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Diurnal variation in air CO_2 concentration near the soil surface can have a strong impact on soil surface CO_2 flux

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The CO_2 diffusion gradient between the soil surface layers and the atmosphere plays an important role in driving soil surface CO_2 flux (Fc). We show experimental evidence demonstrating that prior exposure to high chamber CO_2 concentration leads to elevated Fc in subsequent measurements made at normal ambient CO_2 concentration. The magnitude and duration of Fc increase is determined by the magnitude and duration of prior elevation in chamber CO_2 concentration. A similar phenomenon occurs in nature. Experiments were conducted at two different field sites, one with a light sandy soil and the other with a heavy clay soil, to continuously monitor soil surface CO_2 flux with automated soil CO_2 flux chambers. We found that at night during calm periods when air CO_2 concentration near the soil surface (Ca) was elevated, Fc was suppressed due to the reduced CO_2 diffusion gradient. Furthermore, our data show that when Ca was variable due to intermittent turbulent mixing, nighttime Fc was negatively correlated with changes in Ca. Also, we found that after warm, calm nights with prolonged elevated Ca, increased turbulence at sunrise caused a rapid drop in Ca and a concomitant increase in Fc. The increased Fc occurred before any increase in soil temperature, and sometimes persisted for one to two hours after Ca dropped to the atmospheric background level. We suggest that prolonged elevated Ca leads to increased soil CO_2 concentrations, which cause increased Fc after Ca returns to normal daytime values. Our results strongly suggest that the process of soil CO_2 transport may not always be in a steady state, especially at night and in the morning. Thus instantaneous measurements of Fc should not be assumed to equal total soil respiration. The CO_2 storage term inside the soil profile may not be negligible, and it should be accounted for in studying soil CO_2 flux and in correcting nighttime eddy covariance CO_2 flux during periods of low turbulence.