# Carbon balance modifications in Sphagnum-dominated peat mesocosms invaded by Molinia caerulea

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**Carbon balance modifications in *Sphagnum*-dominated peat mesocosms invaded by *Molinia caerulea***

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**Abstract**

Peatlands are wetlands acting as carbon (C) sink at a global scale. Even if, it represents only 3% of the land area, these specific ecosystems have stored a third of the global soil C. Most peatlands (up to 80%) are located in the northern hemisphere and lie in cool temperate zone in association with waterlogged, nutrient poor conditions and *Sphagnum* mosses, which limit the activity of the soil decomposers. As a result, in spite of the relative small net ecosystem production in peatlands, the imbalance between the primary production and the decomposition is enough to allow organic matter (OM) accumulation as peat (Bragazza et al., 2009). However, global change are expected to cause a plant community shift in peatlands with an increase of vascular plants (such as graminoids at the detriment of *Sphagnum* species (Dieleman et al., 2015). Vascular plants invasion in peatlands have mostly been studied through a change of $CO_2$ and $CH_4$ emissions with different plant community composition. In spite of observed C fluxes modification, the role of vascular plant invasion on the C sink balance in peatlands are still to be elucidated. The aim of this study was to investigate how an invading graminoid plants, *Molinia caerulea*, can affect the C balance of *Sphagnum*-dominated peatland. $CO_2$ fluxes and $CH_4$ emissions were regularly measured in peat mesocoms during fourteen months and related to biotic and abiotic factor to calculate the annual C budget with and without *Molinia caerulea*.

Twelve peat mesocosms (depth and diameter: 30 cm) were collected in March 2015 in La Guette peatland (France). This is an acidic fen invaded by *Molinia caerulea*, a graminoid plant invading numerous peatlands. The mesocosms were buried outdoor and surrounded with a tarpaulin containing water from the peatland. Air and soil temperature at 5 and 20 cm depth were monitored in each mesocosm. The mesocosms were separated into 2 treatments with 6 containing only *Sphagnum rubellum* ('*Sphagnum*' mesocosms) and 6 containing *Sphagnum rubellum* and *Molinia*

*caerulea* ('*Molinia*' mesocosms). *Molinia caerulea* occurs in May and covers up to 80% of mesocosms until its senescence in November. Measurements were performed from May 2015 to June 2016. $CO_2$ and $CH_4$ fluxes were measured twice per week during the growing season (April-October) and every 2 weeks during the winter (November-February). $CO_2$ fluxes were measured using a GMP343 Vaisala probe inserted in a transparent PVC chamber. A transparent chamber was used to measure the net ecosystem exchange (NEE), balance between the gross primary production (GPP; absorption of $CO_2$ by photosynthesis) and the ecosystem respiration (ER, release of $CO_2$ into the atmosphere). ER was measured by placing an opaque cover on the chamber, to block photosynthesis. $CH_4$ emissions was measured during 15 min by using the SPIRIT, a portable infrared laser spectrometer (Guimbaud et al., 2011). All the measurements were performed the same day and were related to water table level (WTL), air and soil temperature at 5 and 20 cm depth. Models taking account the temperature, WTL and vegetation index were used to describe the $CO_2$ fluxes and $CH_4$ emissions based on Bortoluzzi et al. (2006) and Kandel et al. (2013) equations. The GPP, ER and $CH_4$ emissions models were used to compare the net ecosystem C balance (NECB; gC $m^{-2}$ $y^{-1}$) and global warming potential over 100 years ($GWP_{100}$; g $CO_2$ eq $m^{-2}$ $d^{-1}$) under both vegetation cover. The NECB represents the net rate C accumulation or release in or from the ecosystem. In this study, we used a simplified approach based on the GPP, ER and $CH_4$ emissions. The $GWP_{100}$ was calculated for both plant communities by the sum of the GPP and ER and the emissions of $CH_4$. The radiative force of the latter equal to 34 times those of the $CO_2$ (Myhre et al., 2013).

