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Measurements of carbon dioxide fluxes in a free-air carbon dioxide enrichment experiment using closed flux chamber technique

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Carbon dioxide (CO2) fluxes, composing net ecosystem exchange (NEE), ecosystem respiration (ER), and soil respiration (SR) were measured in a temperate heath-land exposed to elevated CO2 by the FACE (free air carbon enrichment) technique, raising the atmospheric CO2 concentration from ca. 380 ppm to 510 ppm. All CO2 fluxes were measured by the static chamber methodology. Although the FACE technique enriches the atmosphere with CO2 to a fixed level, the above ground CO2 concentrations may nevertheless locally vary highly (from about ambient to $\sim$1000 ppm). Deployment of static chambers to FACE experiments should thus be performed with great care in order to sustain reproducible conditions with respect to chamber headspace CO2 concentration. We demonstrate that that the fluxes measured by closed chambers relate linearly to the initial headspace CO2 concentration. The net CO2 assimilation expressed by NEE increased instantaneously 1.51 and 1.71 times, corresponding to 3.5 and 4.2 μmol m-2 sec-1, respectively at control and FACE plots when chamber headspace CO2 concentration were increased from 380 ppm to 510 ppm. This increase in NEE could partly be explained by reduced losses of CO2 via ER and SR, respectively being decreased by 1.1 (control) and 1.5 (FACE) μmol m-2 sec-1, and 0.1 (control) and 0.5 (FACE) μmol m-2 sec-1.
We found that a useful method to achieve stable and reproducible chamber headspace CO2 concentration prior to commencement of flux measurements was to turn off the FACE system at least 10 minutes in advance. Within the 10 minutes a new equilibrium was established between the soil and atmosphere, supposedly due to CO2 degassing from the top soil. An increase in SR in response to increased CO2, however, persisted for up to 18 hrs during which measurements should be performed. Soil CO2 concentrations were increased by up to 500 ppm by the FACE treatment, substantially more than the 130 ppm increase in the atmospheric CO2 suggesting that the increased SR was caused by increased belowground respiration.