Biogeosciences, 19, 1813–1832, 2022
https://doi.org/10.5194/bg-19-1813-2022

Biogeosciences Open Access EGU

Research article

Predicting mangrove forest dynamics across a soil salinity gradient using an individual-based vegetation model linked with plant hydraulics

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Received: 28 September 2021 – Discussion started: 14 October 2021
Revised: 13 January 2022 – Accepted: 23 February 2022 – Published: 31 March 2022

Abstract. In mangrove forests, soil salinity is one of the most significant environmental factors determining forest distribution and productivity as it limits plant water uptake and carbon gain. However, salinity control on mangrove productivity through plant hydraulics has not been investigated by existing mangrove models. Here we present a new individual-based model linked with plant hydraulics to incorporate physiological characterization of mangrove growth under salt stress. Plant hydraulics was associated with mangroves' nutrient uptake and biomass allocation apart from water flux and carbon gain. The developed model was performed for two coexisting species – *Rhizophora stylosa* and *Bruguiera gymnorrhiza* – in a subtropical mangrove forest in Japan. The model predicted that the productivity of both species was affected by soil salinity through downregulation of stomatal conductance. Under low-soil-salinity conditions (< 28 ‰), *B. gymnorrhiza* trees grew faster and suppressed the growth of *R. stylosa* trees by shading that resulted in a *B. gymnorrhiza*-dominated forest. As soil salinity increased, the productivity of *B. gymnorrhiza* was significantly reduced compared to *R. stylosa*, which led to an increase in biomass of *R. stylosa* despite the enhanced salt stress (> 30 ‰). These predicted patterns in forest structures across the soil salinity gradient remarkably agreed with field data, highlighting the control of salinity on productivity and tree competition as factors that shape the mangrove forest structures. The model reproducibility of forest structures was also supported by the predicted self-thinning processes, which likewise agreed with field data. Aside from soil salinity, seasonal dynamics in atmospheric variables (solar radiation and temperature) were highlighted as factors that influence mangrove productivity in a subtropical region. This physiological principle-based improved model has the potential to be extended to other mangrove forests in various environmental settings, thus contributing to a better understanding of mangrove dynamics under future global climate change.

1 Introduction

Mangrove forests grow in intertidal zones in tropical and subtropical regions (Giri et al., 2011) and store a large amount of carbon (C) especially in their soil, commonly referred to as "blue carbon". It has roughly 4 times higher ecosystem-scale carbon stock than other forest ecosystems (Donato et al., 2011), characterizing them as globally important C sinks (Mcleod et al., 2011; Alongi, 2014; Taillardat et al., 2018; Sharma et al. 2020), therefore playing an important role in climate change mitigation. However, mangrove forests have declined worldwide; at least 35 % of the mangrove

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