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Using terrestrial ecosystem modelling to improve our understanding of drought survival strategies of a dry neotropical forest in Brazil (Caatinga)

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The Caatinga is a deciduous seasonally dry neotropical forest, which is the dominant vegetation type in the northeastern region of Brazil. It covers an area of ca. 850,000 km^2 and it consists of over 1,000 vascular plant species, characterized by different biophysical and physiological traits and drought survival strategies, adapted to its semiarid climate. In recent years, this area has endured a number of prolonged droughts that have adversely affected this already severely water-limited region. Our research focus is on increasing the understanding of the functioning of this complex ecosystem, by developing and employing terrestrial ecosystem models; this is fundamental for the design of suitable conservation strategies. We conducted a detailed multi-model study using driving and verification data (from 2011 onwards) for a pristine Caatinga 'Fluxnet' site, near Petrolina, Brazil. Data collected included eddy covariance measurements of whole ecosystem carbon, water and energy fluxes, as well as measurements of leaf area index, phenology, surface temperature and soil moisture content. The models comprised the ecohydrological model Tethys-Chloris (Fatichi et al., 2012), that has already been successfully employed for the simulation of savannah, cerrado and tropical rainforest ecosystems, as well as two other more recently developed models. One of these concerns a bespoke Caatinga terrestrial ecosystem model, CaaTEM, broadly based on the model equations described in Verhoef and Allen (2000) and Wallace and Verhoef (2000). This model estimates the light interception, fluxes of energy and photosynthesis, and surface temperature of the individual components of a multi-species mixture, such as the Caatinga ecosystem. The third model involves a framework that optimizes carbon uptake whilst maintaining hydraulic function, currently being developed at the University of New South Wales, Australia. With these models, we investigated the intricate interactions between Caatinga species with regards to competition for light (above-ground) and water (below-ground), as well as the role of phenology in the seasonal and inter-annual evolution of land surface-atmosphere exchanges. Emphasis was on assessing the relative influence of aerodynamic (as affected by above-ground canopy architecture, phenology and leaf dimensional properties) and surface resistances (determined by the species' physiological and hydraulic plant traits) on energy, water and carbon transfer.

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