Filtering signals: complexity experiments with LAPSUS

Arnaud J.A.M. Temme[1] and Marco J. van de Wiel[2]

1. Introduction

Landscapes respond to external drivers such as climate, tectonics and sea level changes. This response is in many cases indirect and complex. In fact, recent research has suggested that it is by no means certain that input signals are discernible in output signals, such as sediment output. This means that landscapes have a certain filtering or shredding function. It is crucial to understand this function because it poses limits to our predictive capabilities. In other words, we need complexity theory to know what we can and cannot predict.

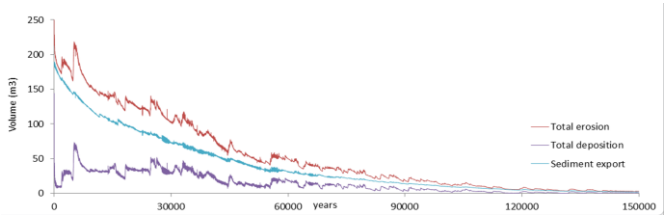
Our objective here is to explore the filtering function over the lifetime of a test-landscape with landscape evolution model LAPSUS. An indirect approach is taken, where landscape filtering is approximated with 150.000 years timeseries analysis of landscape sediment export under stable inputs. Geomorphic processes are varied in scenarios.

2. Landscape evolution model LAPSUS

- Simulates multiple geomorphic processes
- Input for this study:
  - Digital Elevation Model of test area: Alora, Spain
  - Constant climate and other inputs
  - Different geomorphic settings : only overland erosion, added creep, added soildepthand weathering limitation
- Output:
  - Timeseries of total annual erosion and deposition
  - Power spectral analysis of timeseries

3. Results

➢ 150 ka

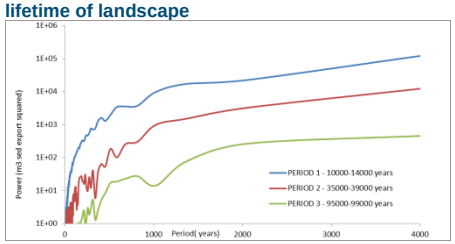


➢

Sources of complexity

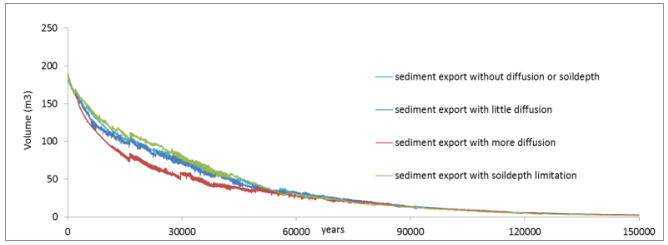
- River piracy (see DEMs)
- Temporary storage through creation, filling and erosion of sinks (Temme et al, 2006)
- No channel bed armouring (van de Wiel and Coulthard): not represented in LAPSUS

Power spectrum of sediment export changes over lifetime of landscape



The period beyond which power becomes almost stable, increases with landscape age. Therefore, climatic or other input signals must have larger periods to register in older landscapes. Powers are a function of average erosion levels and it is not suggested that smaller amplitude input signals register more difficultly in younger landscapes.

Effect of soil diffusion and limited soildepth



More diffusion in the suite of geomorphic processes acting on the test landscape leads to faster removal of sediment. Using limited soildepth in combination with (slow) weathering, leads to slower removal of sediment. However, power spectra (not shown) do not differ appreciably between sediment output signals.

4. Conclusions

1) Besides bed armouring (Van de Wiel and Coulthard, 2010), temporary storage of sediment and river piracy can create complexity in sediment output signals.
2) The filtering function of landscapes changes over (geological) time. Older landscapes with flatter slopes have spectral powers that reach a maximum over longer periods. This suggests that in such landscapes, only input signals with long periodicity are registered. We are currently undertaking a test of this hypothesis.
3) More diffusive processes in addition to overland waterflow erosion change landscape evolution, but not complexity of sediment export

Arnaud Temme PhD.
E-mail: Arnaud.Temme@wur.nl
Phone: +31 317 484445
P.O. Box 47, 6700 AA, Wageningen, The Netherlands

Affiliations:
1. Land Dynamics Group, Wageningen University, the Netherlands
2. Department of Geography, University of Western Ontario, Canada

References:
1.Van de Wiel and Coulthard, Geology 38 (1), 2010
2. Temme et al, Computers and Geosciences 32 (4), 2006