3rd International Conference on Earth System Modelling
Vol. , 3ICESM-143, 2012
3rd International Conference on Earth System Modelling

Permafrost soil carbon balance in a warming world

S. Schaphoff (1), U. Heyder (1), W. Lucht (1,2), and D. Gerten (1)
(1) PIK, Germany (sibylls@pik-potsdam.de), (2) Department of Geography, Humboldt University, Berlin, Germany

Climate warming affects permafrost soil carbon pools in two opposing ways: enhanced vegetation growth leads to higher carbon inputs to the soil, whereas permafrost melting accelerates decomposition and hence carbon release. We calculate temperature response rates for the two processes for several temperature trajectories and estimate at which point in time permafrost soils are likely to turn into a net carbon source. We further investigate whether the trend of net carbon release is reversed on longer time scales (assuming that global mean temperature is stabilized after 2100) and how long that would take at given temperature trajectories. We study these processes with the Dynamic Global Vegetation Model LPJmL. The model simulates plant physiological and ecological processes and includes a newly developed discrete-layer energy balance permafrost module. The model is hence able to reproduce the interactions between vegetation and soil carbon dynamics and to simulate dynamic permafrost changes resulting from changes in the climate. We are using climate response patterns derived from the WCRP CMIP3 climate model database as climate input. Scaling of these patterns gives 8 temperature trajectories reaching global mean temperature increases between 1.5 and 5 K above pre-industrial levels in 2100 and a stabilization scenario extended until 2615 for each of these increases. Corresponding atmospheric CO_2-content trajectories are derived from the reduced-complexity climate model MAGICC. We find that vegetation responds more rapidly to warming of the permafrost zone than soil carbon pools due to long time lags in permafrost thawing. We thus simulate a net uptake of carbon for some decades of warming. However, once the turning point is reached if carbon release exceeds the uptake, carbon is lost irreversibly from the system and cannot be compensated for by increasing vegetation carbon input. Our analysis shows the importance of including dynamic vegetation into analyses of permafrost zone carbon budgets.