ER was significantly higher in *Molinia* mesocosms compared to *Sphagnum* ones. In both vegetation cover, the ER was maximum in July and minimum in January-February (Figure 1a). GPP increased with *Molinia* leaves number, whereas in *Sphagnum* plots the GPP was relatively constant (Figure 1b). After the senescence of *Molinia caerulea*, the GPP did not differ between both treatments in contrary to ER that remained higher in *Molinia* mesocosms compared to *Sphagnum*. As a consequence, the NEE was higher in *Molinia* mesocosms than in *Sphagnum* ones during the growing season, but was lower the rest of the time (Figure 1c). The $CH_4$ emissions significantly increased with *Molinia caerulea* occurrence with a peak of emissions in summer (June to August) and lowest emissions in winter (Figure 1d). While the annual $CO_2$ and $CH_4$ emissions modeling estimated an output of respectively 376 and 7 gC $m^{-2}$ $y^{-1}$ in *Sphagnum* mesocosms, it represented a release of 1018 and 33 gC $m^{-2}$ $y^{-1}$ with *Molinia caerulea* occurrence. Annual modeled GPP was respectively -417 and -1273 gC $m^{-2}$ $y^{-1}$ in *Sphagnum* and *Molinia* mesocosms leading to a NECB of -30 gC $m^{-2}$ $y^{-1}$ in *Sphagnum* mesocosms and of -223 gC $m^{-2}$ $y^{-1}$ for *Molinia* ones (i.e., a C-sink). Even if $CH_4$ emission accounted for a small part of the gaseous C efflux (~ 3%), its global warming potential value to get $CO_2$ equivalent makes both plant communities acting as a warming climate effect (Table I).

