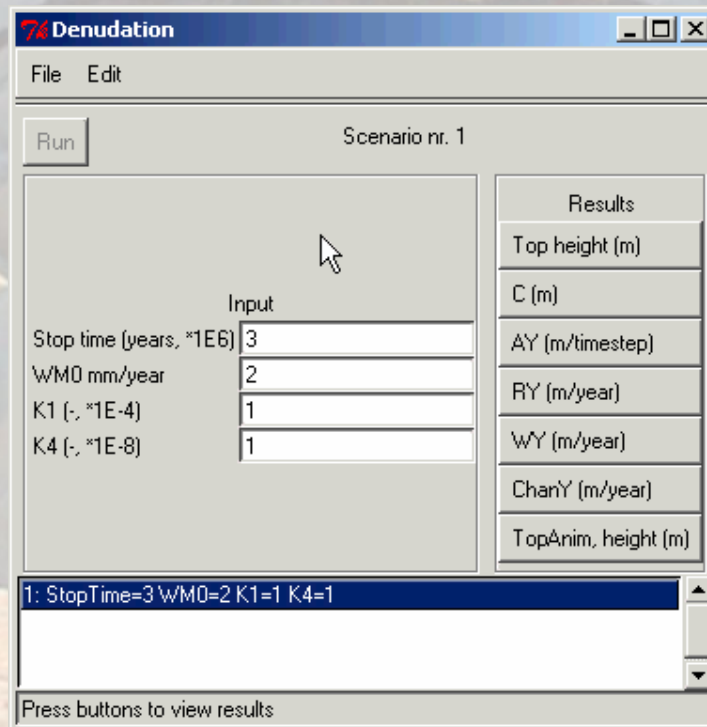
Model implementation

The model interface can be approached from an html or xml document available on the web or cd-rom

In The following sheets I give an example of the working of the 2D model, which simulates the development of a single slope, and the working of the 3D model which is used in a further teaching stage to analyse the development of total landscapes.

The 2D Model

The 2D model is used to familiarise you with the model principles. The effects of two hill slope processes can be modelled: creep and slope-wash. You can change the parameters via the interface.



The screenshot shows the 'Denudation' software window. The title bar reads 'Denudation'. Below the title bar is a menu bar with 'File' and 'Edit'. The main window is titled 'Scenario nr. 1' and contains a 'Run' button. The interface is divided into three main sections: an 'Input' section with four text boxes, a 'Results' section with five buttons, and a status bar at the bottom.

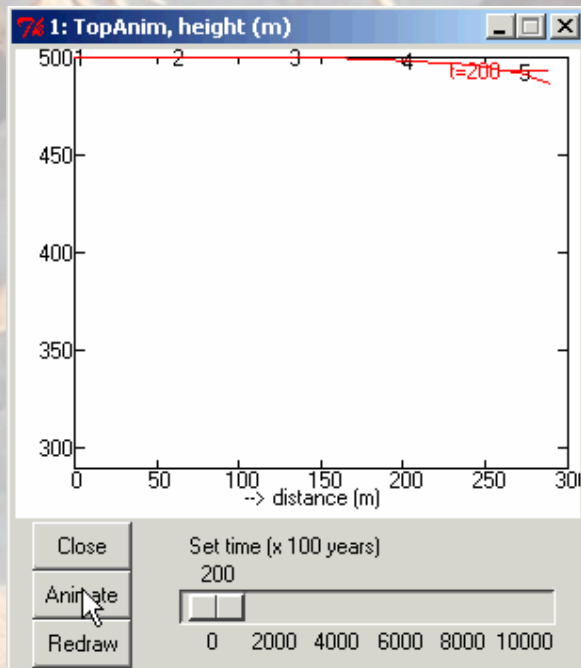
Input	
Stop time (years, *1E6)	3
WM0 mm/year	2
K1 (-, *1E-4)	1
K4 (-, *1E-8)	1

Results	
Top height (m)	
C (m)	
AY (m/timestep)	
RY (m/year)	
WY (m/year)	
ChanY (m/year)	
TopAnim, height (m)	

