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Influence of soil C stocks and interannual climatic variability on the CO_2 and CH4 exchange of maize cultivated on mineral and organic soils in NE Germany

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Due to its glacially influenced genesis and land use history, the soils of the Great Plain Region of NE-Germany show large differences in groundwater levels and soil carbon (C) stocks over short distances. Although generally featuring a rather dry climate, trace gas exchange at individual sites may be influenced by i) interannual climatic variability, particularly with respect to precipitation; as well as by ii) variability of soil C stocks. However, it is still unclear how these factors affect fluxes of CO_2 and CH4, and if there is any positive or negative feedback on the C source or sink function of different soil types.

We present measured and modeled CO_2 and CH4 fluxes of minerally fertilized grain maize for three sites located near Paulinenaue, within the so-called Rhin-Havelluch, a shallow and drained paludification mire complex in NE Germany. The sites are characterized by a distinct gradient of 0–1 m soil organic C stocks: i) Arenosol (AR: mineral soil/distant groundwater; 8 000 g C m-2), ii) Gleysol (GL: organic soil/groundwater-dependent; 35 000 g C m-2), and iii) Histosol (HS: organic soil/near groundwater; 45 000 g C m-2).

CO_2 flux measurements of ecosystem respiration (Reco), net ecosystem exchange (NEE) and gross primary production (GPP; calculated as difference between NEE and Reco) were conducted every four weeks using a flow-through non-steady-state closed chamber system. Measurement gaps of Reco and NEE were filled by using temperature or radiation-based models, respectively. CH4 fluxes were measured bi-weekly using a static closed chamber system with interval sampling, with gap filling via linear interpolation. Cumulated fluxes of CO_2-C (Reco, GPP, NEE) and CH4-C were calculated for a period of four consecutive years (2007–2010).

The intensity of CO_2-C fluxes increased with growing soil organic C stocks (AR < GL < HS). Mean annual values of the years 2008–2010 for Reco ranged between 1 500 g C m-2 and 2 000 g C m-2; annual GPP fluxes ranged from -1 400 g C m-2 to -2 300 g C m-2. NEE balances varied from C source on the mineral AR site (65 g C m-2) to C sink for organic sites (nearly -350 g C m-2). Annual CH4 exchange rates were generally very low < 0.3 g C m-2 and negligible compared to annual CO_2 exchange. However, the exceptionally wet summer of 2007 (May to July) resulted in drastically increased CH4 emissions from the groundwater-influenced organic soils, particularly at the HS site where CH4 emissions were nearly 100 times higher emissions than in the following years (28 g C m-2). The excess moisture levels in 2007 also appeared to influence ecosystem CO_2 exchange – likely through effects on maize growth – resulting in strongly increased Reco and GPP rates at the mineral AR site and drastically decreased Reco and GPP rates at the flooded HS site.

The intensity of gaseous C fluxes seems to strongly depend on interactions between soil C stocks and interannual climatic variability. More detailed conclusions about the nature of these interactions require continuation of these measurements, i.e. long-term investigation.