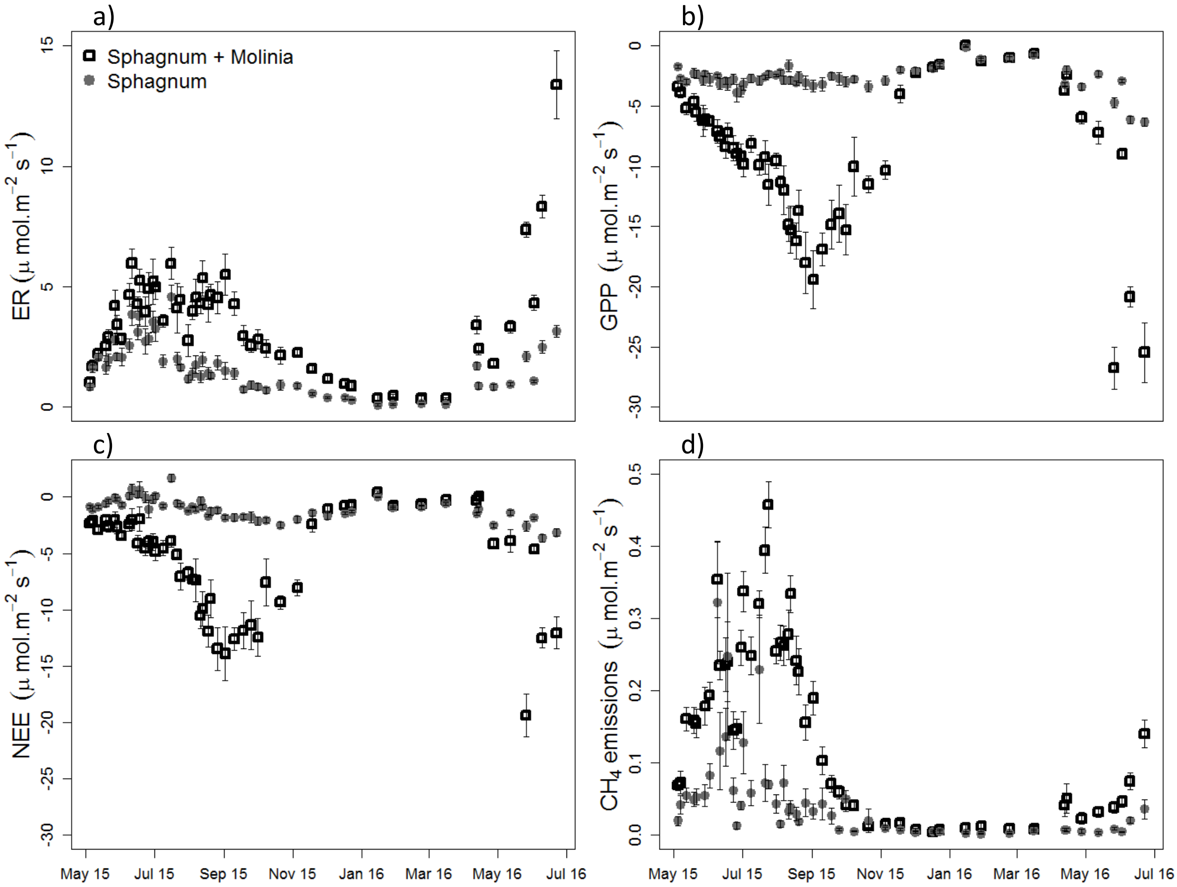


Figure 1: Measurements of ecosystem respiration (ER; a), gross primary production (GPP, b), net ecosystem exchange (NEE, c) and $CH_4$ emissions (d) in *Sphagnum* and *Molinia* mesocosms (±SE, n=6) from May 2015 to June 2016.

Table I: Modelized annual gross primary production (GPP; gC m$^{-2}$ y$^{-1}$), ecosystem respiration (ER; gC m$^{-2}$ y$^{-1}$), net ecosystem exchange (NEE; gC m$^{-2}$ y$^{-1}$), $CH_4$ emissions ($CH_4$; gC m$^{-2}$ y$^{-1}$), net ecosystem carbon balance (NECB; gC m$^{-2}$ y$^{-1}$) and global warning potential over 100 years ($GWP_{100}$; g $CO_2$ eq m$^{-2}$ d$^{-1}$) in *Molinia* and *Sphagnum* mesocosms.

| | GPP | ER | NEE | $CH_4$ | NECB | $GWP_{100}$ |
|---|---|---|---|---|---|---|
| *Molinia* | -1273 | + 1018 | -255 | + 33 | -223 | + 361 |
| *Sphagnum* | -414 | + 376 | 38 | + 7 | -30 | + 154 |

The shift from *Sphagnum* to *Molinia*-dominated peat mesocosms increased the annual C output ($CO_2$ and $CH_4$ emissions, Fig 1), but also lead to higher $CO_2$ uptake by photosynthesis (Fig. 1). The gaseous C balance shows that both plants communities act as C-sink with a storage of 30 gC m$^{-2}$ y$^{-1}$ in *Sphagnum* plots and 223 gC m$^{-2}$ y$^{-1}$ in *Molinia* ones. Nevertheless, the C-sink function of

*Molinia*-dominated peat mesocosms can be questioned because of the biomass production of *Molinia caerulea*. Indeed, the roots production, estimated by Taylor et al. (2001) at 1080 g $m^{-2}$ $y^{-1}$, and shoots biomass were produced with current-year photosynthetates. However, C-stored in roots, litters and leaves of *Molinia caerulea* could contributed to future C emissions by decomposition or respiration not take account here. Even though this C-sink function, $GWP_{100}$ is positive for both vegetation cover. Despite *Molinia* plots acting more as a C sink than *Sphagnum* ones, the higher $GWP_{100}$ of $CH_4$ compared to $CO_2$ combined with the high emissions of $CH_4$ for *Molinia* plot lead to have a higher contribution of these plots to the greenhouse effect than in *Sphagnum* plot.

## LITERATURE


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