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Terrestrial ecosystem modelling studies on the energy, water and carbon balance of a seasonal semi-deciduous dry neotropical forest in Brazil (Caatinga)

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The Caatinga is a seasonal semi-deciduous dry neotropical forest, which is the dominant vegetation in the northeastern region of Brazil. It consists of over 1,000 of vascular plant species characterized by different psysiognomies and drought survival strategies. This vegetation has suffered from intensive degradation due to the lack of protection. Increased understanding of the functioning of this complex ecosystem is fundamental to allow for the design of suitable conservation strategies. To that end, we investigated the complex interactions between Caatinga species with regards to competition for light (above-ground) and water (below-ground), and the additional influence of above-ground canopy architecture on aerodynamic resistances, and hence on atmospheric flux transfer. As part of the Nordeste project, we are developing a bespoke Caatinga terrestrial ecosystem model, based on the model equations described in Wallace and Verhoef (2000) to describe the fluxes of energy, water vapour and CO_2 between a multi-component vegetated land surface and the atmosphere, and so far added to this set-up soil water balance and plant growth models. The model estimates the light interception, fluxes of energy and photosynthesis, and surface temperatures of the individual components of a multi-species mixture. It requires plant architecture and physiological parameters, such as canopy height, leaf area and extinction coefficient, as well as leaf traits such as the maximum rate of carboxylation, obtained during field surveys. The energy partitioning between the various components is calculated using the Penman-Monteith equation and a detailed aerodynamic and surface resistance network, suitable for stands of varying densities and height, consisting of different species of trees, shrubs and understorey, and underlying bare soil substrate. For driving and verification data we used a site with pristine Caatinga vegetation where we used eddy covariance measurements since 2011 of whole ecosystem carbon, water and energy fluxes, as well as measurements of leaf area index, surface temperatures and soil moisture content. Our initial results show a good model performance with regards to energy fluxes and surface temperature. Model sensitivity analyses were conducted, as well as assessments of the relative contributions of the various species to the overall fluxes. We expect that further model developments, such as root competition for water and nutrients, and hydraulic soil-plant water stress models will improve the representation of interactions within the atmosphere-soil-vegetation continuum in the Caatinga. Ultimately, we aim to develop a transferable terrestrial ecosystem model that could be applied as a scientific and management tool for Caatinga and other dry forests.

Reference

Wallace, J.S., and Verhoef, A. (2000) Modelling interactions in mixed-plant communities: light, water and carbon dioxide. In: Leaf development and canopy growth. Editors: B. Marshall and J. Roberts. Sheffield Biological Sciences Series. Sheffield Academic Press: 204-250