Nutrient regulation of tropical ecosystem responses to environmental changes: a case study in the Amazon region

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In spite of its significance in global carbon(C) cycle, tropical C cycling and the feedbacks from tropical ecosystems to the climate system remain critical uncertainties in the current generation Earth System Models. One of the major uncertainties in the tropics comes from the treatment of carbon-nutrient interactions, especially the lack of consideration of phosphorus (P) cycling and P limitation. We have recently implemented P cycle and C-N-P interactions into the CLM-CN model and the newly developed CLM-CNP model has been evaluated against site measurements in Amazon forests. Here we use the CLM-CNP model to evaluate how P cycling affects tropical C cycle responses to changes in environmental factors such as CO_2 and climate in the Amazon region. Model results show that the introduction of P limitation improved heterogeneity of simulated GPP & NPP across the Amazon region, relative to the original CLM-CN model. NPP simulated by CLM-CNP decreases from west to east across the Amazon basin following the gradient of total soil P, consistent with field observations. P coupling greatly reduces simulated historical CO_2 fertilization effect. Exploratory simulations ($2CO_2$ and +4°C) show that tropical ecosystem responses to CO_2 increase and warming interact strongly with drought and nutrient dynamics. Our efforts will improve the treatment of carbon-nutrient interactions in the CCSM4/CESM1 carbon cycle and will increase our confidence in predicting future carbon uptake in tropical ecosystems.