

Influence of phosphorus cycle coupling on land model response to CO₂ fertilization and climate variability

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It is being increasingly recognized that carbon-nutrient interactions play important roles in regulating terrestrial carbon cycle responses to increasing CO₂ in the atmosphere and climate change. Nitrogen-enabled models in CMIP5 indicated that the inclusion of nitrogen cycle reduces CO₂ fertilization effect and warming-induced carbon loss from land ecosystems. None of the CMIP5 models has considered phosphorus (P) as a limiting nutrient. Phosphorus has been commonly considered to be the most limiting nutrient in lowland tropical forests. Only recently a few land models have considered P dynamics and C-N-P interactions (CASA-CNP, JSBACH-CNP and CLM-CNP) and these models show strong P limitation in tropical forest responses to increasing atmospheric CO₂. In this study, we have performed a set of offline global-scale simulations using CLM-CNP constrained by realistic maps of phosphorus distribution. We examine the influence of including phosphorus cycle dynamics and C-N-P interactions on C-climate feedbacks. We illustrate the spatial patterns of dominant nutrient limitation (N-limited vs. P-limited) on the global scale. We show that P-limitation dominates over most of the tropics and sub-tropics, while N limitation dominates over most of the temperate and high-latitude regions. We also show that phosphorus cycle coupling reduces the sensitivity of net carbon exchange to variations in both temperature and precipitation.