Seasonality of Net Ecosystem CO_2 Exchanges in Water-Limited Mediterranean Ecosystems and CO_2 Releases During Drought

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Semi-arid regions are highly vulnerable to climatic change and represent about 47% of the global terrestrial area. However, information regarding carbon dioxide (CO_2) exchange in these systems, where water is the most important limiting factor, is relatively scarce, particularly in Mediterranean areas.

We measured net CO_2 ecosystem exchange (NEE) in 2015-2016 using the eddy covariance technique in five experimental sites in southeastern Spain. On one hand, we studied three non-managed sites. These were natural grasslands and a shrubland located at different altitudes, ranging from 50 to 1600 m a.s.l. and therefore receiving different amounts of rainfall. On the other hand, two managed sites, a wetland and an irrigated olive orchard, were also monitored. In Mediterranean climates there are two contrasting periods that modulate ecosystems functioning. Mid-winter and early-spring represent the period when the most favorable temperatures and soil moisture conditions trigger maximum biological activity. In contrast, water resources become limited during the summer, when the high temperatures and low rainfall lead to strong hydric stress which constrains biological processes. In the study sites, annual rainfall ranged from 220 to 538 mm and mean annual temperatures from 12 to 18°C.

Regarding flux seasonality, we observed two biological hot moments: the first in spring with the highest photosynthetic rates, and the second following rainfall events marking the end of drought, which activate soil microbial communities and plant respiration, resulting in strong CO_2 releases, even in the wetland. In the more water-limited ecosystems, under high hydric stress conditions, non-biological processes greatly contributed to NEE, specifically, substantial CO_2 releases coincided with events of high turbulence. These events seem to be related to ventilation of CO_2 stored underground, which we monitor. The existence of CO_2 releases related to strong rainfall events or originated from non-biological sources, hinder the use of the standardized flux partitioning methodologies and highlight the need to develop alternative methods to distinguish between photosynthesis and respiration in certain ecosystems.