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APPLICATION NOTE 30291

Monitoring of Plant CO_2 Exchange Within Terrestrial Ecosystems

Authors

H.J. Jost,[1] Eric Wapelhorst,[1] Magda Mandic,[1] Nils Stoebener,[1] Ulf Froehlich,[1] Laura Gangi,[2] Roland Bol,[2] and Nicolas Brüggemann[2]

[1]Thermo Fisher Scientific, Bremen, Germany

[2]Forschungszentrum Jülich GmbH, Institute of Bio- and Geosciences - Agrosphere (IBG-3), Jülich, Germany

Keywords

Delta Ray, CO_2 Exchange, Terrestrial Ecosystem, Monitoring, $\delta^{18}O$, $\delta^{13}C$

Goal

- To observe rapid changes in plant metabolism by simultaneously monitoring carbon and oxygen isotope ratios of carbon dioxide under varying ambient conditions in a plant chamber.
- To accurately estimate the CO_2 fluxes in terrestrial ecosystems.

Introduction

The Thermo Scientific™ Delta Ray™ IRIS (Figure 1) consists of a laser-based Isotope Ratio Infrared Spectrometer (IRIS) and a Universal Reference Interface (URI) which can perform accurate and precise, continuous, in-situ monitoring of isotopologues of trace gases at ambient concentration.

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Figure 1. The Thermo Scientific Delta Ray Isotope Ratio Infrared Spectrometer (IRIS)

The Delta Ray IRIS can be integrated into a plant chamber (Figure 2) experiment to detect rapid changes in the metabolism of a plant. The objective of this experiment is to measure the impact of different plants species on the oxygen isotopic signature of atmospheric CO_2 under varying environmental conditions. This is important for an accurate estimation of CO_2 fluxes in terrestrial ecosystems based on $\delta^{18}O$ in CO_2.

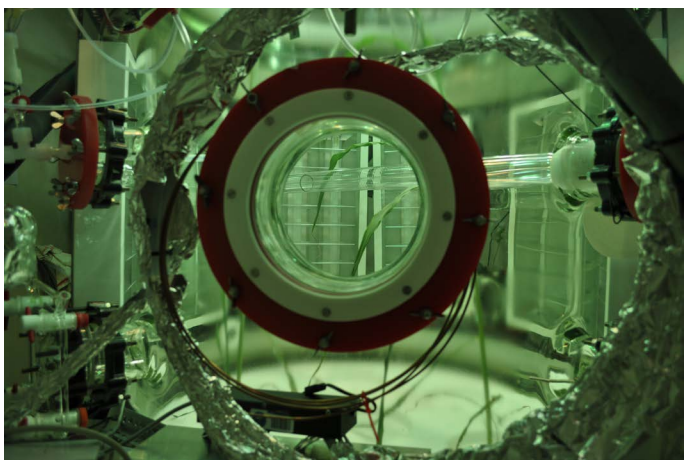

Figure 2. Plant chamber used in the experiment

Method and experimental setup

CO_2 is scrubbed from ambient air to create low CO_2 air, and then CO_2 is added back in to create the desired CO_2 concentration (Figure 3). This air is then directed through the plant chamber. The air at the input of the chamber (“chamber in”) and outlet (“chamber out”) is alternatingly sampled by the Delta Ray IRIS. The Delta Ray IRIS valve A was switched every 5 minutes (300 s) (Figure 3).

The signal from valve A (see Figure 3) was fed to the Delta Ray analyzer and used as a trigger to start the acquisition of the “chamber in” and “chamber out” samples. Table 1 lists the details of the sample sequence. The sequence was started with a reference measurement from the Universal Referencing Interface of 120 seconds. A flush time of 60 seconds was also included between samples, and samples and reference measurements. Measurements were taken for 230 seconds of alternating “chamber in” and “chamber out”. This left a buffer of 10 seconds for Delta Ray IRIS to wait for the next trigger from valve A sent after 300 seconds.

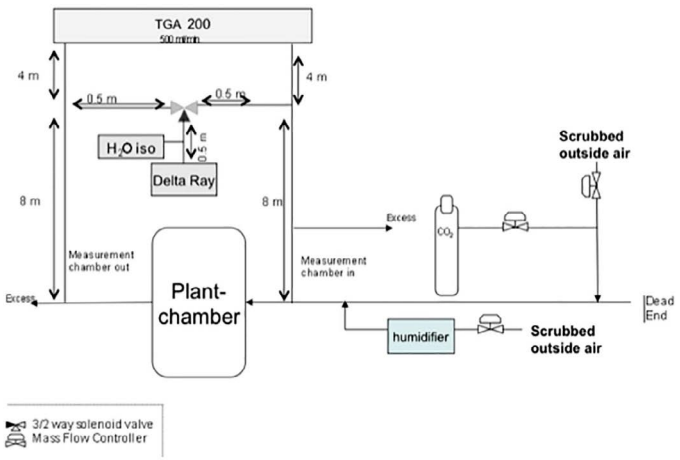

Figure 3. Simplified schematic of the plant chamber experiment

Table 1. Labbook setup for plant chamber measurements. This 30 minute sequence is repeated for 1 day, and then a new labbook started.

