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Export of greenhouse gases across the soil/stream interface in a boreal headwater stream

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The importance of lateral CO2 export from boreal forest soils to surface waters for net ecosystem C balances are becoming increasingly evident. In addition, riparian zones in the boreal landscape often exhibit redox characteristics that promote the production of N2O and CH4 in groundwater discharge areas that subsequently may reach surface waters. The aim of this study was to investigate the annual lateral export of greenhouse gases (CO2, CH4 and N2O) from a 13 ha boreal forest catchment draining into a 1st order stream in order to quantify the total export of greenhouse gases (in CO2 equivalents) from the terrestrial to the aquatic environment. We present export budgets for 2 years, one with annual discharge close to the long-term average and one wet year when discharge was twice as high.

During the year with normal discharge, export of CO2 from the soil to the stream was 11.3 (1.6) g m-2 year-1, while export of N2O and CH4 was 1.4 (0.6) and 0.1 (0.01) mg m-2 year-1 (standard deviation in parenthesis; values normalized for the whole catchment size of 13 ha). In terms of CO2 equivalents the greenhouse gas export was dominated by CO2 (96%). N2O export contributed to ca. 4%, while contribution of CH4 was negligible (<0.1%). In comparison to the estimated annual forest NEE (representing the vertical CO2 exchange driven by photosynthesis and ecosystem respiration) the loss of CO2 equivalents through lateral export corresponded to ca. 4%. During the wet year the lateral export of both CO2 and N2O were much higher, while CH4 remained negligible. CO2 export was almost twice as high while N2O export increased by a factor of 3. Consequently, the contribution of N2O to the lateral export of GHGs in terms of CO2 equivalents increased to ca. 10%. Higher export rates during wet years can mainly be explained by the fact that export dynamics are strongly controlled by discharge. In addition, the increase in N2O export can be attributed to higher groundwater levels in the riparian zone promoting denitrification and, hence, N2O production. Moreover, during the wet year the lateral loss of greenhouse gases in terms of CO2 equivalents corresponded to ca. 14% of estimated forest NEE.

We can conclude that the lateral export of greenhouse gases from the soil to surface waters may significantly influence the net carbon balance of forest ecosystems. In terms of CO2 equivalents the export is dominated by CO2 (i.e. dissolved inorganic carbon, DIC), but it is evident that during wet years the importance of N2O increases.