Karlsruher Institut für Technologie

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research

Natural and Drained Temperate Bog-Forest Ecosystems: Carbon Sink or Carbon Source?

Janina Hommeltenberg[1)], Rainer Steinbrecher[1)], Matthias Drösler[2)], Matthias Mauder[1)], Hans Peter Schmid[1)],

1) Karlsruhe Institute of Technology KIT, Institute of Meteorology and Climate Research IMK-IFU, Garmisch-Partenkirchen
2) University of Applied Sciences Weihenstephan-Triesdorf, Chair of Vegetation-Ecology, Freising
janina.hommeltenberg@kit.edu

Introduction

Generally drained peatlands are considered as CO_2 sources and natural peatlands as CO_2 sinks. However, to date sound greenhouse gas emission factors of peatland forests of the temperate climate zone are still rare.

This study aims to shed more light on the GHG exchange of peatland forests in the temperate, pre-alpine region of southern Germany. Therefore, we compared directly the CO_2 exchange of a natural bog-pine forest (Schechenfilz) and of a bog drained for forestry (Mooseurach), by eddy covariance measurements over two annual cycles (July 2010 to June 2012). In addition, the CH_4 exchange is studied at the natural site since summer 2012, to account for all relevant greenhouse gases. Both sites are separated only by a few kilometers, thus weather conditions and peat-formation history are the same, and differences in the GHG exchange are mainly attributable to differences in land use, land use history and management.

Differences and similarities in the CO_2 budgets and of the component fluxes respiration (R_{eco}) and gross primary production (GPP) have been determined. Furthermore, most relevant driving factors for methane fluxes at the natural site must be identified and finally it must be examined whether methane emissions offset the expected radiative cooling effect, caused by CO_2 uptake.

Furthermore, for meaningful carbon budgets of drained and managed peat-forest sites the total carbon accumulation of the trees as well as the carbon loss from the peat in the same time frame have to be taken into account.

Study sites

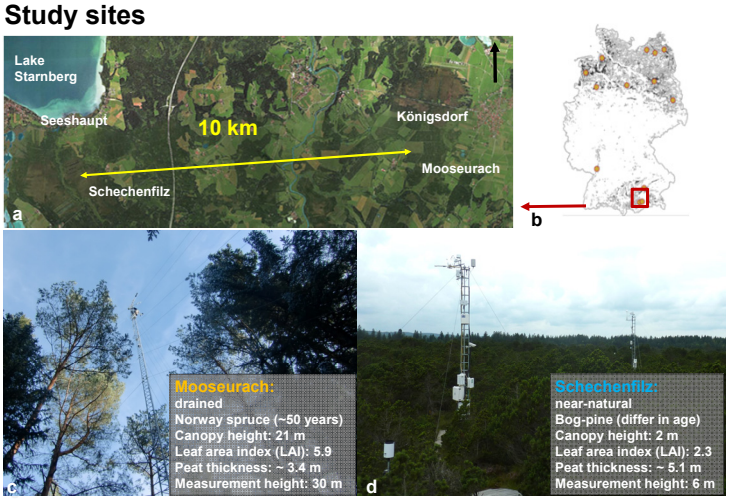

Fig.1 a) Aerial image of the peatland forests Schechenfilz and Mooseurach, source: Google Earth; b) Distribution of peatland in Germany (grey-shaded) and location of the study sites of the project „organic soils"; c) measurement tower at the drained spruce forest Mooseurach and d) measurement towers at the natural bog-pine forest at the Schechenfilz site.

Carbon dioxide exchange

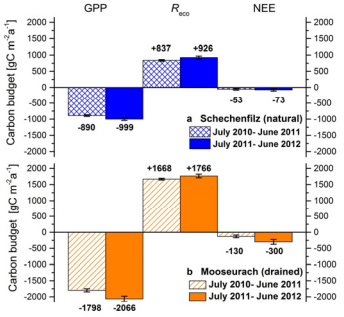

Fig . 2 Annual sums of GPP, R_{eco}, NEE at a) Schechenfilz and b) Mooseurach.

