Geophysical Research Abstracts
Vol. 15, EGU2013-9174-1, 2013
EGU General Assembly 2013


# Nitrogen cycle implementation in the Dynamic Global Vegetation Model LPJmL: description, evaluation and sensitivity analysis

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Nitrogen (N) cycling affects carbon uptake by the terrestrial biosphere and imposes controls on carbon cycle response to variation in temperature and precipitation. In the absence of carbon–nitrogen interactions, surface warming significantly reduces carbon sequestration in both vegetation and soil by increasing respiration and decomposition (a positive feedback). If plant carbon uptake, however, is assumed to be nitrogen limited, an increase in decomposition leads to an increase in nitrogen availability stimulating plant growth. The resulting increase in carbon uptake by vegetation can exceed carbon loss from the soil, leading to enhanced carbon sequestration (a negative feedback).

Cultivation of biofuel crops is expanding because of its potential for climate mitigation, whereas the environmental impacts of bioenergy production still remain unknown. While carbon payback times are being increasingly investigated, non-$CO_2$ greenhouse gas emissions of bioenergy production have received little attention so far.

We introduced a process-based nitrogen cycle to the LPJmL model at the global scale (each grid cell being 0.5° latitude by 0.5° longitude in size). The model captures mechanisms essential for N cycling and their feedbacks on C cycling: the uptake, allocation and turnover on N in plants, N limitation of plant productivity, and soil N transformation including mineralization, N2 fixation, nitrification and denitrification, NH3 volatilization, N leaching and N2O emissions. Our model captures many essential characteristics of C-N interactions and is capable of broadly recreating spatial and temporal variations in N and C dynamics.

Here we evaluate LPJmL by comparing the predicted variables with data from sites with sufficient observations to describe ecosystem nitrogen and carbon fluxes and contents and their responses to climate as well as with estimates of N-dynamics at the global scale. The simulations presented here use no site-specific parameterizations in order to analyze unbiased model behavior relevant to regional to global scales. The same model setup is used for all simulations, and only external parameters (i.e. climate and physical soil properties) are prescribed from observations. We test the robustness of the model by systematically varying key parameters related to N processes and vary model input and initialization. In a first set of scenarios, we analyze the effect of bioenergy plantations on N2O emissions to better understand their potential role in climate mitigation.