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Response of soil C fluxes to warming and irrigation in a lysimeter experiment

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Current climate change alters the temperature and precipitation regime of alpine forests, but its impact on soil carbon (C) dynamics is not well known. Recent studies suggest substantial soil C losses through persistently enhanced mineralization of soil organic matter in the Northern European Calcareous Alps. These C losses could result from increasing soil respiration as the most important pathway of soil C processes followed by leaching of dissolved inorganic and organic C (DIC, DOC). Here, we studied the response of these three C fluxes to (I) soil warming (+4°C), (II) irrigation (+40% water), and (III) a combination of soil warming and irrigation relative to a (IV) control in a field lysimeter experiment. The lysimeters (n=5 per treatment) were filled with mineral soil from a humus-rich A-horizon of a Rendzic Leptosol and detrital dolomite (C-horizon). Soil warming revealed an increase in soil respiration by 52%, but no or little change in soil CO_2 concentration, DIC and DOC leaching during the growing season. Irrigation increased DIC and DOC leaching by >70% but had no effect on soil respiration. The combination of soil warming and irrigation increased soil CO_2 efflux by only 28%, while the DIC and DOC fluxes increased by about 70% as in the irrigation treatment. The positive correlation between seepage fluxes and DIC fluxes (R2=0.97) suggests that precipitation is a strong driver of DIC losses. Despite the strong linear relationship between DIC and soil CO_2 concentrations (R2=0.82), latter was poorly correlated with DIC losses (R2=0.44). A first estimate using the concentrations of dissolved Mg and Ca cations in seepage suggests that abiogenic DIC from dolomite weathering contributed about 30% to the total DIC flux. The biogenic DIC flux contributed 1-3% and the DOC flux <1% to the total soil C loss during the growing season. Taking average seepage fluxes of about 1000 mm into account, as typical for the Northern European Alps, the DIC flux could account for up to 7% of the annual soil C loss. Our results suggest that warming triggers elevated C losses by CO_2 efflux, while increasing precipitation enhances DIC losses.