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Effect of vegetation change on denudation: Landscape response to transient climate and vegetation cover

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The influence of surface vegetation cover on the evolution of catchment scale erosion and topographic evolution is still not well understood. This is due to the non-linear interactions between biota and surface processes as well as lack of completely non-biotic landscapes on Earth for comparison. We present a numerical modeling investigation into the interactions between transient climate and vegetation cover with hillslope and fluvial processes. We do this within the scope of the German priority research project EarthShape which focuses on the role of biota in Earth surface shaping in four different focus areas along the vegetation and climate gradient in the Chilean Coastal Cordillera. Model simulations are designed to investigate the effects of climate change and associated changes in surface vegetation cover on topographic basin metrics such as: slope, relief and channel steepness. The Landlab surface process model was modified to include the effects of temporal variations in vegetation cover on hillslope diffusion and detachment limited fluvial erosion. A suite of simulations were conducted which are representative of the present day vegetation cover and climate observed in present day satellite and reanalysis data (respectively) of the four EarthShape study areas. Two different transient variations in climate and vegetation cover were explored including a step change in climate and/or vegetation, as well as 100 kyr oscillations over 5 Myr. These transient forcings were chosen to investigate the magnitude and adjustment (i.e. response) time of catchment properties to disturbances in steady-state conditions. Results indicate that the coupled influence of surface vegetation cover and mean annual precipitation shifts basin landforms towards a new steady state, with magnitude of change highly sensitive to initial vegetation and climate conditions of the basin. Dry, non-vegetated basins show higher magnitudes of adjustment than basins that are situated in wetter conditions with higher vegetation cover. For coupled conditions when surface vegetation cover and mean annual precipitation change simultaneously, landscapes tend to react generally with lower magnitudes of adjustment. When vegetation cover and mean annual precipitation change independently from each other, higher magnitude shifts in topographic metrics are observable in model-landscapes. Changes in vegetation cover show higher impact on topography for low initial surface cover values whereas for areas with high initial surface cover the effect of changes in precipitation dominate the formation of landscapes. This study demonstrates a sensitivity of catchment characteristics to different transient forcings in vegetation cover and mean annual precipitation, but the response is sensitive to the initial vegetation and climate conditions prior to the onset of transient conditions.