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Jérôme Ogée, Lisa Wingate, Alexandre Bosc, Régis Burlett

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

Jerome Ogee (1), Lisa Wingate (1), Alexandre Bosc (1), Régis Burlett (1,2)

(1) INRA, UMR1391 ISPA, 33140 Villenave d'Ornon, France (jerome.ogee@bordeaux.inra.fr), (2) Now at Université de Bordeaux, UMR1202 BIOGECO, 33405 Talence, France

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_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_2, provided that we have a good knowledge of the $\delta^{18}O$ signatures of the terrestrial CO_2 fluxes (1,4). The latter reflect the $\delta^{18}O$ of leaf and soil water pools because CO_2 exchanges "isotopically" with water [CO_2+$H_2^{18}O \Leftrightarrow H_2O$+$CO^{18}O$]. 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_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_2 (δ_a). There is growing evidence that the accelerated isotopic exchange between CO_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 δ_a, thus changing the estimates of terrestrial gross CO_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.

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