Geophysical Research Abstracts
Vol. 13, EGU2011-2092, 2011
EGU General Assembly 2011

Modelling sediment dynamics due to hillslope-river interactions: incorporating fluvial behaviour in landscape evolution model LAPSUS

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Landscape evolution models (LEMs) predict or simulate the three-dimensional development of landscapes over time. Different LEMs have different foci, e.g. the fluvial domain, hillslopes or a combination and erosional behaviour or river dynamics (e.g. meandering). LEM LAPSUS (Landscape Process Modelling at Multi Dimensions and Scales) is a relatively simple cellular model working on annual timesteps that has had a hillslope focus. Our objective in this study was to incorporate fluvial behaviour in LAPSUS without changing the existing model equations. Furthermore, the model should be able to reproduce, depending on simulated conditions, alternating aggradation and incision. Testing was done using an artificial DEM consisting of a steeper hinterland and almost flat floodplain. The ability for fluvial simulation was demonstrated for a real landscape (Torrealvilla catchment, SE Spain).

Different parameter values were assigned to river and hillslope domains based on the amount of annual waterflow. Thus, equations to calculate sediment dynamics and water routing were similar for both hillslope and fluvial conditions. Parameters changed are convergence factor p, which is used in the multiple flow algorithm to route water, and fluvial transport parameters m and n, used in calculation of transport capacity. On a temporal basis, erodibility and 'sedimentability' factors K and P were changed between glacial (little vegetation; high erodibility) and interglacial conditions (more vegetation, lower erodibility). Results show that the combined effect of these adapted parameters reproduced alternating aggradation, due to divergent flow in the floodplain and sediment supply during simulated glacial conditions, and incision due to reduced sediment supply and resulting clean water erosion during simulated interglacial conditions. The simulated results are due to interaction between hillslopes and floodplain, as the former provide the sediments that are deposited in the floodplain. Similar behaviour was simulated when using a 'real' DEM. Sensitivity analysis shows that the model is sensitive to changes in parameters m, n and p but less to changes in K and P. The adapted LEM LAPSUS simulates sediment dynamics as a result of hillslope - fluvial interactions. This allows us to gain insight in the processes and conditions under which observed sediment bodies are deposited in natural catchments, especially if other process that are incorporated in LAPSUS are included (e.g. tillage erosion, effects of land use change, effect of time-lag between vegetation (re)growth after climate amelioration, landsliding etc.).