Geophysical Research Abstracts
Vol. 18, EGU2016-15671, 2016
EGU General Assembly 2016

Effect of photosynthesis on the abundance of $^{18}O^{13}C^{16}O$ in atmospheric CO_2

Magdalena E.G. Hofmann (1), Thijs L. Pons (2), Martin Ziegler (3), Lucas J. Lourens (3), and Thomas Röckmann (1)

(1) University of Utrecht, IMAU, Utrecht, The Netherlands, (2) University of Utrecht, Institute of Environmental Biology, Utrecht, The Netherlands, (3) University of Utrecht, Department of Earth Sciences, Utrecht, The Netherlands

The abundance of the isotopologue $^{18}O^{13}C^{16}O$ (Δ_{47}) in atmospheric air is a promising new tracer for the atmospheric carbon cycle (Eiler and Schauble, 2004; Affek and Eiler, 2006; Affek et al., 2007). The large gross fluxes in CO_2 between the atmosphere and biosphere are supposed to play a major role in controlling its abundance. Eiler and Schauble (2004) set up a box model describing the effect of air-leaf interaction on the abundance of $^{18}O^{13}C^{16}O$ in atmospheric air. The main assumption is that the exchange between CO_2 and water within the mesophyll cells will imprint a Δ_{47} value on the back-diffusing CO_2 that reflects the leaf temperature. Additionally, kinetic effects due to CO_2 diffusion into and out of the stomata are thought to play a role. We investigated the effect of photosynthesis on the residual CO_2 under controlled conditions using a leaf chamber set-up to quantitatively test the model assumptions suggested by Eiler and Schauble (2004).

We studied the effect of photosynthesis on the residual CO_2 using two C_3 and one C_4 plant species: (i) sunflower (*Helianthus annuus*), a C_3 species with a high leaf conductance for CO_2 diffusion, (ii) ivy (*Hedera hibernica*), a C_3 species with a low conductance, and (iii), maize (*Zea mays*), a species with the C_4 photosynthetic pathway. We also investigated the effect of different light intensities (photosynthetic photon flux density of 200, 700 and 1800 μmol $m^2 s^{-1}$), and thus, photosynthetic rate in sunflower and maize.

A leaf was mounted in a cuvette with a transparent window and an adjustable light source. The air inside was thoroughly mixed, making the composition of the outgoing air equal to the air inside. A gas-mixing unit was attached at the entrance of the cuvette that mixed air with a high concentration of scrambled CO_2 with a Δ_{47} value of 0 to 0.1‰ with CO_2 free air to set the CO_2 concentration of ingoing air at 500 ppm. The flow rate through the cuvette was adjusted to the photosynthetic activity of the leaf so that the CO_2 concentration at the outlet was 400 ppm and varied between 0.6 and 1.5 L min^{-1}. CO_2 and H_2O concentrations in air were monitored with an IRGA and air was sampled at the outlet with flasks.

We found that the effect on Δ_{47} of the residual CO_2 for the C_3 species sunflower and ivy was proportional to the effect on $\delta^{18}O$ of the residual CO_2. The difference in Δ_{47} between the in- and outgoing CO_2 was between -0.07 and 0.49‰ varying with the CO_2 concentration in the chloroplasts relative to the bulk air (C_c/C_a). The C_c/C_a depends on conductance and photosynthetic activity, and was different for the two species and was manipulated with the light intensity. For the C_4 species maize, a Δ_{47} value of -0.08±0.02‰ was observed. The slightly negative effect on Δ_{47}may be related to its lower C_c/C_a ratio and possibly a lower carbonic anhydrase activity causing incomplete exchange with leaf water. We will discuss these results in light of the suggested fractionation processes and discuss the implication for the global Δ_{47} value of atmospheric CO_2.

References

Affek H. P. and Eiler J. M., *GCA* 70, 1–12 (2006).

Affek H. P., Xu X. and Eiler J. M., *GCA* 71, 5033–5043 (2007).

Eiler J. M. and Schauble E., *GCA* 68, 4767–4777 (2004).