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Modeling coupled erosion and vegetation dynamics in alpine badlands

Caroline Le Bouteiller (1), Alexandra Carriere (1), Patrick Vallet (2), Thomas Cordonnier (2), and Greg Tucker (3)

(1) Universite Grenoble Alpes, IRSTEA, UR ETNA, Saint Martin d'Heres, France, (2) Universite Grenoble Alpes, IRSTEA, UR LESSEM, Saint Martin d'Heres, France, (3) University of Colorado, Boulder, USA

Badlands are generally characterized by high erosion rates, steep slopes and poor vegetation cover. However it is not clear whether vegetation growth is limited by the intensity of erosive processes, or if the intensity of erosion results on the contrary from the lack of vegetation. Interactions between erosion processes and vegetation dynamics include in particular the influence of vegetation on soil stability and erodibility, the influence of topography (slope, aspect, elevation) on vegetation colonization and growth, the influence of erosive processes such as landslide on vegetation.

In the present study we focus on the Laval catchment in Draix-Bleone observatory, in the French Alps. This catchment is located in a marly badland area and has been monitored for hydrology and sediment yield for the last 30 years. Vegetation cover is currently around 32% but it has been increasing by natural colonization for the last decades. The objective is to simulate the evolution of the topography, sediment yield and biomass over a few decades accounting for vegetation-erosion interactions. We use the Landlab library as a landscape evolution model.

First, the influence of vegetation on local erosive properties (critical slope and erosion diffusivity) is calibrated using sediment yield data from a denuded and a reforested catchment within Draix-Bleone observatory. Secondly, a stochastic vegetation colonization model is built based on historical aerial photographs of the area. We find that vegetation cover has increased over the last 60 years of almost 20% of catchment area, and that colonization is related to slope, elevation and the vicinity of vegetated areas. Thirdly, a vegetation growth model is built based on the data base from the French National Forest Inventory. Using a wide range of sites with similar type of vegetation, statistical analysis indicates that basal area increase is significantly related to slope and elevation.

We couple these three models to simulate the evolution of topography, sediment yield and vegetation in the Laval catchment, with varying rainfall scenarios, and compare this evolution with predictions without accounting for vegetation.