Experimental soil warming in a mountain forest ecosystem

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Background

Global warming will rise forest soil temperatures and thereby accelerate enzyme kinetic driven processes like organic matter decomposition. Already fixed carbon in the humus may become vulnerable to decomposition and leave the soil as CO₂. This temperature induced increase in soil respiration could, in worst case, have the potential to shift temperate forest ecosystems from a net sink to a net source of atmospheric CO₂. The temporal and quantitative degree of the temperature induced feedback on global warming is still under debate.

Methods | Winter

We measured CO₂ emissions directly from the snow surface using a home made closed dynamic chamber. Additionally, we installed nine Teflon tubes with a small air collector made of a stainless steel mesh at the soil-air interface. The tubes were fixed to tree trunks, so that the other end was accessible even during thick snow cover. CO₂ fluxes were calculated from the concentration gradient (CO₂ at the soil surface; CO₂ at the snow surface) and the snow porosity following Messman et al., 1985. Furthermore we measured concentration gradients through the snow profile using a snow probe in 20 cm depth intervals. This allowed us a better calculation of the flux through snow packs with distinctive layering.

Results | Winter

- The soil was never frozen under the snow and the CO₂ flux through the snow ranged between 17.6 and 41.0 mg CO₂-C m⁻² h⁻¹ until the end of March.
- Flux estimates from the chamber measurements on the snow surface were 3-5 times less than flux estimates calculated with the diffusion approach.
- Distinct ice layers can impact the CO₂ flux through snowpacks (Fig. 6).

Conclusions

The soil respiration strongly responded (+30%) to a soil temperature increase of 3°C throughout the first observation year. The coming years will show if this response was only an initial flush of easily decomposed organic matter or if higher temperatures will lead to a decomposition of humic substrates, thereby leading to long-term elevated CO₂ emissions from forest soils.

At our site, the winter CO₂ fluxes through snow amounted to 10-15% of the annual soil respiration. This carbon was fixed during summer and was lost to the atmosphere during winter. Therefore we strongly recommend measuring soil respiration in winter, especially if one is calculating annual soil respiration, or carbon budgets, respectively.

References


Figures:

1. Carbon cycle
2. Mean CO₂ flux from the forest soil
3. Automated plot with automatic chambers, chambers for manual measurements (orange) and the tech box (behind) equipped with the infrared gas analyser, the control unit and the data loggers (b) The heating unit, it consists of 3 transformers and a 50 kVA converter, which is operated by a specially programmed compact data logger (c) Open plot during the trenching procedure
4. Percent root respiration as calculated by subtracting the CO₂ fluxes of the heated and control plots from the fluxes of the heated and control trench plots, respectively. The red line shows the start of the heating period

Created by Robert Winter