Photosynthetic enhancement and diurnal stem and soil carbon fluxes in a mature Norway spruce stand under elevated CO2

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Understanding the effects of elevated atmospheric CO2 on carbon (C) relations of mature forest trees is central to understanding ecosystem C fluxes and pools in a future high-CO2 world. Here, we investigated the CO2-induced photosynthetic enhancement and the diurnal variation in shoot carbon assimilation, stem CO2 efflux and soil respiration associated with ca. 110-year-old and 37 m tall Norway spruce trees (Picea abies (L.) H. Karst.) growing under free air CO2 enrichment (FACE) in a mixed, near-natural forest in Northern Switzerland. Diurnal measurements of these major C fluxes were conducted simultaneously on three occasions: one week before and after the start of CO2 enrichment, and one year later. Under controlled leaf chamber conditions, an increase in the atmospheric CO2 concentration of ca. 150 ppm above ambient stimulated light-saturated rates of photosynthesis in previous- and current-year upper-canopy shoots equally by 73 ś 2%. In the course of the day such large differences in C assimilation between trees growing under elevated CO2 (eCO2) and ambient conditions (aCO2) only occurred around midday under non-limiting light conditions. The CO2 efflux rates from spruce stems (CEstem) and surrounding soil (Rsoil) shared a similar range during night- and daytime (3–5 μmol m$-$2 s$-$1) but were not stimulated by eCO2. Both CEstem stem and Rsoil were still rising when photosynthesis approached evening light compensation potentially reflecting the time lag in assimilate allocation to stem tissue and fine roots. Our findings suggest a strong photosynthetic enhancement during the initial CO2 enrichment phase but provide no evidence for an overall or daytime-dependent stimulation of respiratory CO2 fluxes indicating that the extra C was not quickly returned to the atmosphere through respiratory processes in spruce stems or surrounding soil.
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