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The dynamics of a coupled soilscape-landscape evolution model

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In this study we present results obtained from a landform evolution model coupled with SSSPAM5D soilscape evolution model. This presentation will show a number of computer animations with this coupled model using a range of widely accepted soil profile weathering models, and erosion/armouring models. The animations clearly show that subtle changes in process can result in dramatic changes in long-term equilibrium hillslope and soilscape form. We will discuss the reasons for these differences, arguing from the various mathematical and physical assumptions modelled, and infer how observed hillslope form may provide identifiable (and perhaps quantifiable) landform and soilscape signatures of landscape and soilscape process, and in particular the coupling between the landscape and the soilscape.

Specifically we have simulated soilscapes using 3 depth dependent weathering functions: 1) Exponential, 2) Humped and 3) Reversed exponential. The Exponential weathering function simulates physical weathering due to thermal effects, and the weathering rate exponentially decreases with depth. The Humped function simulates chemical and/or physical weathering with moisture feedbacks, where the highest weathering rate is at a finite depth below the surface and exponentially declines with depth. The Reversed exponential function simulates chemical weathering, and the highest weathering rate is at the soil-saprolite interface and exponentially decreases both above and below the interface. Both the Humped and Reversed exponential functions can be used as approximations to chemical weathering as they can be derived analytically by solving widely accepted geochemical weathering equations. The Humped function can arise where the weathering fluid is introduced at the top of the soil profile (e.g. rainfall equilibrated with carbon dioxide in the atmosphere), while the Reversed exponential can be derived when carbon dioxide is generated within the profile (e.g. by biodegradation of soil organic matter). We couple these soilscape weathering sensitivity studies with different erosion approximations. We will discuss how the combinations of weathering and erosion potentially drive the interaction between the soilscape and the landform. Simulations to be shown were run for two case studies (1) a synthetic one dimensional hillslope with a constant gradient of 2.1 % and (2) a two dimensional digital elevation model of an engineered landform from the Ranger Uranium Mine, Northern Territory, Australia.