- CO_2 uptake at the drained site is 2.5 to 4 times larger than at the natural bog site:

→ **-130** ±41 and **-300** ±74 g C m^{-2}a^{-1} vs. **-53** ±28 and **-73** ±38 g C m^{-2} a^{-1}

But:

- measurements are just a „snapshot" of two years
- Estimated carbon accumulation of the spruces in the last 50 years is 86 t C ha^{-1} (biometric estimation)
- Roughly estimated carbon loss of the peat is 244 t C ha^{-1}at the drained site in the same time

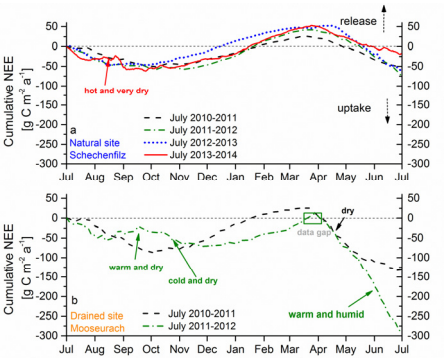

Fig. 3 Comparison of annual CO_2 exchange from July 2010-June 2014 at a) Schechenfilz and from July 2010 to June 2012 at b) Mooseurach.

Schechenfilz

→ Similar CO_2 uptake in four years

→ **Robust behavior**

Mooseurach

→ High variability, strong influence of environmental drivers

→ **More sensitive**

Methane exchange at the natural site Schechenfilz

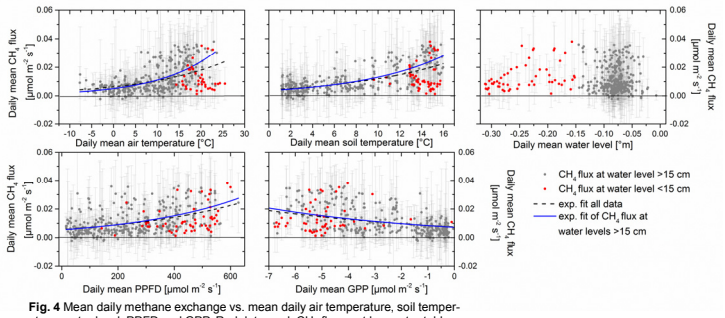

Fig. 4 Mean daily methane exchange vs. mean daily air temperature, soil temperature, water level, PPFD and GPP. Red dots mark CH_4 fluxes at low water tables.

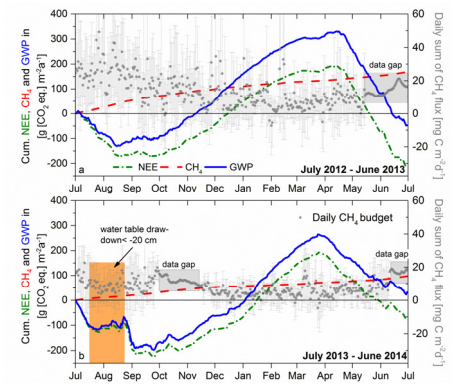

Fig. 5 Annual cumulative NEE, CH_4 and GWP exchange and the daily sum of methane exchange from July 2012-June 2014.

- Mean daily methane exchange correlates well with soil temperature, except for water table drawdown events
- The natural bog-pine site is a weak but robust CO_2 sink, but a minor source of CH_4

→ Neutral global warming potential (GWP) balance of the 100-yr time horizon (-50 and +32 g [CO_2-eq.] m^{-2}a^{-1})

- Extraordinary water table drawdown has a strong impact on the carbon and GWP balance

Conclusion

- Two years of eddy covariance measurements indicate larger CO_2 uptake at the drained site

→ However, respiration rates are two times larger at the drained site

→ At the natural site the CO_2 balance is more robust than at the drained site

- In the long-term perspective:
  carbon losses from the drained soil are three times stronger than the carbon uptake of the trees over a period of 50 years

→ To compensate the former carbon loss, the spruces have to fix carbon for another 100 years at the current rate

- Considering a realistic life cycle of a spruce forest (60 to 100 years), the drained spruce forest site is a greenhouse gas (GHG) source
- At the natural site methane exchange correlates best with soil temperature, except during an extraordinary dry period of six weeks
- Currently, in terms of its global warming potential (GWP), the natural bog-pine site could be considered as neutral, while the drained site is a significant GHG sink