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Biogeosciences Discussions

Interactive comment on "Summer drought reduces total and litter-derived soil CO_2 effluxes in temperate grassland – clues from a ^{13}C litter addition experiment" *by* O. Joos et al.

O. Joos et al.

hagedorn@wsl.ch

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Response to Anonymous Referee #1

1. General comments

C3489

1. "A 'small gap' in the soil moisture data set at 5 cm depth covers the entire drought treatment period plus the about 10 preceding and 10 succeeding days. Consequently, results and conclusions derived in this respect can also at best be rough estimates."

–> The soil moisture sensor at 5 cm depth failed, very likely because it was too dry

and soil shrinkage led to an insufficient contact with the soil matrix. In the revised manuscript, we replaced the 5 cm data by those at 15 and 30 cm depth that were measured throughout the experimental period (Figure 1). We also used the soil moisture data sets at 15 and 30 cm depth to estimate potential relationships to environmental drivers.

2. "However, there is an even more problematic issue in the drought experiment. I doubt that a drought can be simulated with rain shelters the size of 3.0 m x 3.5 m. The shelters will in their centre definitely keep the soil surface dry but with increasing soil depth soil moisture will approach similar levels to those outside the shelter. I am not familiar with the situation at the experimental site. Yet, I assume rooting depth of at least 1 m for most species. So plants underneath the shelter will have benefited during the drought treatment from precipitation that has fallen outside the shelter and that has moved by gravity flow and/or capillary rise into their rooting zone. The same applies to the soil microbial community, especially in the deeper soil layers. For reasons of the half-way nature of the induced drought and missing soil moisture data during the course of the treatment, I would remove this part entirely from the manuscript."

–> Although the shelters may seem rather small, we believe that the simulation of a drought in our study was effective: Soil moisture measurements clearly indicated a substantial reduction by the drought at least down to 30 cm (40 vs. 10% in volume under ambient and drought). To validate volumetric soil moisture measurements, we additionally measured gravimetric soil water content a couple of times in 2007. The gravimetric measurements showed a similar pattern as the continuous volumetric measurements (Gilgen and Buchmann, 2009). We added the soil moisture data of 15 and 30 cm depth in the revised Figure 1. We agree that some roots may have reached down to 1m, but the majority of roots were most likely present in the 0-30 cm soil layer as in most grasslands (Jackson et al., 1996; Bessler et al., 2009). In our experiment, there is a clear support for a drought impact on plant growth and the root system: aboveground productivity was reduced by 30% (Gilgen and Buchmann, 2009) and gas exchange as well as leaf water potentials were significantly smaller under drought (Signarbieux, 2009). We therefore believe that the experimental roofs induced a drought that affected a number of ecological processes. To avoid potential edge effects, we have conducted all measurements in a core area (1m x 2m) in the centre of the plots (see page 11009, Line 21, old manuscript). Earlier experiments with the same roofs have shown that the buffers on either side of the core area are large enough (Kahmen et al., 2005). To demonstrate the effectiveness of our experiment in the revised manuscript, we added soil moisture data of 15 and 30 cm depth in Figure 1. We also discussed the experimental drought effect as follows (Chapter 4.3): The rainfall removal by the roofs induced a drought in the plant and soil system. Volumetric soil moisture at 30 cm was reduced from 40% under ambient precipitation to 10% under drought (Figure 1). Plant productivity, photosynthesis as well as leaf water potentials also declined substantially (Gilgen and Buchmann, 2009; Signarbieux, 2009). As 80% of the roots are typically in the uppermost 30 m depth (Jackson et al., 1996; Bessler et al., 2009) and most of the CO2 production occurs in the uppermost 10 cm of a Swiss grassland soils under similar site conditions (Flechard et al., 2007), we assume that the experimental drought affected the major part of the biologically active soil.

3. “Also the finding that applied litter is decomposed much more slowly when kept in a dry place underneath a plastic shelter, compared to when it is exposed to rain, is trivial. In fact keeping things dry is one way to conserve them (we all have read sentences like this on boxes of tea, coffee, biscuits. . .: ‘store in a cool and dry place’).”

