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Spatial variability of greenhouse gases emissions (CO_2, CH4, N2O) in a tropical hydroelectric reservoir flooding primary forest (Petit Saut Reservoir, French Guiana)

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At the Petit Saut Reservoir (PSR, French Guiana, South America), vertical profiles were performed at 5 stations in the open waters (OW) and 6 stations in two shallow flooded forest (FF) areas between April 2012 and September 2013. Measurements included physico-chemical parameters, ammonium, nitrate and dissolved greenhouse gas (CO_2, CH4, N2O) concentrations, dissolved and particulate organic carbon (DOC, POC) and nitrogen (PN), δ13C-POC and δ15N-PN . The diffusive fluxes were calculated from surface concentrations. The aim of this study was to estimate the spatial variations of greenhouse gas emissions at a dentrical hydroelectric reservoir located in the tropics and flooding primary forest.

Twenty years after impoundment, the water column of the PSR is permanently and tightly stratified thermally in the FF whereas in the OW, the thermal gradients are not as stable. The different hydrodynamical behaviours between the two different zones have significant consequences on the biogeochemistry: oxygen barely diffuses down to the hypolimnion in the FF whereas destratification occurs sporadically during the rainy season in the OW. Although we found the same range of POC in the FF and the OW (2.5-29 μmol L-1) and 20% more DOC at the bottom of OW than in the FF (229-878 μmol L-1), CO_2 and CH4 concentrations were always significantly higher in the FF (CO_2: 11-1412 μmol L-1, CH4: 0.001-1015 μmol L-1) than in the OW. On average, the CO_2 concentrations were 30-40% higher in the FF than in the OW and the CH4 concentrations were three times higher in the FF than in the OW. The δ13C-POC and C:N values did not suggest substantial differences in the sources of OM between the FF and OW. At all stations, POC at the bottom has an isotopic signature slightly lighter than the terrestrial OM in the surrounding forest whereas the isotopic signature of surface POM would result from phytoplankton and methanotrophs. The vertical profiles of nitrogen compounds reveal that the main source of nitrogen in the water column of the PSR is the NH4+ produced during the mineralisation of the OM at the bottom of the reservoir. In OW, the production of NO_3- and N2O is enhanced compared to the FF. As a result, N2O concentrations are three times higher at the bottom of OW but surface concentrations are similar in the FF and OW.

CO_2 diffusive fluxes are 40% higher and CH4 diffusive fluxes are three times higher in FF (CO_2: 42±20 mmol m-2 d-1 ; CH4: 0.7±1.4 mmol m-2 d-1) than in OW (CO_2: 27±17 mmol m-2 d-1 ; CH4: 0.2±0.3 mmol m-2 d-1). In shallow FF, average CH4 ebullition is 3±10 mmol m-2 d-1 whereas ebullition was never observed in OW. N2O emissions did not exhibit any spatial variability (9±4 μmol m-2 d-1). At the PSR, FF which represents one third of the surface area, is responsible of half of the GHG emissions from the reservoir. This implies that the emissions from most of the tropical reservoirs flooding primary forest need to be reassessed since FF environments are usually overlooked.