Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11762, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11762
EGU General Assembly 2008

CO_2-emissions in warming, northern peatlands: where does the increase come from?

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Northern peatlands store about one-third of the total global soil carbon pool in only 3 % of the earth's land surface. Considerable increases in temperature have been recorded at high latitudes over the past decades and continued warming is projected for the coming century. Moreover, expected changes in winter snow conditions will not only affect moisture, but temperature as well. Release of the large carbon stores in northern peatlands, through temperature-enhanced decay rates, may form a major, positive feedback to our global climate. However, the net long-term effects on the carbon balance remain uncertain. There are indications that climate warming may only affect the respiration of plants, their fresh litter and young soil organic matter, with transient effects on soil CO_2 efflux, while older peat is hardly sensitive to higher temperatures due to its recalcitrant nature. Such differences in the responsiveness of short-term and longer-term C-cycles to climate change under realistic field conditions have received little attention so far.

Our aims were therefore (1) to investigate the responses of CO_2 emissions of a sub-arctic peatland to realistic year-round climate change scenarios, including changes in summer temperatures and winter snow cover, and (2) to identify the sources of increases in respired CO_2 ($i.e.$ living plants *versus* superficial, young peat layers *versus* deep, old peat). We subjected a sub-arctic peatland (Abisko, north Sweden) to seven different climate change scenarios, using open-top chambers (OTCs). Each scenario was created by using different combinations of summer warming, spring warming, and increased winter snow.

(1) The climate manipulations had clear effects on ecosystem respiration throughout the growing season (May-September), both in the short term (3 years) and after prolonged climate manipulation (5-7 years). The treatments including spring or summer warming strongly enhanced respiration within their respective seasons of application (May or June-September). Winter snow addition seemed to have a small, enhancing carry-over effect on the respiration in early spring (early May).

(2) To find out whether climate warming only enhances the fast turn-over of recently fixated carbon in plants, the decay of freshly senesced, superficial organic material or whether even older, deeper peat layers respond, we used two different approaches. Removal of the aboveground vegetation showed that the respiration of peat without living vegetation or roots was as responsive to summer warming as CO_2 emission in the presence of vegetation, at least in the first 2 years, indicating that climate change may stimulate carbon cycling through carbon pools in both plants and peat. In addition to this we developed a novel method to track the origin of the emitted carbon by comparing the delta ^{13}C isotopic signatures of the emitted CO_2 with that of different peat layers. Laboratory incubations of six different peat layers (down to -50 cm) showed that delta ^{13}C values of bulk and respired carbon consistently increase along our peat profile (up to 1.7 permil). Moreover, field measurements showed seasonal patterns as well as clear increases in delta ^{13}C signatures of respired CO_2 upon warming, suggesting that the decay of deeper peat layers might be enhanced by climate change.