

Hydrologic Dynamics And Ecosystem Structure

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Abstract. The key variable in water-controlled ecosystems is the soil moisture content whose temporal fluctuations are governed by the intermittent and random character of rainfall. The focus here is on the impact of interannual rainfall variability on the statistics of soil moisture and through them on the water stress that vegetation may have to undergo during the growing season. A hierarchical competition-colonization model extensively used in ecological dynamics is driven by the stress conditions resulting from the annual fluctuations in rainfall to assess vegetation competition in water-limited ecosystems. The results show that ecosystem structure is very sensitive to the inclusion of realistic amounts of interannual rainfall variability. The distribution of mean soil water content during the growing season becomes bimodal and concentrated either on a dry type of state or in a wet-like condition. The evolutionary dynamics of competing trees and grasses exhibit self-affine characteristics with power law spectra for the temporal changes of the relative density of the species. This spectral structure results from the internal dynamics of the competition-colonization process, which is driven by Markovian annual rainfall amounts. The model was also implemented to approximately describe the conditions of two ecosystems characterized by grass-tree competition, namely that near La Copita, Texas, and the one of Nylsvley, South Africa. Long term simulations run for many different characteristics of the annual rainfall amounts show that the information entropy of the temporal evolution of the relative amounts of trees and grasses is a maximum at the historically observed rainfall characteristics. This suggests that under commonly observed interannual rainfall fluctuations, water-controlled ecosystems tend to self-organize in a manner which reflects a maximum in the richness of possible dynamical responses.