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To cite this version:
Angela Augusti, D Landais, Marie-Lise Benot, R Hasibeder, M Bahn, et al.. Effects of summer extreme events on grassland soil CO2 efflux in a context of future climate change. OpenScienceConference on Climate Extremes and Biogeochemical Cycles in the Terrestrial Biosphere: Impacts and Feedbacks Across Scales, 2013, Seefeld, Austria. 1 p., 2013. hal-02806429

HAL Id: hal-02806429
https://hal.inrae.fr/hal-02806429
Submitted on 6 Jun 2020

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Effects of summer extreme events on grassland soil CO₂ efflux in a context of future climate change

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INTRODUCTION

Climate models forecast, for the coming century, not only a gradual warming and drier climate, but an increase in frequency of extreme events, too.

In grassland ecosystem most of the carbon is stored in the soil. Below-ground processes act as feedback on atmospheric CO₂ concentration. Soil CO₂ efflux derives from two main components, autotrophic respiration being associated with root and rhizosphere respiration and heterotrophic respiration associated with the turnover of soil organic matter by microorganisms. The aim of this study was to evaluate the extreme event effects on soil efflux and on its autotrophic and heterotrophic components, in a context of future climate change. A possible mitigation effect of increasing CO₂ on soil CO₂ efflux and its components was evaluated.

METHODS

- Forty eight grassland monoliths, coming from an upland site in Auvergne Region, France, were grouped in 12 experimental units.
- Since May 2010, the 12 units were exposed to air temperature (T) and precipitation (P) expected for the period 2040-2060 (in table indicated as 2050). This corresponded to an increase of 2.3°C in T and to a decrease of 10% in the P compared to a reference year, 1999.
- Since January 2011, 6 out of the 12 units were exposed to a CO₂ enrichment of 140 ppm more than ambient.
- During summer 2011 a heat wave and drought stress were applied.

RESULTS

Total efflux (Fig.1) is strongly reduced during the extreme event treatments both at ambient and at elevated CO₂. The reduction is mainly due to the autotrophic component since the treatments had a milder effect on heterotrophic respiration (Fig.2). Total respiration shows a faster recovery compared to heterotrophic respiration.

The reduction in total soil CO₂ efflux is well described by the reduction in soil moisture (Fig.3a and b).

The recovery of total soil CO₂ efflux is associated to a sustained recovery in root respiration (both in newly formed roots from ingrowth core and from soil core), (Fig. 5). A mild effect of increasing CO₂ can be observed.

CONCLUSIONS

- Summer drought and heat wave stress caused a decrease in soil respiration even if the kinetics differ between total and heterotrophic components.
- They caused a sustained decrease in root growth and in canopy photosynthesis (see talk of Jacques Roy).
- The increasing CO₂ had a mitigation effect of the extreme on root growth rate and on root respiration, but not on soil CO₂ efflux.