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Introducing litter quality to the ecosystem model LPJ-GUESS: Effects on short- and long-term soil carbon dynamics

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Many biogeochemical models have been applied to study the response of the carbon cycle to changes in climate, whereby the process of carbon uptake (photosynthesis) has usually gained more attention than the equally important process of carbon release by respiration. The decomposition of soil organic matter is driven by a combination of factors like soil temperature, soil moisture and litter quality. We have introduced dependence on litter substrate quality to heterotrophic soil respiration in the ecosystem model LPJ-GUESS [Smith et al.(2001)]. We were interested in differences in model projections before and after the inclusion of the dependency both in respect to short- and long-term soil carbon dynamics.

The standard implementation of heterotrophic soil respiration in LPJ-GUESS is a simple carbon three-pool model whose decay rates are dependent on soil temperature and soil moisture. We have added dependence on litter quality by coupling LPJ-GUESS to the soil carbon model Yasso07 [Tuomi et al.(2008)]. The Yasso07 model is based on an extensive number of measurements of litter decomposition of forest soils. Apart from the dependence on soil temperature and soil moisture, the Yasso07 model uses carbon soil pools representing different substrate qualities: acid hydrolyzable, water soluble, ethanol soluble, lignin compounds and humus. Additionally Yasso07 differentiates between woody and non-woody litter. In contrary to the reference implementation of LPJ-GUESS, in the new model implementation, the litter now is divided according to its specific quality and added to the corresponding soil carbon pool. The litter quality thereby differs between litter source (leaves, roots, stems) and plant functional type (broadleaved, needleleaved, grass). The two contrasting model implementations were compared and validated at one specific CarboEuropeIP site (Lägern, Switzerland) and on a broader scale all over Switzerland. Our focus lay on the soil respiration for the years 2006 and 2007 [Rühr(2009)] and present soil carbon stocks [Heim et al.(2009)].

Our Results show, that for short-term soil carbon dynamics, e.g. estimates of heterotrophic soil respiration on an annual basis, the inclusion of the dependency on litter quality is not necessary, as the differences are minor only. However, when considering long-term soil carbon dynamics, e.g. simulated estimates of present soil carbon content, the dependency on litter quality shows effect, as there are correlations with specific site factors such as site location and forest type. The inclusion of the dependence on litter quality therefore may be of importance for the projection of future soil carbon dynamics, as forest types may well be altered due to climatic change.

References

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