Interannual CO_2 - CH_4 flux variation linked with precipitation in a boreal peatland, Québec, Canada

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INTRODUCTION

Climate scenarios predict that Quebec's boreal region will experience for the 2041-2070 period an increase in temperature between 2 – 6 °C combined with an increase in precipitations (Caya *and* Laprise, 1999, Plummer *et al*. 2006). The effect of these changes on ombrotrophic peatlands water table depth (WTD) are poorly documented. Roulet *et al*. (1992) predicted a drop in water table between 14 and 22 cm based on a fen hydrology model assuming no change in relative humidity. The impacts of WTD change have been looked at in terms of carbon dioxide (CO_2) exchanges and methane (CH_4) fluxes following a lowering of the water table via a drainage ditch (eg: Strack *et al*. 2009). The outcome of the lowered WTD is a decrease in gross photosynthesis and increase in ecosystem respiration and a decrease in CH_4 fluxes. However, the impact of an increase in WTD remains poorly documented.

This study presents the results of Net Ecosystem Exchange (NEE-CO_2) and CH_4 flux measurements using static chambers. NEE and CH_4 fluxes were measured during 3 growing seasons (2006-2008) in an ombrotrophic peatland located in humid mid-boreal wetland region in Québec, Canada (National Wetlands Working Group, 1988)(Figure 1). The main objective is to measure spatial and inter-annual variability in greenhouse gas emissions at a microsite scale in relation with precipitation/WTD to see how the inter-annual variations could represent predicted climate conditions based on the recent climate scenarios.

Figure 1: Study site location

Figure 2: Microsites gradient; left to right, high hummock (HH), Low Hummock (LH), Lawn (L) and Hollow (H).

GROWING SEASONS CLIMATE CONDITIONS

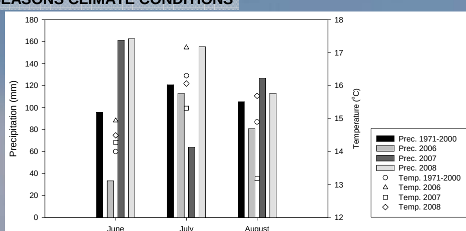

Figure 3: Growing seasons climate conditions from the Chapais 2 meteorological station.

- 2006: precipitations deficit of 100mm compared to 30 yrs average with close to normal temperatures.
- 2007: close to normal precipitations with summer temperature 0.8 °C lower compared to 30 yrs average.
- 2008: precipitations excess of100mm and temperatures 0.35 °C higher compared to 30 yrs average

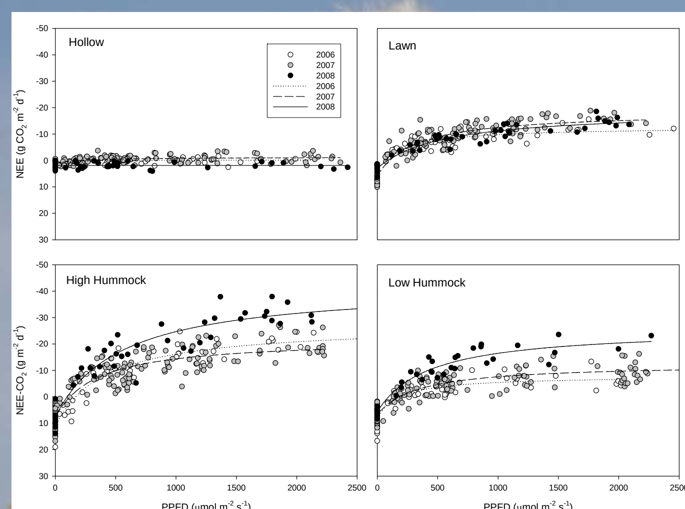

Figure 4: NEE/PPFD curves for the four microsites during the 2006-2008 growing seasons

