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Effects of vegetation structure on biomass accumulation in a coupled water-carbon-energy balance model in West Africa

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A myriad of interactions exist between vegetation and local climate for arid and semi-arid regions. Vegetation function, structure and individual behavior have enormous impacts on carbon-water-energy balances, which consequently influence local climate variability that, in turn, feeds back to the vegetation. In this study, a conceptual vegetation structure scheme is formulated and tested in a new carbon-water-energy coupled model to explore the importance of vegetation structure on equilibrium biomass states. Two different strategies of vegetation adaptation to water stress are included. Surface energy, water and carbon fluxes are simulated for a range of vegetation structures across a precipitation gradient in West Africa and optimal vegetation structures that maximize biomass for each precipitation regime are determined. Under dry conditions vegetation tries to maximize the Water Use Efficiency and Leaf Area Index as it tries to maximize carbon gain. However, as the vegetation can also engineer its environment by extracting water from the surrounding bare soil (thereby forming patches of vertical vegetation) it can also minimize its vegetation cover. With increasing precipitation, the vegetation tries to maximize its cover as it then can reduce water loss from bare soil while having maximum carbon gain due to a large Leaf Area Index. The competition between vegetation and bare soil determines a transition between a 'survival' regime to a 'growing' regime. The new modeling framework is useful to represent the effects of dynamic vegetation structure in coupled land-atmosphere feedback models.