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Biosphere-atmosphere exchange of N_2O, CH_4 and CO_2 in natural savannah and rainfed agriculture in Burkina Faso (W Africa)

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Tropical savannahs cover an area of 17 x 10^6 km^2 worldwide. Their role in the global greenhouse gas budget still remains uncertain. In the past large parts of the former native African savannahs had been converted to agricultural land. It can be hypothesized that these widespread land conversions triggered mineralization processes followed by a rapid reduction of soil C and N as well as increasing losses of gaseous C and N compounds, which could in turn affect the carbon and nitrogen balance of these sensitive ecosystems.

The objective of this study was to reduce the uncertainty of greenhouse gas exchange of tropical savannah ecosystems, especially in sub-Saharan Africa. Biosphere-atmosphere exchange of N_2O, CH_4 and CO_2 was quantified in natural savannah and in rainfed agricultural land in Burkina Faso by means of eddy covariance (EC) and chamber measurements. An EC tower was established in a nature reserve to determine the net ecosystem exchange of CO_2 (NEE_C) and energy fluxes from November 2004 to October 2006. Soil-atmosphere exchange of N_2O, CH_4 and CO_2 was measured during the rainy seasons 2005 and 2006 with chambers in the nature reserve and on plots with the three dominating crop species in Burkina Faso, i.e. sorghum, cotton and peanut. The EC measurements revealed that the natural savannah acted as a small

C source in the dry period, whereas large amounts of CO_2-C were bound during the rainy seasons, particularly from June to September. The balance of the first year of our observations indicated a C uptake of 373 g m^{-2} of the ecosystem, which is comparable to deciduous forests in Europe. The CO_2 fluxes showed clear diurnal patterns with the highest uptake rates at noon (up to 1 mg m^{-2} s^{-1} in July and August) and a permanent slight release to the atmosphere during night-time.

Results of the chamber measurements show low emission rates of N_2O on an average of 1-10 μg N_2O-N m^{-2} h^{-1}, whereas the highest single fluxes were observed at the beginning of the rainy seasons of 2005 and 2006. Differences among the investigated crop types were marginal. CH_4 fluxes, however, showed a more sophisticated pattern. While the agricultural fields were characterised by average CH_4 uptake rates of 3-8 μg CH_4-C m^{-2} h^{-1} during the rainy season 2005 –interrupted by periods of net CH_4 production after heavy rainfall events– emission rates of up to 85 μg CH_4-C m^{-2} h^{-1} were measured at the natural savannah site. So far CH_4 emissions of this magnitude have been known just for wetlands.

The natural savannah acted as a substantial source of CH_4, whereas the agricultural land was a moderate sink of this greenhouse gas. Soil respiration and N_2O fluxes were also highest in the natural savannah, but differences among all sites were rather small. Highest CH_4 and N_2O flux rates at the savannah site could be explained by the assumption that the input of organic material into the soil decreased rapidly after conversion to cropland, leading to significantly decreased C and N availability and turnover.