1: StopTime=3 WM0=2 K1=1 K4=1

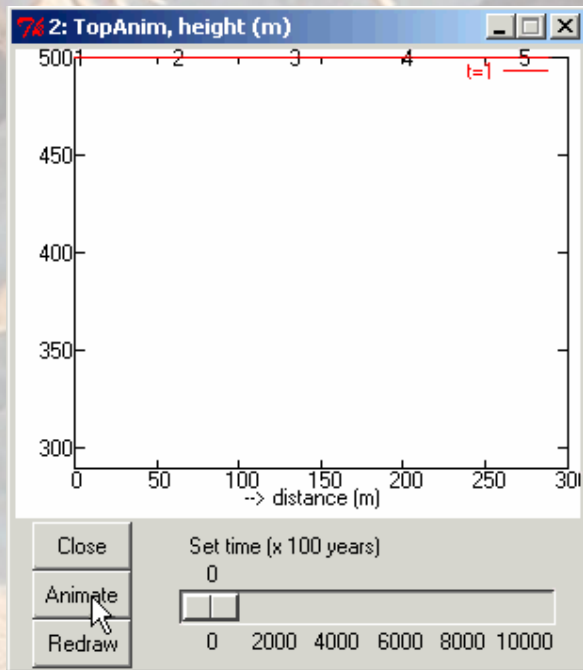
Press buttons to view results

The 2D Model



Result:
Animation of creep dominated
slope development.....

The 2D Model



Result:
Animation of wash dominated
slope development.....

The 3D Model

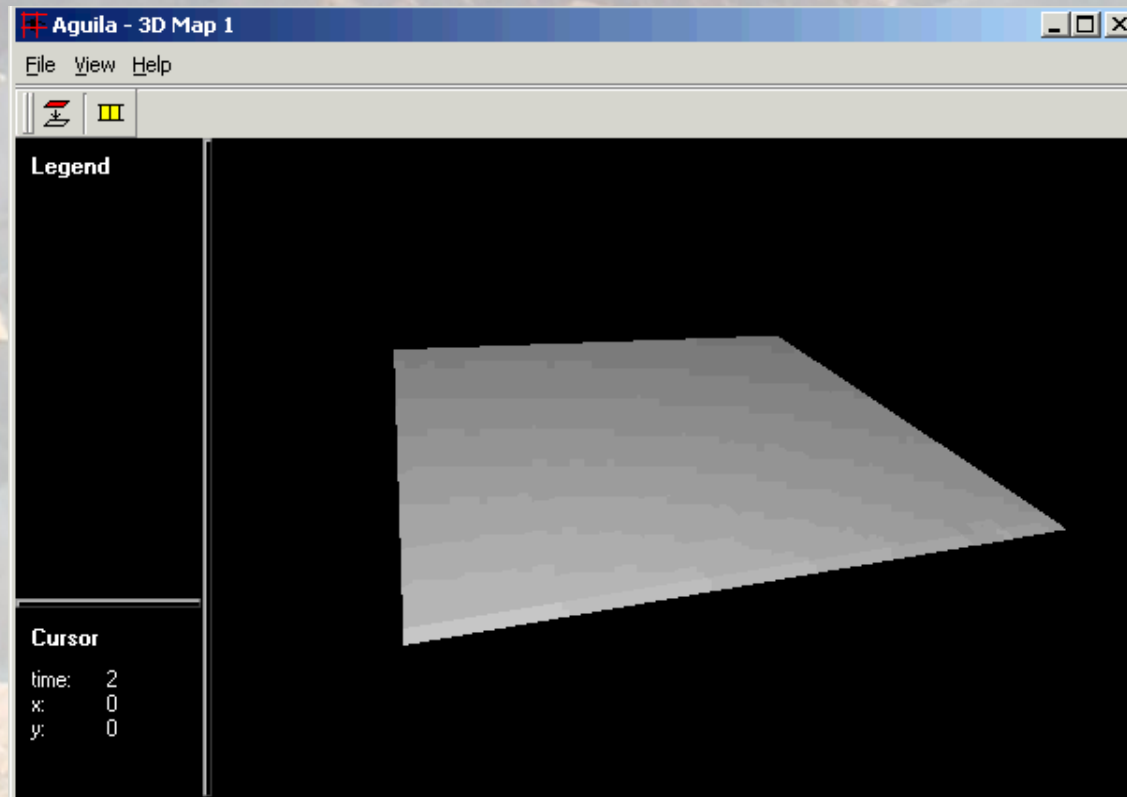
With the 3D model total landscapes (schematical and real landscapes) can be studied.

Examples of questions that can be asked are:

- Under which conditions of process and material can certain specific landscapes develop ?
- How does a landscape develop under a specified set of weathering and denudation processes ?
- Is it possible to reach a dynamic equilibrium under a specified set of weathering and denudation processes ?

