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Publication date
2008
Document Version
Final published version

Geophysical Research Abstracts,
Vol. 10, EGU2008-A-07823, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-07823
EGU General Assembly 2008

Upscaling vegetation cover for runoff and erosion modeling

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In semi-arid ecosystems the lack of available water and inter-plant competition leads to sparse vegetation, often resulting in spotted or banded vegetation patterns. As a result of the positive feedback between vegetation and water infiltration soil properties become spatially heterogeneous as well with more organic matter and improved soil physical properties under vegetated patches Consequently, vegetation is the key factor controlling overland flow generation and the distribution of vegetation patches also determines whether runoff becomes connected at the hillslope scale. Runoff and erosion models should therefore include the influence of vegetation, and consequently vegetation patterns have to be scaled up to run these models at catchment scales.

At plot scale we described vegetation patterns and erosion pathways and took detailed aerial photographs of vegetation patterns. These images were classified and spatial metrics of these patterns were calculated with FRAGSTATS. We found a linear relationship between fractional vegetation cover and most spatial metrics, which offered us a proxy to upscale vegetation patterns. From a QuickBird image we derived a fractional vegetation cover map using a linear regression that had a R^2 of 0.90. At hillslope scale we mapped connectivity patterns after a large rain event in November 2006. These connectivity patterns were compared with the fractional vegetation cover map. The results showed that vegetation largely controls runoff and erosion patterns, not only at the plot scale, but also at the hillslope scale, where 77% of all observed rills were on areas with less than 30% vegetation cover.

We used the LAPSUS model to simulate runoff and erosion at the catchment scale and included the fractional vegetation cover map as extra layer to take account for the effect of vegetation patters by adapting the infiltration characteristics. The simulations show more realistic runoff and erosion patterns, because runoff was less connected due to the sink function of the vegetation patches. This demonstrates that erosion models should incorporate the relevant sinks of the hydrological system to prevent overestimation of runoff and erosion at broader scales.