Geophysical Research Abstracts,
Vol. 11, EGU2009-6079-1, 2009
EGU General Assembly 2009

Scale, thresholds and connectivity: sediment pathways and delivery from the patch to the catchment scale

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Geomorphological processes including soil erosion are active in specific spatio-temporal domains and lead eventually to various emerging soil properties and landscape structures which are evidently also scale dependent. In this study the scale and threshold dependency of landscapes will be compared involving three different landscapes from the temperate, Mediterranean and semi-arid Sahelian geo-ecosystems, especially with regard to the connectivity of water and sediment redistribution. The dominant processes and feed-backs interwoven with soil erosion processes will be discussed from a hierarchical theory type of approach. However, current processes are almost always affected by the presence of inherited soil and landscape properties that might be formed under very different climatological conditions than those that are dominant today. Another important factor in these processes is the role of animals and plants. It will be shown that in all discussed geo-ecosystems plants and animals can be seen as geo-ecosystem engineers and are also important at broader scales with respect to runoff generation and sediment transport.
For the temperate zone a case study from the cuesta landscape of the Paris Basin will be discussed, showing that fine scale, soil physico-chemical processes, soil animal and vegetation related processes lead to the emergence of partial areas and also play an important role in the formation of the cuestas itself.
For the Mediterranean a case study is discussed where vegetation pattern heterogeneity determines water and sediment distribution from the patch to the sub-catchment scale leading to the emergence of either sheetwash generated slopes (pediments) or concentrated flow generated slopes (gullies), but where inherited landscape elements such as pediments with calcretes strongly affect runoff generation and the availability of sediments and hence have a strong impact on the sediment redistribution and measured erosion rates that strongly vary with the scale at which they are measured.
Finally a case study from a semi-arid Sahelian ecosystem is discussed where runoff generation and sediment sources are strongly related to the semi-natural upper landscape zones with a strong interplay between vegetation and surface conditions, and where land use in the lower landscape units is an important sink area for both sediment and water.
Landscape heterogeneity and the distribution of source and sinks of water and sediment is often strongly disconnected and shows clear physical thresholds that can be either of natural origin (e.g. vegetation clumps and patterns) or man-made (e.g. terraces). These physical thresholds are also important as temporary sediment sinks, that may convert to sediment sources during high magnitude events. The connectivity of sediment flow and hence sediment delivery to lower landscape units or larger channels is therefore highly variable and strongly dependent on both finer scale landscape elements and their specific position in the landscape, and the frequency-magnitude relationships of rainfall.
It can be concluded that aspects of hydrological connectivity, temporary sinks of water and sediment in combination with biophysical and anthropogenic thresholds as well as storm characteristics should be included when scaling landscape processes to understand erosion and sediment yields. Furthermore the role and importance of biotic components in erosion studies is still underrated, despite the fact that vegetation is more and more applied to reduce erosion.