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Drought and rewetting responses of soil CO_2 –production and -emission dynamics in a future climate

David Reinthaler (1), Erich Pötsch (2), Markus Herndl (2), and Michael Bahn (1)

(1) LFU Innsbruck, Istitute of Ecology, Ecophysiology & ES Processes, Innsbruck, Austria (david.reinthaler@student.uibk.ac.at), (2) AREC Raumberg-Gumpenstein, Austria

As a result of climate change, extreme climatic events such as drought are expected to increase in intensity and in frequency, which will have huge impacts on global carbon cycling. Terrestrial soils contain very large amounts of carbon, and soil respiration (Rs) is the biggest flux of CO_2 from terrestrial ecosystems to the atmosphere. Global warming is expected to enhance drought-impacts on soil respiration whereas elevated CO_2 has been suggested to enhance soil respiration and slow down the drying of soils. The combined consequences on soil respiration are yet unclear. Studying the vertical soil CO_2 distribution and production under drought can shed light on the mechanisms and processes underpinning soil respiration responses to drought.

Within the ClimGrass-project at AREC Raumberg-Gumpenstein, we assessed above- and belowground soil CO_2 flux- and concentration dynamics during and after an experimental drought event under ambient conditions (C0T0) and under a +3°C warming scenario with a CO_2 increase of 300ppm (C2T2). For each of the four treatments three replicated grassland plots were equipped with an automated soil respiration system to assess high-resolution Rs fluxes before, during and after drought. Additionally we investigated soil CO_2 concentrations with a multiplexed membrane tube system installed across the soil profile at 3, 9, 18 and 36 cm soil depth.

Our results show that future (C2T2) climate increased, and that drought strongly reduced Rs fluxes compared to ambient (C0T0) climate conditions, indicating lower resistance of Rs under future climate. All drought and post-drought effects on Rs were more strongly pronounced in a future compared to a current climate, including Rs reduction during drought and CO_2 pulses after rewetting. Rewetting led to a transient overshooting of corresponding control-fluxes after the drought.

An in-depth analysis of soil CO_2 gradients and fluxes across the soil profile showed unexpected modifications of soil-CO_2 production and transport processes, concerning both drought and post-drought effects, especially when considering the duration of detectable drought effects.

CO_2 production in the most active layers got decreased to almost zero, with the highest activity moving down to 36cm soil depth. While soil CO_2 production in both climate scenarios recovered in rather expected timeframes, CO_2 concentration reestablishment lasted up to 5 months after rewetting.