Diurnal courses of concentration, $\delta^{13}C$ and $\delta^{18}O$ of CO$_2$ from the soil and above the canopy of maize growing on a former C$_3$-plant dominated field

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Study

More than three full diurnal courses of CO$_2$ concentration, $\delta^{13}C$ and $\delta^{18}O$ of CO$_2$ from the soil and above the canopy of a maize field were measured in high time resolution (22.5 min) with an isotope-specific TDL instrument (TGA100A, Campbell Scientific, Logan, UT, USA) in a field campaign from July 24 to July 28, 2006. The maize field was located in the Southwest of Germany (Eimeldingen) and was formerly dominated by C$_3$ crops. The meteorological conditions were characterized by hot and dry summer conditions with very low soil moisture values. However, the maize plants were still green and photosynthetically active. During daytime air temperatures exceeded 30°C, and soil temperatures ranged between 23°C and 26°C. Rainfall occurred only once during the investigation period in the form of a short thunderstorm. Above-canopy air samples were taken 0.5 m and 3 m above the maize canopy. Soil CO$_2$ efflux was measured dynamically with four replicates with simple 10 L plastic buckets as soil chambers, provided with an inlet and an outlet.

Soil CO$_2$

![Graphical representation of Soil CO$_2$](image1)

Results

Both above canopy and near soil CO$_2$ ($^{12}C^{16}O_2$) concentrations and $\delta^{13}C$ values showed clear diurnal patterns with maximum CO$_2$ concentrations of up to 600 ppm and minimum $\delta^{13}C$ values down to -16 ‰ (vs. V-PDB) during nighttime. In contrast, $\delta^{18}O$ values above the canopy and close to the soil showed only a weak diurnal pattern with mean values around +13 ‰ (vs. V-PDB) and a maximum amplitude of approx. 2 ‰. Soil CO$_2$ efflux completely reversed the pattern of $\delta^{13}C$ and $\delta^{18}O$ values. The chamber outlet air showed a strongly dampened diurnal amplitude of $\delta^{13}C$ with mean values around -16 ‰. In contrast, $\delta^{18}O$ values of soil chamber outlet air showed an enhanced diurnal amplitude of up to 4 ‰. However, the phase of the diurnal variation of $\delta^{18}O$ was shifted by half a day, leading to minimum values of approx. +10 ‰ around midday when $\delta^{18}O$ of ambient air was maximal. Keeling-type plots resulted in $\delta^{13}C$ values between -24 and -25 ‰, indicating that the vast majority of the respired CO$_2$ must have come from C$_3$ plant material, thus, from heterotrophic respiration.

Soil respiration

![Graphical representation of Soil respiration](image2)

Ecosystem CO$_2$

![Graphical representation of Ecosystem CO$_2$](image3)

Figure 1. Concentration, $\delta^{13}C$ and $\delta^{18}O$ of CO$_2$ measured at the inlet (black lines) and the outlet (grey lines) of the four soil chambers.

Figure 2. Keeling plots for the determination of $\delta^{13}C$ and $\delta^{18}O$ of the source of CO$_2$ measured at the inlet of the four soil chambers.

Figure 3. Soil respiration rates determined with the four soil chambers.

Figure 4. Concentration, $\delta^{13}C$ and $\delta^{18}O$ of CO$_2$ measured 0.5 and 3 m above the canopy.

Figure 5. Keeling plots for the determination of $\delta^{13}C$ and $\delta^{18}O$ of the source of CO$_2$ measured 0.5 and 3 m above the canopy.