Landscape Evolution Modelling - LAPSUS

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ABSTRACT

Landscape evolution modeling can make the consequences of landscape evolution hypotheses explicit and theoretically allows for their falsification and improvement. Ideally, landscape evolution models (LEMs) combine the results of all relevant landscape forming processes into an ever-adapting digital landscape (e.g. DEM). These processes may act on different spatial and temporal scales. LAPSUS is such a LEM. Processes that have in different studies been included in LAPSUS are water erosion and deposition, landslide activity, creep, solifluction, weathering, tectonics and tillage. Process descriptions are as simple and generic as possible, ensuring wide applicability. Vegetation-effects can be included. Interactions between processes are turn-based: volumes of one process are calculated and used to update the DEM before another process starts. LAPSUS uses multiple flow techniques to model flows of water and sediment over the landscape. Though computationally costly, this gives a more natural result than steepest descent methods. In addition, the combination of different processes may create sinks during modelling. Since these sinks are not spurious, the model has been adapted to deal with them in natural ways. This is crucial for several purposes, for instance when studying damming of valleys by landslides, and subsequent infilling of the resulting lake with sediments from upstream.

Keywords: Landscape Evolution Modelling, LAPSUS, soil redistribution, erosion

INTRODUCTION

This extended abstract is merely a review of the work undertaken and developments into the future with the LAPSUS model. LAPSUS is a landscape evolution model (e.g. LEM erosion model) that combines the results of multiple landscape forming processes into one dynamic landscape. Spatial and temporal extent and resolution may vary from slope, catchment to basins, grids from 1 to 1000 m2, timesteps of multiple events, seasons, years, decades and simulation periods from years to millennial.
Interactions between processes are turn-based: volumes of one process are calculated and used to update the DEM before another process starts. Processes that have been included in LAPSUS are water erosion and deposition, landslide activity, creep, solifluction, physical weathering, frost weathering, tectonics and tillage (See Figure 1).
Process descriptions are as simple and generic as possible, ensuring wide applicability. Vegetation-effects are included to different degrees in different case studies. LAPSUS uses multiple flow techniques to model the flow of water and sediment over the landscape. This is computationally costly, but yields a more natural result than steepest descent methods, especially when combining multiple processes over multiple timesteps.
The combination of different processes may create sinks during modelling. Since these sinks are not spurious, the model has been adapted to deal with them in a natural way. This is crucial when studying damming of valleys by landslides, and subsequent infilling of the resulting lake with sediments from upstream.

RESULTS AND DISCUSSION

LAPSUS has been used for erosion and landscape evolution studies in many landscapes in many countries. LAPSUS has been founded in the year 2000 with the development, calibration and validation of the LAPSUS model and applications concerning land use in Spain and Ecuador (Schoorl et al., 2000, 2002, 2004, 2006; Schoorl and Veldkamp, 2001, 2006). Firstly, the model has been extended in order to cover the process of landsliding in New Zealand and Taiwan (Claessens et al., 2005, 2006a, 2006b, 2007a, 2007b). Secondly, issues of DEM resolution and the treatment of sinks and pits in the landscape have been investigated (Temme et al., 2006, 2009) as well as stretching the models time scale to landscape evolution time spans in South Africa (Temme and Veldkamp, 2009). Thirdly, different applications with specific processes have been developed, for example, the model has been used in regional nutrient balance studies in Africa (Haileslassie et al., 2005, 2006, 2007; Roy et al., 2004; Lesschen et al., 2005). aplying the model in desert environments of Israel (Buis and Veldkamp, 2008), using LAPSUS in combination with geostatistical tools and tillage in Canada (Heuvelink et al, 2006), investigating the faith of phosphor in the landscapes of the Netherlands (Sonneveld et al., 2006) and new developments concerning connectivity, agricultural terraces and land abandonment (Lesschen et al., 2007, 2009) and the processing of feedbacks between land use and soil redistribution (Claessens et al., 2009)

Figure 1. Overview of processes incorporated within the Lapsus modelling framework (see also www.lapsusmodel.nl)

CONCLUSIONS

Landscape evolution modelling allows for falsification and improvement of landscape evolution hypotheses and can make the consequences temporal and spatial explicit. Ideally, landscape evolution models (LEMs) combine the results of all relevant landscape forming processes into an ever-adapting digital landscape (e.g. DEM). These processes may act and interact on different spatial and temporal scales.

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