–> We agree that slower litter decomposition can be expected – it was one of our hypotheses. However, the drought period itself is only part of the story, because it is followed by a rewetting and a moist period. In a recent review article, Borken & Matzner (2009) highlighted that drying and wetting effects might be very different between ecosystem types (e.g. forests with a hydrophobic organic layer and grasslands without an organic layer) and that current knowledge is mainly based on laboratory studies. Our results show a flushing after the drought (Figures 1 and 3). However, the

increased respiration after the rewetting did not fully compensate for the reduced respiration rates during the drought itself. To speak in the words of the reviewer: it makes a difference for the tea or coffee you drink, if the herbs or the coffee beans were kept moist or dry. Moreover, the tea and coffee quality depends on the drying procedure.

C3490 4. “The part to save from this manuscript is the labelled litter experiment in the control plots only. I think this is a neat and interesting study, which is scientifically sound. The authors may consider re-submitting a short communication on this part of their experiment.“

–> We do not agree with the reviewer to remove the drought part, because we think that also our drought experiment contributes to the scientific knowledge as (1) the experimental drought successfully reduced soil moisture across the biologically most active soil horizons. Measurements of CO2 gradients in Swiss grassland with comparable site conditions by Flechard et al. (2007) clearly indicate that the major part of the CO2 production occurs in the topsoil. (2) Drought affected the sources and rates of soil CO2 efflux in the following rewetting period (see Figures 1, 2, and 3), and (3) there is hardly any field study that assessed the drought effects on different components of soil CO2 efflux, especially not in grassland.

References Bessler, H., Temperton, V. M., Roscher, C., Buchmann, N., Schmid, B., Schulze, E. D., Weisser, W. W., and Engels, C.: Aboveground overyielding in grassland mixtures is associated with reduced biomass partitioning to belowground organs, Ecology, 90, 1520-1530, 2009. Borken, W., and Matzner, E.: Reappraisal of drying and wetting effects on C and N mineralization, Glob. Change Biol., 15, 808–824, 2009. Flechard, C. R., Neftel, A., Jocher, M., Ammann, C., Leifeld, J., and Fuhrer, J.: Temporal changes in soil pore space CO2 concentration under permanent grassland, Agr. For. Meteorol., 142, 66-84, 2007. Gilgen, A. K., and Buchmann, N.: Response of temperate grasslands at different altitudes to simulated summer drought differed but scaled with annual precipitation, Biogeosciences, 6, 2525-2539, 2009. Jackson, R. B., Canadell, J. Ehleringer, J. R., Mooney, H. A., Sala, O. E., and Schulze, E.-D.: A global

analysis of root distributions for terrestrial biomes, Oecologia, 108, 389-411, 1996.
Kahmen, A., Perner, J., and Buchmann, N.: Diversity-dependent productivity in seminatural grasslands following climate perturbations, Funct. Ecol., 19, 594-601, 2005.
Signarbieux, C.: Grasslands in a changing climate in Switzerland: photosynthetic performance and water relations of selected species under artificial drought, PhD Thesis, University of Bern, 127 pp., 2009.

Interactive comment on Biogeosciences Discuss., 6, 11005, 2009.

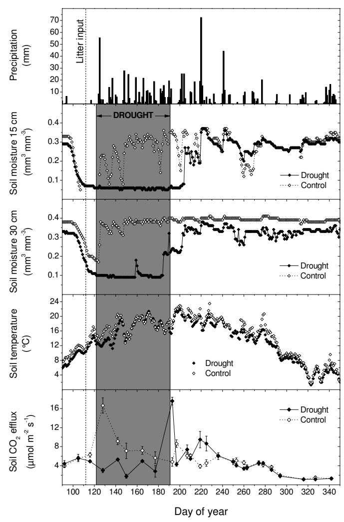

Figure 1: Precipitation, soil moisture at 15 and 30 cm depth, soil temperature and soil CO_2 efflux measured in drought and control plots during a litter addition experiment in 2007. Means and standard errors for soil CO_2 effluxes of 3 plots.

Fig. 1.