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The role of inland freshwaters in summer CO2, CH4 and N2O emissions from northeast Siberian Arctic tundra

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Inland waters can be significant sources of greenhouse gases (GHGs; CO_2, CH_4 and N_2O) to the atmosphere, yet they are often excluded from terrestrial GHG balances. Vast stocks of carbon stored in Arctic tundra permafrost soils are vulnerable to mobilisation due to permafrost thawing accelerated by the amplified effects of climate warming at high latitudes. The carbon that is released becomes available to (partial) degradation producing GHGs which inland waters emit to the atmosphere, thus forming a positive feedback to climate warming. Rising temperatures, longer summers and increased precipitation in the Arctic tundra are expected to increase permafrost thaw and degradation rates, therefore the contribution of inland waters to the tundra terrestrial GHG budgets needs to be better understood to assess the strength and timing of the feedback effect in the future.

Field data from lakes, ponds and streams throughout the summer season of three years and from floodplain water present in one of the years was collected. This data was used to calculate CO_2 equivalent diffusive fluxes from inland freshwaters, and combined with eddy covariance flux tower measurements and with satellite remote sensing to calculate total GHG emissions of the study area.

The results indicate that ponds are the largest contributors to upscaled inland water GHG emissions (around 50%) followed by streams and finally lakes. Streams had the highest emission rates followed by lakes and ponds the lowest, however due to the large surface area coverage of ponds (15% of the study area) they become the largest contributor to the upscaled freshwater GHG emissions. Upscaling of CH_4 and CO_2 fluxes shows that while the study region remains a GHG sink, inclusion of freshwater emissions reduces its sink capacity by 28% during our reference month July. Assuming that 10% of the study area is flooded in this month, it reduces the terrestrial GHG sink estimate to 45% instead of 28%, partially due to N_2O oversaturation in the flood water in relation to the atmosphere whereas N_2O concentrations in lakes, streams and ponds are close to zero. Overall the results show that if the Siberian Arctic tundra becomes wetter or more frequently flooded due to climate warming it will significantly affect the total terrestrial GHG balance.