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IMPLEMENTING A TERRESTRIAL NITROGEN AND PHOSPHORUS CYCLE IN THE UVIC ESCM: Validation and first results

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Nitrogen and phosphorus biogeochemical dynamics are crucial for the regulation of the terrestrial carbon cycle. In ESMs and EMICS the implementation of nutrient limitation has shown to improve the carbon feedbacks representation and hence, the response of land to atmospheric CO₂ rising in simulation scenarios. We aimed to implement a nitrogen and phosphorus cycle in the UVic ESCM to improve projections of the future CO₂ fertilization feedbacks. The nitrogen cycle is a modified version of the original N model developed in 2012, the basic structure was left in place with the most prominent changes being the enforcement of N mass conservation and the merger with a deep land-surface and wetland module that allowed the estimation of N₂O and NO fluxes. The N cycle estimates fluxes from three organic (litter, soil organic matter and vegetation) and 2 inorganic (NH₄⁺ and NO₃⁻) pools, it accounts inputs from biological nitrogen fixation and N deposition. The P cycle contains the same organic pools with one inorganic P pool, it estimates influx of P from rock weathering and losses from leaching and occlusion. Two historical simulations were carried for the different nutrient limitation setups of the model: CN and CNP, with a control run that consisted in an only C cycle simulation. The N cycle now conserves mass, the original and added fluxes (NO and N₂O), along with the N and P pools are within the range of other studies and literature. The implementation of nutrient limitation resulted in a reduction of GPP from the CN (125 Pg yr⁻¹) and CNP (111 Pg yr⁻¹) simulations compared the C only control (148 Pg yr⁻¹) by the year 2020; which implies that the model efficiently represents a nutrient limitation over the CO₂ fertilization effect. Furthermore, the tropical latitudes in the CNP simulation resulted in a reduction of 33% of the mean GPP and 41% of the vegetation biomass compared to the C only run; these results are in better agreement with observations and with the notion that P limitation have been shown to limit vegetation specially in tropical regions. In summary, the implementation of the nitrogen and phosphorus cycle have successfully enforced a nutrient limitation in the terrestrial system, which now have reduced the primary productivity and the capacity of land to uptake atmospheric carbon.