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Noise-driven cooperative dynamics between vegetation and topography in riparian zones

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Riparian ecosystems exhibit complex biotic and abiotic dynamics, where the triad vegetation-sediments-stream determines the eco-geomorphological features of the river landscape.
Random fluctuations of the water stage are a key trait of this triad, and a number of behaviors of the fluvial environment can be understood only taking into consideration the role of noise. In fact, in a given plot, vegetation biomass can grow (if the stage is below the plot elevation) or decay (if the stage is above the plot elevation). As a result, biomass exhibits significant temporal variations.
In this framework, the capability of vegetation to alter the transect topography (namely, the plot elevation) is crucial. Vegetation can increase the plot elevation by a number of mechanisms (trapping of water- and wind-transported sediment particles, production of organic soil, stabilization of the soil surface). The increment of plot elevation induces the reduction of the plot-specific magnitude, frequency and duration of floods. These more favorable plot-specific hydrological conditions, in turn, induce an increment of biomass. Moreover, the higher the vegetation biomass, the higher the plot elevation increment induced by these mechanisms.
In order to elucidate how the stochastically varying water stage and the vegetation-induced topographic alteration shape the bio-morphological characteristics of riparian transects, a stochastic model that takes into account the main links between vegetation, sediments and the stream was adopted. In particular, the capability of vegetation to alter the plot topography was emphasized.
In modeling such interactions, the minimalistic approach was pursued. The complex vegetation-sediments-stream interactions were modeled by a set of state-depended stochastic eco-hydraulic equations. The probability density function of vegetation biomass was then analytically evaluated in any transect plot. This pdf strongly depends on the vegetation-topography feedback.
We found that the vegetation-induced modifications of the bed topography create more suitable conditions for the survival of vegetation in a stochastically dominated environment.