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

Nicolas Brüggemann and Dominik Steigner

Centre for Stable Isotope Analysis in Ecosystem Research (CSI)
Institute for Meteorology and Climate Research – Atmospheric Environmental Research (IMK-IFU)
Forschungszentrum Karlsruhe, Kreuzeckbahnstrasse 19, 82467 Garmisch-Partenkirchen, Germany

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 25°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

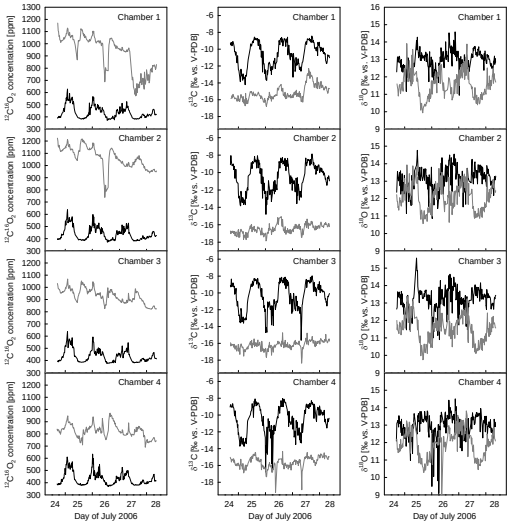

Figure 1. Concentration, $\delta^{13}C$ and $\delta^{18}O$ of CO_2 measured at the inlet (black lines) and the outlet (grey lines) of the four soil chambers.

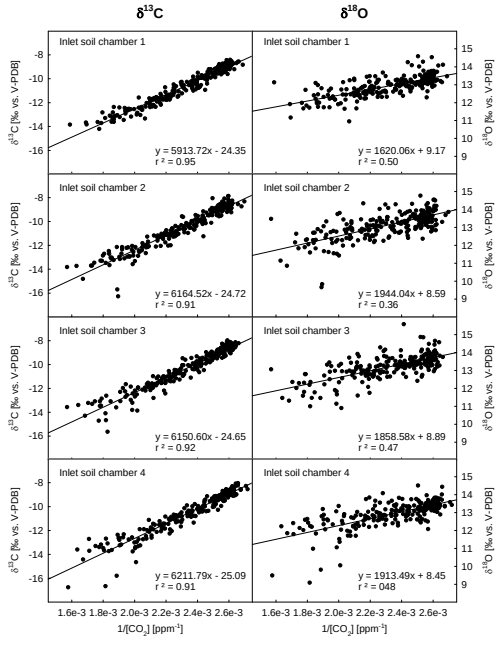

Figure 2. Keeling plots for the determination of $\delta^{13}C$ and $\delta^{18}O$ of the source of CO_2 measured at the inlet of the four soil chambers.

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

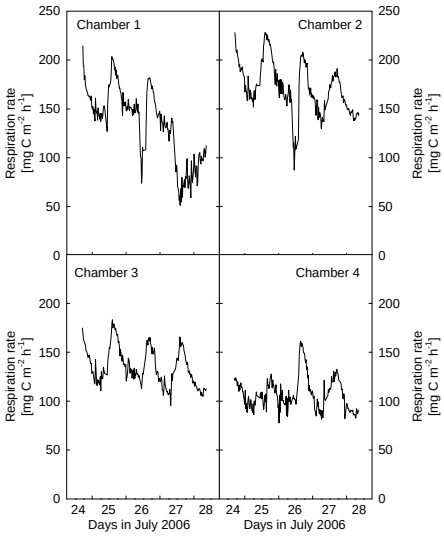

Figure 3. Soil respiration rates determined with the four soil chambers.

Ecosystem CO_2

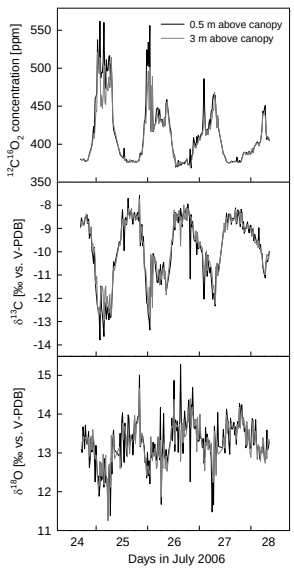

Figure 4. Concentration, $\delta^{13}C$ and $\delta^{18}O$ of CO_2 measured 0.5 and 3 m above the canopy.

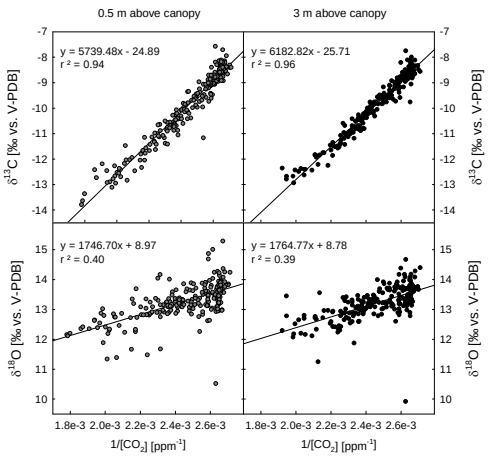

Figure 5. Keeling plots for the determination of $\delta^{13}C$ and $\delta^{18}O$ of the source of CO_2 measured 0.5 and 3 m above the canopy.

Contact: Dr. Nicolas Brüggemann (nicolas.brueggemann@imk.fzk.de)
Phone: +49-(0)8821-183226, Fax: +49-(0)8821-183294
Funding: Helmholtz Society, Germany (VI_VH-129)

KIT – a cooperation between Karlsruhe Research Center and University of Karlsruhe

Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft