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Analysis of co-evolving soil depths, vegetation patterns, and connectivity on drylands.

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Arid and semiarid landscapes cover more than 30% of the Earth's surface. Vegetation in these areas is usually patchy due limited resource availability. This self-organized patchiness results from the nonlinear feedbacks between water redistribution, soils, landforms, and biota. These complex interactions make the understanding and prediction of landscape responses to climate and land use change highly challenging. Though several models have been recently developed and used to understand these feedbacks and the emergence of vegetation patterns in drylands, these models do not explicitly incorporate feedbacks with coevolving soil depths.

Here we analyse feedback effects resulting from co-evolving soil depths, which play a key role in the re-distribution of surface runoff and therefore on the patterns of vegetation and landscape connectivity. We present modelling results using a coupled landform evolution-dynamic vegetation model, which includes a soil depth evolution module accounts and for soil production and sediment erosion and deposition processes. We analyse the co-evolution of soil depths and vegetation patterns for varying soil erodibilities, slopes and plant functional types. We find that for deeper soils, facilitation effects of vegetation gives rise to the formation of regular patterns, and slope and soil erodibility are the key factors for recovery after disturbance. Disturbances in areas with high slope and/or soil erodibility lead to an increase in connectivity and a degraded state. In contrast, we find that for shallow soils, the facilitation effect of vegetation becomes less important and vegetation patterns are more irregular. In this case, soil depth becomes the key factor prescribing surface connectivity and for the recovery of the system after disturbance. These results have critical implications for effective management and restoration efforts, and for understanding the effects of changes in climate and land use.