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Modelling ecogeomorphological feedback mechanisms for the analysis of land degradation patterns of a semi-arid shrubland-grassland transition zone

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Land degradation through water erosion is driven by ecogeomorphological processes which may alter transfer paths at the hillslope, the soil-hydraulic conditions of the upper soil layers and the vegetation structure of the hillslope. These processes are interlinked with each other through augmenting feedback mechanisms in such a way that a small change in land use (e.g. temporary overgrazing, cattle trails) may result in a re-organisation of the affected landscape. A grassland-shrubland transition zone in the south-western United States is being investigated here for soil-vegetation-transfer feedback mechanisms. For this purpose, an ecogeomorphological, process-based model has been developed which simulates the redistribution of sediments and nutrients during high-intensity rainstorms in 1-sec time steps, the soil moisture and transpiration dynamics in daily time steps, and the vegetation dynamics (establishment, growth, mortality) in 14-day time steps for a high-resolution grid of 1x1 m2. Through long-term modelling and the modelling of extremes (prolonged droughts or overgrazing), the numerical approach is employed to analyse which types of feedbacks may occur and may trigger persistent vegetation change and land degradation of the hillslope. Using this model it is for the first time possible to couple the occurrence of self-organisational patterns of moisture and soil resource availability of a hillslope with redistribution processes that occur during high-intensity storms. The model thus closes the gap of current modelling approaches that either investigate only individual extreme events or models the long-term dynamics of a landscape without including the detailed erosion processes.