EGU22-11276, updated on 11 Aug 2022
https://doi.org/10.5194/egusphere-egu22-11276
EGU General Assembly 2022

Modeling soil-microbial nutrient cycling feedbacks to elevated CO_2 concentrations in old-growth tropical forest sites

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Nutrient cycles are tightly linked to the carbon cycle in tropical forests, controlling its responses to environmental change such as elevated CO_2 concentrations (eCO_2). In tropical wet forests of the Amazon, plants tend to grow slower in low fertility soils, while their relative investments in nutrient acquisition are likely higher due to costly mechanisms of nutrient mobilization. In low fertility soils where weatherable minerals have been depleted, decomposition and mineralization of soil organic matter and plant litter by free-living microorganisms may represent the dominant nutrient source for plants. The availability of soil nutrients for plants is a key constraint on tropical forest growth under future climate change. However, soil microbial communities not only drive the mineralization, but require nutrients for growth and biomass production themselves, and therefore from a plant's perspective, soil microbial communities may act as a source or sink of nutrients under eCO_2.

Here, we employ the process-based terrestrial biosphere model QUINCY (Thum et al., 2019), coupled to the microbial-explicit soil model JSM (Yu et al., 2020) to model shifts in coupled nutrient and carbon cycling rates at field sites with differing soil fertility in the Amazon forest sites, and to confront the modeled ecosystems with elevated CO_2. QUINCY-JSM reflects our current understanding of governing carbon and nutrient cycling feedbacks, allowing for dynamic plant carbon investment in growth and nutrient acquisition, and microbial-explicit growth, turnover, and nutrient cycling. We compiled a unique dataset of forest growth, soil and litter chemistry, as well as microbial growth and stoichiometry from a set of Amazon forest plots that cover a large gradient in soil fertility. Microbial stoichiometry and soil texture data are used to calibrate QUINCY-JSM, and data on forest aboveground growth, microbial growth, litter chemistry, and soil carbon and nutrients are used for model evaluation. We test the hypothesis that the contribution of microbial-driven nutrient mineralization to the nutrient supply of plants increases with lowering soil fertility and explore the soil microbial-induced nutrient feedback to eCO_2-induced carbon sequestration in wet lowland Amazon forest sites. We examine the consequences of model assumptions on the conditions in space and time under which soil microorganisms alleviate or

enforce the plants' nutrient limitation under eCO_2. Directly testable hypotheses for old-growth wet forests' response to elevated CO_2 in ecosystem-scale experiments like AmazonFACE are formulated.

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