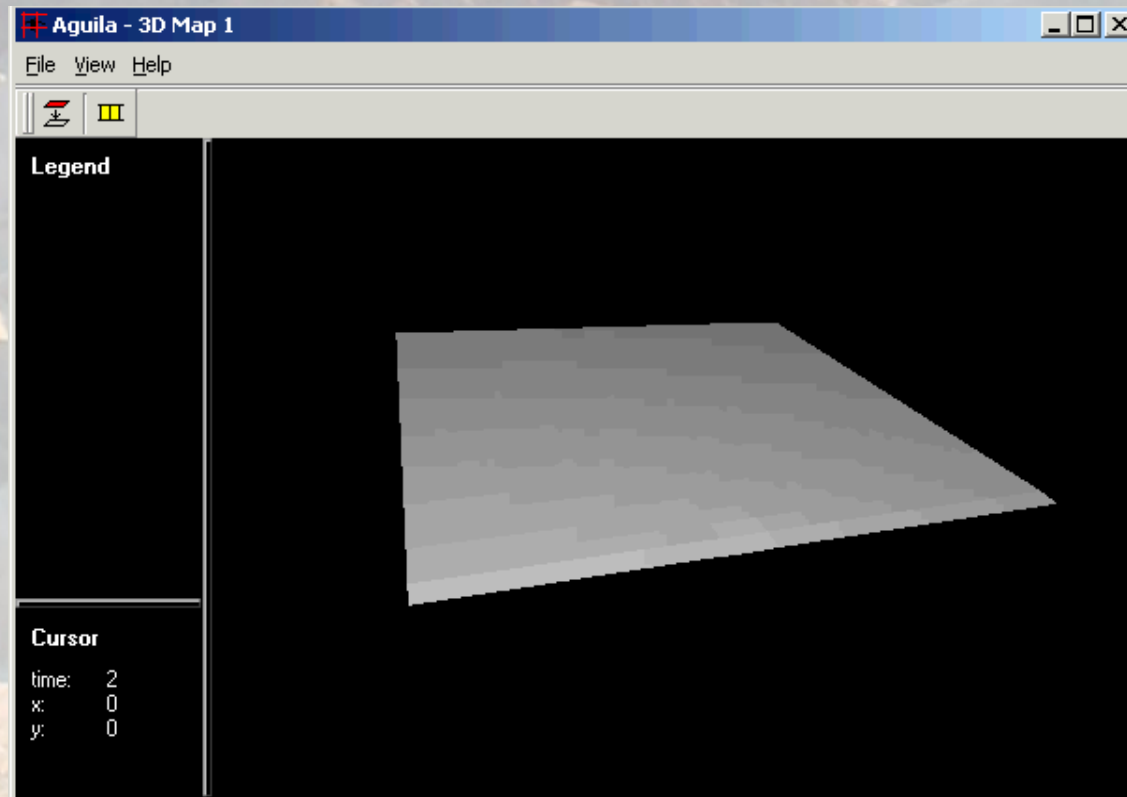
The 3D Model

3D Animation of the model output.
(1) Wash dominated slope development.....



