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To cite this version:
Jérôme Ogée, Lisa Wingate, Alexandre Bosc, Régis Burlett. Seasonal variations in soil carbonic anhydrase activity in a pine forest ecosystem as inferred from soil CO18O flux measurements. EGU 2015, European Geosciences Union General Assembly, European Geosciences Union (EGU). DEU., Apr 2015, Vienne, Austria. hal-02739331

HAL Id: hal-02739331
https://hal.inrae.fr/hal-02739331
Submitted on 2 Jun 2020

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Seasonal variations in soil carbonic anhydrase activity in a pine forest ecosystem as inferred from soil CO\textsuperscript{18}O flux measurements

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Quantifying terrestrial carbon storage and predicting the sensitivity of ecosystems to climate change relies on our ability to obtain observational constraints on photosynthesis and respiration at large scales (ecosystem, regional and global). Photosynthesis (GPP), the largest CO\textsubscript{2} flux from the land surface, is currently estimated with considerable uncertainty (1-3). Robust estimates of global GPP can be obtained from an atmospheric budget of the oxygen isotopic composition ($\delta^{18}$O) of atmospheric CO\textsubscript{2}, provided that we have a good knowledge of the $\delta^{18}$O signatures of the terrestrial CO\textsubscript{2} fluxes (1,4). The latter reflect the $\delta^{18}$O of leaf and soil water pools because CO\textsubscript{2} exchanges “isotopically” with water [CO\textsubscript{2}+H\textsubscript{18}O$\rightleftharpoons$H\textsubscript{2}O+CO\textsubscript{18}O]. This exchange can be accelerated by the enzyme carbonic anhydrase (CA). In leaves, where CA is present and abundant, this isotopic equilibrium is reached almost instantaneously. As a consequence, and because soil and leaf water pools have different $\delta^{18}$O signatures, CO\textsubscript{2} fluxes from leaves and soils carry very distinct $\delta^{18}$O signals and can thus be tracked from the fluctuations in the $\delta^{18}$O of atmospheric CO\textsubscript{2} ($\delta_{a}$). There is growing evidence that the accelerated isotopic exchange between CO\textsubscript{2} and water due to CA activity is a widespread phenomenon in soils as well (4). At the global scale, accounting for soil CA activity dramatically shifts the influence of soil and leaf fluxes on $\delta_{a}$, thus changing the estimates of terrestrial gross CO\textsubscript{2} fluxes (1,4). In this talk we will briefly present the current state of understanding of the environmental and ecological causes behind the variability in CA activity observed in soils and illustrate, using field data from a temperate pine forest, how soil CA activity varies over a single growing season and how it responds to soil surface environmental variables.

References