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A first step towards a more process-oriented description of the terrestrial vegetation carbon balance in models of the global carbon cycle

T. G. Reichenau
University of Cologne, Institut of Geography, Germany (tim.reichenau@uni-koeln.de)

In models of the global carbon cycle, the carbon balance of the terrestrial biosphere is often modelled as NPP or with respiration directly linked to photosynthesis. In these cases, respiration can never exceed photosynthesis, thus avoiding net losses of carbon that are independent of litter production. As a first step towards a more process-oriented description of the terrestrial biosphere carbon balance, the model CABIN (CArbon Balance Influenced by Nitrogen) was developed. CABIN calculates NPP from the balance of a Farquhar-type description of photosynthesis and a newly developed model of autotrophic respiration driven by both demand of energy and supply of carbohydrates. Both process models account for the influence of nitrogen. Additional pools for available carbohydrates and carbon reserves are used to model the internal carbon budget of the vegetation. The formulation of fluxes was kept simple to keep CABIN usable on a global scale.

The main aims of the study were (1) to find out to which extent descriptions of carbon exchange processes as implemented in CABIN can be used to model the terrestrial vegetation carbon balance and (2) to identify the processes and parameters with the highest potential to improve CABIN's applicability for different vegetation types.

To address these points, CABIN was run with carbon and nitrogen pools from a global model of coupled carbon and nitrogen cycles. The NPP calculated by CABIN was compared to measured NPP data from sites of the major vegetation types. The same parametrisation was used for all sites.

Using average values for the main parameters of CABIN, the NPP of temperate ecosystems could be reproduced. For ecosystems with higher mean annual temperatures, CABIN underestimated NPP whereas NPP of vegetation types with lower mean annual temperatures was overestimated.

To address question (2), multiple runs of CABIN were conducted with the values of its main parameters varied within plausible ranges. The resulting ranges of modelled NPP included the measured values for most of the measurement sites, suggesting the need of different parameterisations for different vegetation types. Basic respiratory metabolism, nitrogen dependency of both photosynthesis and respiration and reference temperature were identified as the parameters with the strongest influence on the modelled NPP.

Taking a closer look at these parameters will provide the basis for making CABIN usable on a global scale and thus introduce a more process-oriented description of the vegetation carbon budget to models of the global carbon cycle.