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Nitrous oxide (N_2O) and methane (CH_4) in rivers and estuaries of northwestern Borneo

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Abstract. Nitrous oxide (N_2O) and methane (CH_4) are atmospheric trace gases which play important roles in the climate and atmospheric chemistry of the Earth. However, little is known about their emissions from rivers and estuaries, which seem to contribute significantly to the atmospheric budget of both gases. To this end concentrations of N_2O and CH_4 were measured in the Rajang, Maludam, Sebuyau and Simunjan rivers draining peatland in northwestern (NW) Borneo during two campaigns in March and September 2017. The Rajang River was additionally sampled in August 2016 and the Samunsam and Sematan rivers were additionally sampled in March 2017. The Maludam, Sebuyau, and Simunjan rivers are typical "blackwater" rivers with very low pH (3.7–7.8), very high dissolved organic carbon (DOC) concentrations (235–4387 mmol L^{-1}) and very low O_2 concentrations (31–246 µmol L^{-1}; i.e. 13 %–116 % O_2 saturation). The spatial and temporal variability of N_2O and CH_4 concentrations (saturations) in the six rivers or estuaries was large and ranged from 2.0 nmol L^{-1} (28 %) to 41.4 nmol L^{-1} (570 %) and from 2.5 nmol L^{-1} (106 %) to 1372 nmol L^{-1} (57 459 %), respectively. We found no overall trends of N_2O with O_2 or NO_3^-, NO_2^- or NH_4^+, and there were no trends of CH_4 with O_2 or dissolved nutrients or DOC. N_2O concentrations showed a positive linear correlation with rainfall. We conclude, therefore, that rainfall is the main factor determining the riverine N_2O concentrations since N_2O production or consumption in the blackwater rivers themselves seems to be low because of the low pH. CH_4 concentrations were highest at salinity = 0 and most probably result from methanogenesis as part of the decomposition of organic matter under anoxic conditions. CH_4 in the concentrations in the blackwater rivers showed an inverse relationship with rainfall. We suggest that CH_4 oxidation in combination with an enhanced river flow after the rainfall events might be responsible for the decrease in the CH_4 concentrations. The rivers and estuaries studied here were an overall net source of N_2O and CH_4 to the atmosphere. The total annual N_2O and CH_4 emissions were 1.09 Gg N_2O yr^{-1} (0.7 Gg N yr^{-1}) and 23.8 Gg CH_4 yr^{-1}, respectively. This represents about 0.3 %–0.7 % of the global annual riverine and estuarine N_2O emissions and about 0.1 %–1 % of the global riverine and estuarine CH_4 emissions. Therefore, we conclude that rivers and estuaries in NW Borneo – despite the fact their water area covers only 0.05 % of the global river/estuarine area – contribute significantly to global riverine and estuarine emissions of N_2O and CH_4.

1 Introduction

Nitrous oxide (N_2O) and methane (CH_4) are atmospheric trace gases which influence the climate and atmospheric chemistry of the Earth (IPCC, 2013; WMO, 2014). They act as greenhouse gases in the troposphere and are indirectly involved in stratospheric ozone depletion. Emission estimates indicate that rivers and estuaries contribute significantly to the atmospheric budget of both N_2O and CH_4. N_2O emission estimates for rivers and estuaries range from 0.05