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Spatiotemporal patterns of soil CO_2 efflux in drylands are modulated by the type of cover: The role of biocrusts

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Although the quantification of carbon (C) flux dynamics in arid and semiarid ecosystems has acquired relevant interest, it is recognized that C fluxes of drylands have been poorly measured and modeled, despite these regions represent 40% of the Earth land's surface and are known to play a crucial role in the global C cycle. Scarce vegetation and heterogeneity of non vegetated areas contributes to significant uncertainty in evaluating the roles of these ecosystems in C fluxes. In addition, interplant soils in most arid and semiarid areas are covered by biocrusts (communities of cyanobacteria, algae, lichens and mosses in association with soil particles) which strongly affect C uptake and release and also contribute to increasing uncertainty in the assessment of C balance in these ecosystems. A better understanding of CO_2 efflux in different soil covers and how they are regulated by environmental factors is necessary for identifying the relationships between C sinks and sources of arid and semiarid ecosystems. Our goal was to analyse temporal dynamics of soil CO_2 on representative cover types of semiarid ecosystems (soil under plant, biocrusts and bare soil) and the influence of environmental factors (soil moisture and temperature) on soil CO_2 patterns. The study area chosen was a badlands site (El Cautivo, Almería, SE Spain) where biocrusts occupy up to 50% of soil surface. Soil CO_2 molar fraction (χc) was continuously monitored using small solid-state CO_2 sensors (GM222, Vaisala, Helsinki, Finland) buried at 5 cm under the different covers, during one year. Soil temperature and soil moisture were also measured under these covers. From the CO_2 time-series measured, we calculated soil CO_2 efflux (Fs) from the 0-5 cm soil profile using Fick's law of diffusion.

Our results demonstrate that soil moisture was the main factor driving soil χc. During summer, when soil was dry, all cover types showed similar soil χc. Following a rain, there was a rapid increase in soil χc in all cover types but marked differences were found among them: soil under plant reached the highest values, while in the interplant soil, soils covered by biocrusts showed up to 2 times greater soil χc than bare soils. Soil χc also varied depending on the type of biocrust, with higher values under lichen than cyanobacteria biocrusts, attributed to higher organic matter content and higher abundance and diversity of microfauna under more developed than less developed biocrusts. At daily scale, there was a positive relationship between soil χc and soil temperature. Positive values of Fs (CO_2 emissions) were frequently found after rain. Fs was higher in soil under plant (up to 2 μmol m-2 s-1), followed by soil covered by lichens and the lowest in soils covered by cyanobacteria and bare soils ($\sim$0.5 μmol m-2 s-1). Our results demonstrate the high spatial variability in CO_2 efflux in arid and semiarid areas and the need to consider the contributions of the different representative ground covers to improve C quantification and to make more accurate predictions of the effects of climate change in arid and semiarid regions.