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Modelling ecosystem nitrogen dynamics to simulate historical and future terrestrial greenhouse gas budgets

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Plant nitrogen availability may strongly limit any future terrestrial carbon sequestration due to CO_2 fertilisation and/or increased growing season length. Greater nitrogen deposition or increased mineralization due to global warming could potentially counteract or even negate this nitrogen limitation. Changes in terrestrial nitrogen inputs or climate may alter terrestrial N_2O emissions, and thereby further modify the interaction between the terrestrial biosphere and the climate system. To understand the relative contributions of these processes, we use an advanced terrestrial biogeochemical model (ORCHIDEE-CN) that includes the most important nitrogen cycle feedbacks on the terrestrial carbon and water cycles.

This newly developed model fully couples the cycles of carbon, nitrogen and water in natural and anthropogenic terrestrial ecosystems. It treats nitrogen inputs from atmospheric deposition (reduced/oxidized, wet/dry), fertiliser use, and biological nitrogen fixation. The model is built on novel approaches to canopy processes and plant nitrogen dynamics at a level of detail adequate for global modelling studies, and explicitly represents soil organic and inorganic nitrogen turnover to enable calculation of leaching of inorganic nitrogen and dissolved organic matter, as well as gaseous losses of NH_3, NO_x and N_2O.

First, we evaluate the model against intensively monitored plots to test whether the model realistically simulates carbon and nitrogen cycling and fluxes across a range of temperate and boreal forest sites. The model produces estimates of ecosystem pro-

ductivity, foliage mass and leaf nitrogen concentrations consistent with current understanding of the global carbon and nitrogen cycles. Next, we evaluate the capacity of the model to adequately represent the responses of carbon and nitrogen cycles to ecosystem manipulation through chronic N inputs and elevated atmospheric CO_2 concentrations. Finally, we analyse the relative contributions of changes in nitrogen inputs (deposition and fertiliser use), climate and atmospheric CO_2 to the historical global carbon and nitrogen budgets. We discuss implications for estimates of terrestrial biosphere climate feedbacks in view of the recent findings of Thornton et al. (2007) who suggested that accounting for the N cycle in carbon-climate feedback studies changes not only the magnitude but also the sign of the feedback.