Label	Flush time [s]	Measurement time [s]	Trigger
Ref 1	60	120	
Chamber out	60	230	0
Chamber in	60	230	1
Chamber out	60	230	0
Chamber in	60	230	1
Chamber out	60	230	0
Chamber in	60	50	1

Results

Nine days of continuous measurements starting after plant watering was stopped are shown in Figure 4. Changes in isotopic composition between light on and off are clearly visible. Uptake of CO_2 by photosynthesis imposes an isotopic signature on the remaining CO_2 by preferentially removing the main isotopologue ($^{12}C^{16}O^{16}O$). The change is >3‰ and 1.5‰ for $\delta^{18}O$ and for $\delta^{13}C$, respectively. The input isotopic composition is also changing over time, due to incomplete scrubbing of CO_2 from ambient air. The scientific interpretation of similar data combined with additional measurements can be found in Gangi 2015.[1]

Conclusion

The Delta Ray Isotope Ratio Infrared Spectrometer provides continuous, feature-rich data for plant research. By providing high precision, and automatically fully referenced data the Delta Ray IRIS proved to be a valuable solution for the analysis of plant metabolism. The carbon isotope ratio $\delta^{13}C$-CO_2 and oxygen isotope ratio of atmospheric carbon dioxide ($\delta^{18}O$-CO_2) can be used to partition the gross fluxes of CO_2 in terrestrial ecosystems, such as plant respiration, soil respiration and plant assimilation. The characteristic $\delta^{13}C$ value is modified by plant metabolism and photosynthesis. The $\delta^{18}O$ is affected by the oxygen exchange between the molecules of CO_2 and H_2O stemming from different water pools. Similar measurements could for example be used to determine the efficiency of plants in phenotyping, studying the impact of elevated CO_2 concentrations in a future climate or even exchanges at ecosystem level.

Reference

1. Gangi L, Real-time quantification of oxygen isotope exchange between carbon dioxide and leaf/soil water in terrestrial ecosystems with laser-based spectroscopy. Dissertation 2015, University of Bonn, Germany L. Gangi et al., *Agricultural and Forest Meteorology 201* (**2015**) 128–140.

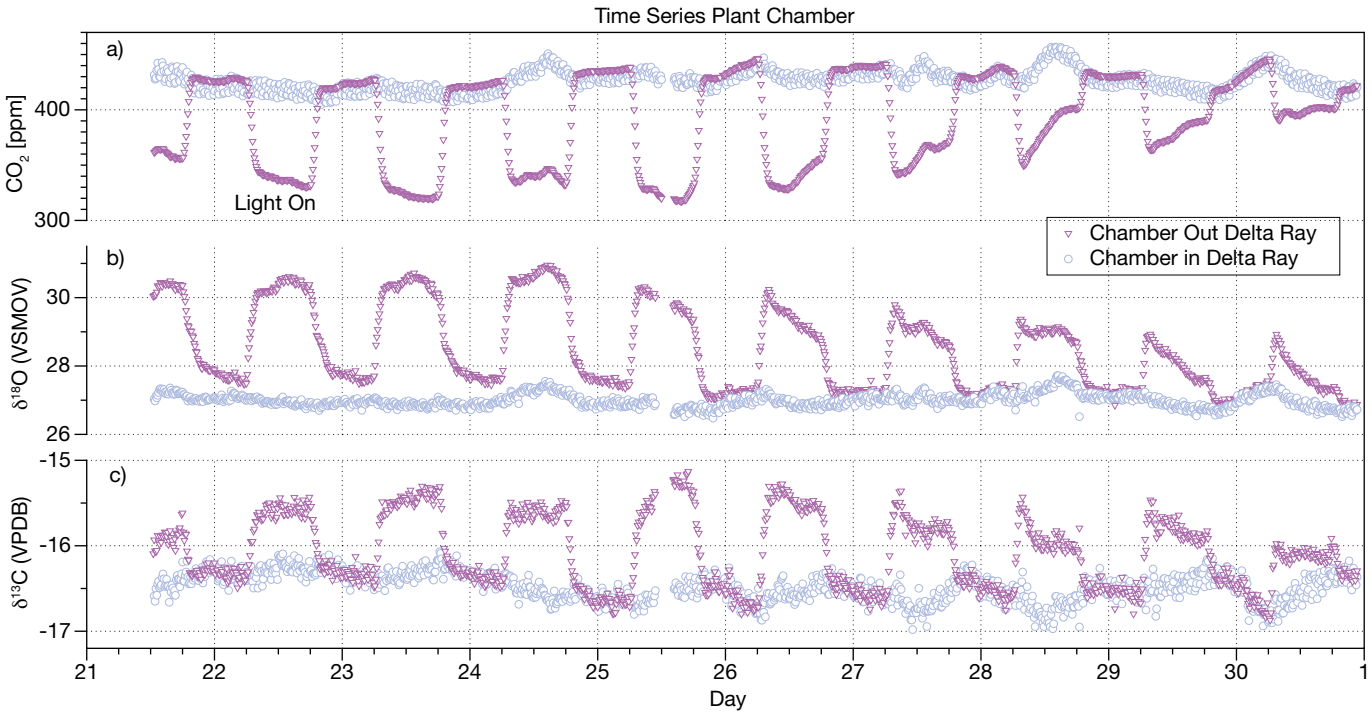

Figure 4. a) Time series of CO_2 concentration of Delta Ray chamber in and chamber out; b) time series of $\delta^{18}O$ of the Delta Ray IRIS of plant chamber in and out; c) $\delta^{13}C$ of the Delta Ray IRIS of plant chamber in and out

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AN30291-EN 0518S