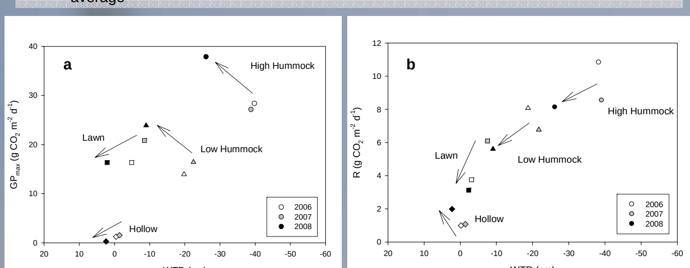

Figure 5: Mean GP_{max} / WTD (a) and R / WTD (b) relationships for all microsites during the 2006-2008 growing seasons

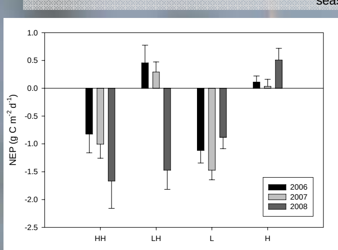

Figure 6: Mean NEP for the four microsites during the 2006-2008 growing seasons

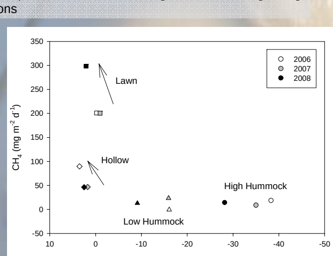

Figure 7: Mean CH_4/WTD relationship for the four microsites during the 2006-2008 growing seasons

RESULTS

CO_2

- High and low hummock NEE light response curves were significantly different in 2008 (Figure 4).
- Mean growing season GP_{max} values increased significantly in 2008 on the high and low hummock microsites while decreasing on the hollow and lawn for the same period (Figure 5a).
- Mean growing season R values decreased for all microsites (except hollow) in 2008 (Figure 5b).
- Modelled NEP from hourly measured PPFD and peat temperatures increased for high hummock and a switch from source to sink on the low hummock between 2006 to 2008. (Figure 6).
- Assuming each microsite covers 25% of the surface area, the LLC peatland would have been a C sink of 0.34, 0.54, 0.88 g C m^{-2} d^{-1} for 2006, 2007 and 2008 growing seasons respectively. Integrated result from an Eddy Covariance tower on the same peatland in 2008 are presented on poster #8, Bonneville *et al*.).

CH_4

- No significant year-to-year variations within the high hummock, low hummock and hollow microsites (Figure 7).
- Largest emissions during the 3 growing seasons were measured on the lawn. This microsite also had the largest year-to-year variation.

Discussion and conclusion

Our study has shown that an increase in WTD as a result of greater precipitations can significantly change NEE on the microsites which normally have lower water table depth (HH and LH) while having no effect on their CH_4 fluxes. Greater NEE during wetter than normal growing season has also been measured at the ecosystem level using an eddy covariance tower by Lafleur *et al.* (2003) in a temperate bog where the wetter conditions lead to a reduction in respiration. At microsite scale, Bubier *et al*. (2003) have found NEE to increase on microsites with shrub vegetation in a fen during a summer with lower than normal WTD. Our results and those of Bubier *et al*. (2003) seem contradictory, they could also represent microsite positions at the opposite of optimal WTD, similar to what is presented in Belyea *and* Clymo (1998) for local rate of burial.

In terms of CH_4 fluxes on the HH and LH microsites, the increase in WTD in 2008 did not reduce aerobic zone thickness enough to have a significant effect in reducing oxydation. Therefore, CH_4 fluxes were not different in 2008. On the other hand, the lawn microsite CH_4 flux increased significantly in 2008 with an increase of 2 cm in wtd.

Overall, the change in NEE with an increase in WTD has significantly modified the peatland's CO_2 dynamics. Latest climate models predict that temperature will be 2 – 6 °C higher and that precipitations and relative humidity will increase for the 2041-2070 period (Caya *and* Laprise, 1999, Plummer *et al*. 2006). Based on our contemporary results and assuming an increase in WTD (2041-2070), we might observe an increase in NEP in Quebec's boreal peatlands.

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