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Linking carbon-water- and nitrogen fluxes at forest ecosystems throughout Europe with a coupled soil-vegetation process model "LandscapeDNDC"

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Forest ecosystems in Europe play a key role in the emission reduction commitment agreed in the Kyoto Protocol for mitigating climatic change. Forest ecological functioning and potential services (such as carbon sequestration) are a matter of debate for policy decision makers resulting from the need of identifying affordable strategies for forest management and exploitation against climate change. Forest ecosystem functioning and the linkages governing carbon-, water- and nitrogen fluxes at site scale was evaluated for three dominant tree species (Pinus sylvestris, Picea abies and Fagus sylvatica) grown on 10 different sites across Europe. We did answer in particular the following questions: a) is LandscapeDNDC able to represent NEE, GPP, TER and ET fluxes for dominant forest types in Europe at different sites with only a species specific parameterization? b) What is the relation between carbon input into the ecosystem and on the emission of carbon and nitrogen from the forest soil? Furthermore we analyzed the interaction between carbon-, nitrogen-, and water cycle, in particular the dependence of gaseous fluxes on water and litter availability.
LandscapeDNDC is a process based model that integrates modules for carbon, nitrogen and water cycling within terrestrial ecosystems (i.e. forest) on the site and regional scale. Biosphere, atmosphere and hydrosphere processes in forest ecosystems are linked by daily time step integration of the microclimate, water cycle, soil biogeochemistry and tree physiology and dimensional growth modules which balances all three aforementioned cycles. All processes and state variables are considered in a vertically structured one dimensional vertical column that reaches from rooting depth (more than 1 m depth) to the uppermost canopy layer.
LandscapeDNDC was tested against long term (about 10 years) field data. The capability of the applied model for reproducing daily derived GPP and TER was accompanied by a high statistical precision (r2), accuracy (r2eff) and agreement (RMSPEn) while for reproducing daily NEE and ET as well as soil moisture was accompanied by a good statistical precision and agreement. In addition, beside C fixation also simulated C allocation into different vegetation compartments agreed well with measured data on biomass development and vegetation structure. Also soil respiration and N2O emissions agreed well with field observations. Soil respiration was driven by GPP and the rates of N2O fluxes depended on soil ecosystem properties and were influenced by litter C/N inputs and weather conditions.
In conclusion by use of general tree species parameterizations LandscapeDNDC was capable to simulate and capture impacts of a multitude of environmental drivers on forest ecosystem C-, N-, water dynamics, as well as linking above - and belowground processes across various sites in Europe. Nevertheless, the quality of measured data (e.g. spatial representation, time resolution) as well as the existing description of ecosystem processes in the model should be considered when evaluating the capability of process based models to be used for evaluation of biogeochemical ecosystem functioning.