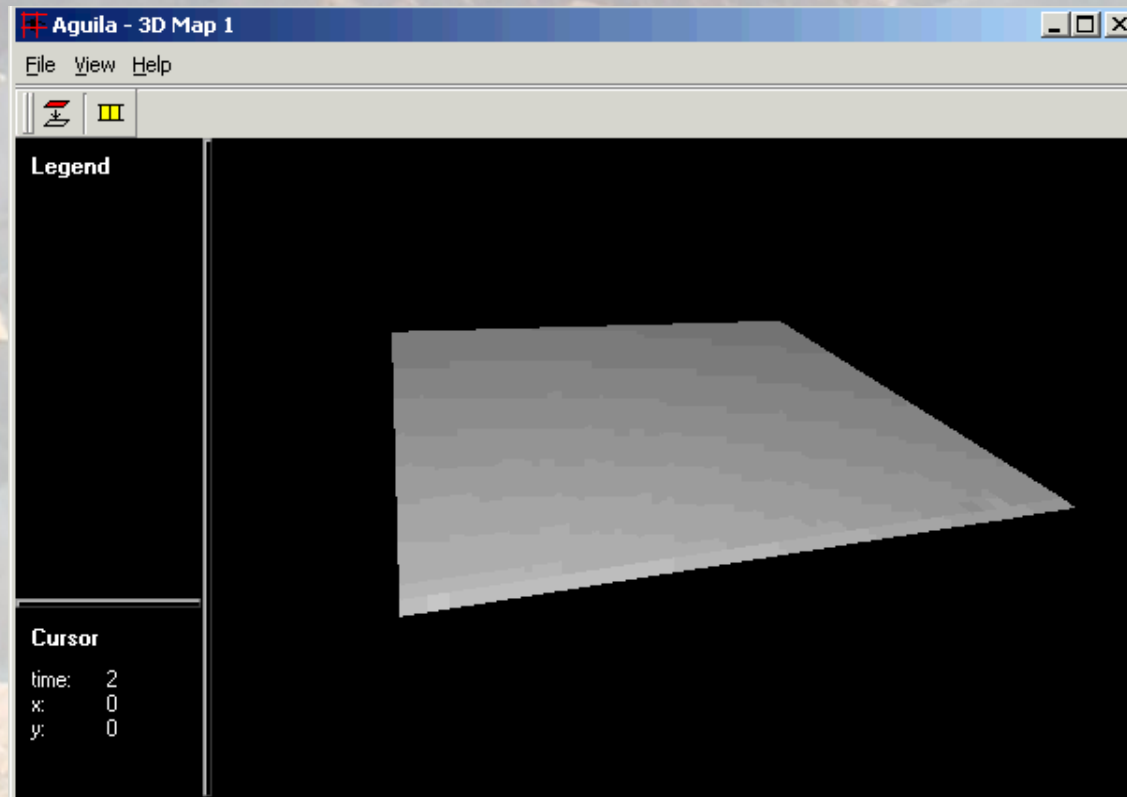
The 3D Model

3D Animation of the model output.
(2) Creep dominated slope development.....



The 3D Model

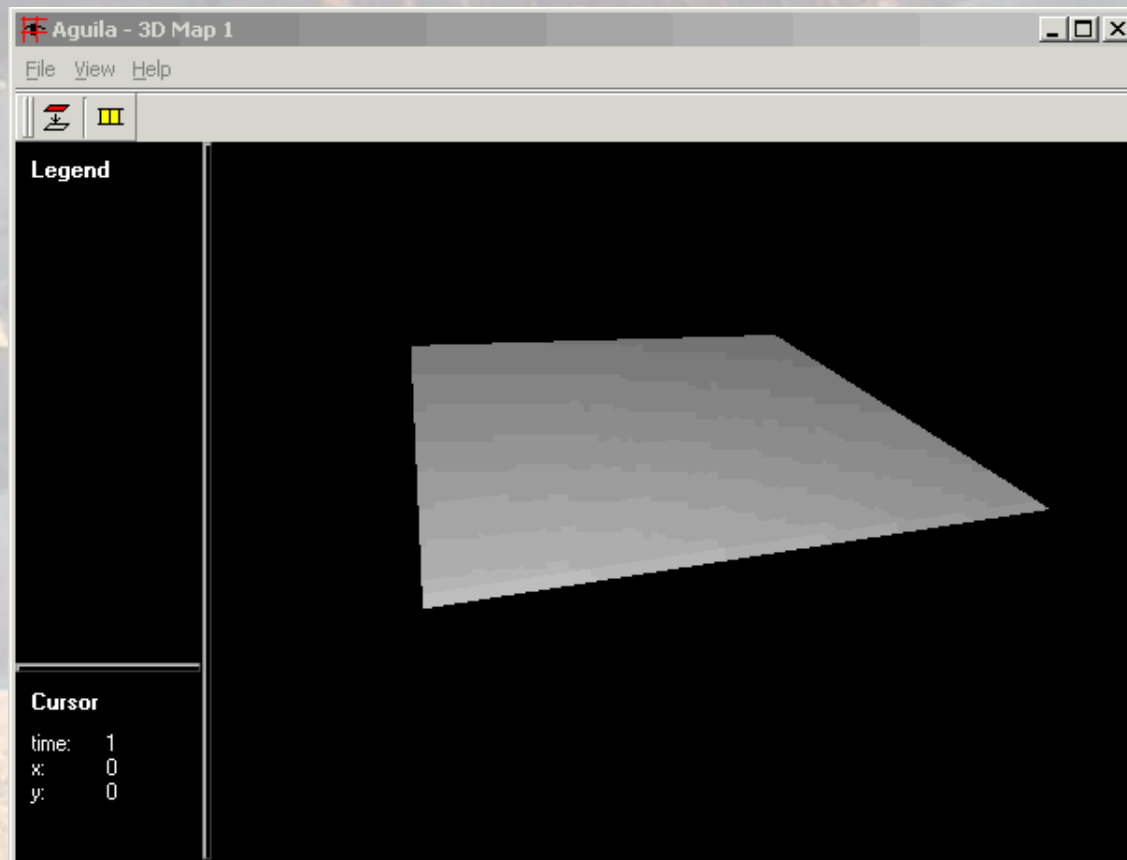
3D Animation of the model output.
(3) Intermediate creep and wash scenario.....



The 3D Model

3D Animation of the model output.

(3) 3D animation of a landscape in dynamic equilibrium....



More Virtual Landscapes...

- Catchment Hydrology
- Ecological modelling: growth & dispersal
- Ecological modelling: competition
- Ecological modelling: grazing capacity modelling
- Land degradation: land slide modelling