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Effects of extreme droughts on soil CO2 efflux in a Mediterranean Quercus ilex forest

Laurent Misson, Julien Battut, Elsa Donon, Raquel Rodriguez, Alain Rocheteau, Jean-Marc Ourcival, David Degueldre, and Christian Collin

CNRS / CEFE, CEFE, France (laurent.misson@cefe.cnrs.fr)

Simulations with coupled atmosphere-ocean regional climate models indicate substantial drying and warming of the Mediterranean region, especially during the warm season. Changes in rainfall frequency, duration and intensity are also expected in this region, resulting in a more extreme precipitation regime and more frequent and severe droughts. How such changes might affect the vulnerability of ecosystems, their exchange of CO2 with the atmosphere, and thus their interactions with the climate, is still unknown. The objective of this study was to test the effect of an extreme drought on tree physiology, soil carbon inputs (litterfall and root) and outputs (respiration) in a typical Mediterranean forest dominated by Quercus ilex in south of France. In 2007, a mobile rainfall shelter was constructed, to exclude 100% of rainfall at different periods of the year, without changes in other meteorological variables. The experimental design consisted of three 195 m2 plots, including spring rainfall exclusion, fall rainfall exclusion and a control. Rainfall exclusion was achieved using a retractable rainfall shelter programmed to slide automatically along 60 m-long rails to prevent rainfall in the desired plot and return to its parking position at the end of each event. The two exclusion plots were situated at opposing ends of the rails, while the middle section served as a parking position for the shelter in the absence of rain. Results showed that root growth was strongly affected by the exclusion treatments. In addition, the spring exclusion occurred during the period of important phenological changes. Leaf development was highly affected by this treatment, with several trees showing no signs of bud-burst. Because litterfall is linked to the development of new leaves in Quercus ilex, the absence of new leaves influenced higher retention rate and lower litterfall. This affected indirectly the amount and the quality of organic matter inputted to the soil. Partly as a consequence of these changes and partly because of direct effect of drought on microbial decomposition, soil respiration was negatively affected by precipitation exclusion and the temperature sensitivity of soil respiration decreased in the stressed plot. However, the exclusion plots showed much higher soil respiration rate for several months after the treatments ended probably because of priming effect. The importance of these results for biogeochemical cycles and vegetation-climate feedback under future climate changes will be discussed.