Geophysical Research Abstracts
Vol. 13, EGU2011-9643, 2011
EGU General Assembly 2011

What consequences can have small changes in heterotrophic respiration on the global carbon cycle?

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Soil is the largest global pool of terrestrial C and the soil organic C pool (approximately 2300 Pg of C, Davidson and Janssens, 2006) is at least three times larger than the size of the atmospheric carbon pool. The heterotrophic respiration (RH), the conversion of soil organic carbon to CO_2 by the soil microbial community, depends on organic matter recalcitrance, on soil temperature and moisture. Because of its strong sensitivity to temperature, it is believed that the carbon transfer of from soils to the atmosphere due to the potential increase in global temperatures could counterbalance the global NPP. The terrestrial biosphere would then become a net source of carbon.

Global carbon cycle models of terrestrial ecosystems use empirical formulations, for the dependence of RH on temperature, resting on empirical relationship obtained by curve-fitting observed respiration rates and temperature. This leads to the question "how well could these formulations simulate RH in a changing climate?" No one can answer to this question today since there is no consensus on a mechanistic relationship able to describe RH in a single model at the global scale. Inversely can we explore the impact of changes in decomposition rates on the behavior of an Earth system Model (ESM)?

To answer this question we used the "Bergen Climate Model – Carbon" (BCM-C, Tjiputra et al., 2010). The BCM-C consists of global atmospheric and oceanic general circulation models coupled to oceanic and terrestrial carbon cycle models (Tjiputra et al., 2010). This ESM is able to interactively simulate the known global carbon-cycles processes, including the radiative feedback necessary for climate change simulations. The terrestrial carbon cycle is simulated with the Lund-Postdam-Jena Model (LPJ) (Sitch et al., 2003). LPJ is run at a horizontal resolution of approximately $2.5^{\circ}\times2.5^{\circ}$ with monthly model time step. In LPJ, SOM decomposition follows a first order kinetics that is soil temperature and moisture dependent. Temperature dependence follows the Arrhenius relationship modified by Lloyd and Taylor (1994).

For this study, we modified the SOM decomposition dependence to soil temperature by a constant factor: R: $\pm15\%$, $\pm10\%$, and 0%. These modified decomposition rates are in the range of those obtained by Portner et al. (2010) with a linearized form of Lloyd and Taylor function. Two series of multi-century simulations were realized with the different values of R: 1) Simulations with pre-industrial climate forcings (i.e., atmospheric CO_2 concentration at 284.7 ppm, an estimated value for year 1850). 2) Fully interactive simulations based on historical and SRES-A2 emission scenario (only for 0% and $\pm$ 5% sensitivity factor). These 10 simulations will show us how a small change in RH can have consequences on the global carbon cycle.

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