Geophysical Research Abstracts,
Vol. 11, EGU2009-9780, 2009
EGU General Assembly 2009

Temperature response functions introduce high uncertainty in modelled carbon stocks in cold temperature regimes

H. Portner, A. Wolf, and H. Bugmann

Swiss Federal Institute of Technology (ETH), Institute of Terrestrial Ecosystems, Department of Environmental Sciences, Zürich, Switzerland (hanspeter.portner@env.ethz.ch)

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 with a prominent one being soil temperature [Berg and Laskowski(2005)]. One uncertainty concerns the response function used to describe the sensitivity of soil organic matter decomposition to temperature. This relationship is often described by one out of a set of similar exponential functions, but it has not been investigated how uncertainties in the choice of the response function influence the long term predictions of biogeochemical models.

We built upon the well-established LPJ-GUESS model [Smith et al.(2001)]. We tested five candidate functions and calibrated them against eight datasets from different Ameriflux and CarboEuropeIP sites [Hibbard et al.(2006)]. We used a simple Exponential function with a constant Q_{10}, the Arrhenius function, the Gaussian function [Tuomi et al.(2008), O'Connell(1990)], the Van't Hoff function [Van't Hoff(1901)] and the Lloyd&Taylor function [Lloyd and Taylor(1994)]. We assessed the impact of uncertainty in model formulation of temperature response on estimates of present and future long-term carbon storage in ecosystems and hence on the CO_2 feedback potential to the atmosphere. We specifically investigated the relative importance of model formulation and the error introduced by using different data sets for the parameterization.

Our results suggested that the Exponential and Arrhenius functions are inappropriate, as they overestimated the respiration rates at lower temperatures. The Gaussian, Van't Hoff and Lloyd&Taylor functions all fit the observed data better, whereby the functions of Gaussian and Van't Hoff underestimated the response at higher temperatures. We suggest, that the function of Lloyd&Taylor therefore is an adequate choice to model the temperature dependency of soil organic matter decomposition. The Ticino catchment (300-2300m) in Southern Switzerland was used to study the sensitivity of long-term changes (100 years) in the prediction of carbon storage. The uncertainty in temperature response introduced into the model lead to high uncertainties in long-term soil carbon stocks. Interestingly, the uncertainty increased with decreasing temperature and increasing elevation. The carbon pools in lower elevations (mean annual temperature $> 15°C$) turned over faster and little carbon accumulated in the soil. The carbon pools in higher elevations and hence in higher latitudes experiencing colder temperature (mean annual temperature $< 15°C$) turned over slower and therefore accumulated more carbon over the simulation period. Therefore, the high elevation soils stored more carbon, but the prediction of the carbon pool size had a much higher uncertainty than the low elevation soils.

We concluded that with our model, the predictions of the potential loss of soil carbon in cold temperature regimes is more uncertain than the carbon loss in warmer regions, both due to the higher soil carbon pools, but also due to the higher uncertainty found in our simulations.

References

[Berg and Laskowski(2005)] Björn Berg and Ryszard Laskowski. Anthropogenic impacts on litter decomposition and soil organic matter. *Advances in Ecological Research*, 38:263–290, 2005.

[Lloyd and Taylor(1994)] J. Lloyd and J. A Taylor. On the temperature dependence of soil respiration. *Functional Ecology*, 8:315–323, 1994.

[O'Connell(1990)] A. M. O'Connell. Microbial decomposition (respiration) of litter in eucalypt forests of south-western australia: An empirical model based on laboratory incubations. *Soil Biology and Biochemistry*, 22: 153–160, 1990.

[Smith et al.(2001)] Benjamin Smith, I. Colin Prentice, and Martin T. Sykes. Representation of vegetation dynamics in the modelling of terrestrial ecosystems: comparing two contrasting approaches within european climate space. *Global Ecology and Biogeography*, 10:621–637, 2001.

[Tuomi et al.(2008)] Mikko Tuomi, Pekka Vanhala, Kristiina Karhu, Hannu Fritze, and Jari Liski. Heterotrophic soil respiration–comparison of different models describing its temperature dependence. *Ecological Modelling*, 211:182–190, 2008.

[Van't Hoff(1901)] J. H. Van't Hoff. *Vorlesungen über theoretische und physicalische Chemie. Erstes Heft: Die chemische Dynamik*. Druck und Verlag von Friedrich Vieweg und Sohn, Braunschweig, 1901.