

## ***Interactive comment on “Drought in forest understory ecosystems – a novel rainfall reduction experiment” by K. F. Gimbel et al.***

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### General comments

1. Referee: ... how their rainfall manipulation experiments can prevent the soil water flow from the surrounding to the plots, especially for the subplots with only 3m\*3m? As they admitted, the adult trees could extract water through root systems from outside. This issue needs to be addressed.

Answer: Adult trees are not incorporated under the small roofs; therefore water extraction from the surrounding of the plot is not an issue for the small roofs. Parts of the phytometer experiments were performed under the small roofs; the main experiments were realized exclusively under the large roofs, where a distance to the borders was

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kept. Anyway, the focus of our study was on understory vegetation, which is not prone to extract water from outside the plots. (Please see also the answers to comment no. 10 and 11 of referee#1, comment no. 1 of referee#2, and comment no. 3 of referee#3). To address the soil water flow issue, the selected plots are all situated on flat angled slopes to avoid water input through overland and subsurface flow. We might assume that some hydraulic redistribution via the rooting system of the adult trees might occur and that the understory vegetation might also benefit from such redistribution. We can, however, show that the roofs cause a clear reduction of soil water content and we did not see any diurnal rhythms in soil moisture that would be a indication of hydraulic redistribution. We thus have good reasons to assume this effect to be negligible.

2. Referee: ... in the manuscript, they presented both the experiment design and the drought effects on forest understory ecosystems in the first year. Generally, after the disturbance, the ecosystem response to drought in the first year is not good information. Hence, it's not a good idea to address the point of drought effects at this stage. It's better to focus on the novelty and unique of their experiment design.

Answer: We do not fully understand this point raised by the referee: We agree with the referee, that freshly disturbed (after roof and probe installation etc.) plots may give unsteady data. Therefore, (as stated in 14332 L14 – 18) the installation of the roofing construction took place between September and early December in the year before the described experiment. All work was performed with maximal care to avoid unnecessary stepping and disturbing on the experimental area. If the referee assumes that one year of drought is not sufficient to address ecosystem responses we disagree: Our aim was to induce an extreme drought with a return period of 40 years. We certainly need to assume that such extreme drought events will occur more often when we refer to the climate scenarios for the future but we still cannot assume that we will have many of such extreme years in sequence. As a consequence we consider it fully justified to study ecosystem reactions after one year and strongly believe that it is necessary to study realistic drought effects and responses in the time frame as we did. We certainly

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agree that also long-term precipitation manipulation experiments are needed to study trajectories of ecosystem reactions and developments but we think the assessments of long- and short-term responses are highly complementary.

3.Referee: . . . the drought conditions in the natural settings are generally characterized by a long dry period and some intense rainfall before or after the drought. From their Figure 4, the removal of rainfall is quite uniformly distributed over the growing season. Can this design represent the natural drought events?

Answer: Here, we simulated not a short drought spell, but an overall reduced precipitation input, similar to the ones forecasted for Central Europe (increased summer dryness, Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao, 2007: Global Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA). But, as stated in 14336 L18 – 24 the construction is flexible enough to realize a (total) reduction over longer periods (weeks, months) and can be combined with irrigation equipment.

Specific comments:

Abstract 4.Referee: The first sentence is not clear. In my opinion, changes in precipitation patterns is part of climate change, rather not climate change affecting it. Also, they need one sentence which stated how novel is their experiment.

Answer: We changed the sentences; the Abstract reads now as follows: "Precipitation pattern across Central Europe are expected to change over the 21st century due to climate change. This may reduce water availability during the plant-growing season and hence affect the performance and vitality of forest ecosystems. We established a novel rainfall reduction experiment on nine sites in Germany to investigate drought effects

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on soil-forest-understory-ecosystems. A realistic, but extreme annual drought with a return period of 40 years, which corresponds to the 2.5 %-percentile of the annual precipitation, was imposed. At all sites, we were able to reach the target values of rainfall reduction, while other important ecosystem variables like air temperature, humidity and soil temperature remained unaffected due to the novel design of a flexible roof. The first year of drought showed considerable changes in the soil moisture dynamics relative to the control sites, which affected leaf stomatal conductance of understory species as well as evapotranspiration rates of the forest understory."

Introduction

5.Referee: They need provide more information about previous studies in which how they make their rainfall manipulation experiments and the drawback.

Answer: We agree with the referee and inserted following sentence: "In addition, the constructions used in previous studies often need electrical supply or intensive technical installation, supervision, and maintenance (e.g. Beier et al. 2004, Albert et al. 2011, Parra et al. 2012, Kopittke et al. 2014)."

Material and methods

6.Referee: 2.1 This part about the sites could be simplified. A table could be more clear.

Answer: We agree with the referee, shortened the section, and inserted a table. The section now reads as follows: "The site of the Biodiversity Exploratory Schwäbische Alb is located in the low mountain ranges of south-western Germany; the underlying geology consists of Jurassic shell limestone. The soils at the investigation sites are extremely rich in clay, are very shallow (25 cm to 35 cm) and have a very high stone content. The soils of the Hainich-Dün site (situated in central Germany) generally have a loamy to clayey texture with soil depths between 45 and 65 cm and low water conductivity. Here, the underlying geology consists of Triassic limestone. The site of

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the Biodiversity Exploratory Schorfheide-Chorin is located in a young glacial landscape in the lowlands of north-eastern Germany. The dominant geological substrate is glacial till covered by glacio-fluvial or aeolian sands. Therefore, soils have textures in the range of sandy loam to pure sand. Due to their sandy texture, the soil depth in this area is identified by rooting depths. More information on general plot properties is prepared in Table 2. All weather data is taken from stations of the German weather service (DWD, actual and annual data years 1950-2010) nearby (station-IDs 03402, 00487, and 00164).”

The Table can be found in the Supplement to this comment (Table 2).

7.Referee: 2.4 Specific leaf area has special definition as the ratio of leaf area to dry mass. Need another term for LAIsp.

Answer: We now don't refer to specific leaf area index any longer but just to leaf area index (LAI), a term which is generally used to indicate the leaf area per ground area. We now also do not refer any longer to specific leaf area when we refer to the area of an average leaf of a species.

Discussion

8.Referee: There are many conclusions which are not support by the experimental results, at least at this stage, but from other references or 'expect'. This should be avoided. As suggested in the general comments, the discussion of drought effects is not appropriate from only one-year data. They should focus on the experiment design.

Answer: We have now considerably shortened the discussion section 4.3 the referee refers to. We have omitted the sections where we describe our expectations for longer term reactions of the ecosystem to keep the paper more focused on the experimental design.

9.Referee: P14337, L16-19: why not measure CO2 flux?

Answer: We fully agree that measurements of CO2 concentrations and fluxes would  
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be an important complement to the assessments shown here and such approaches need to be included in future studies using such a roof design.

10.Referee: P14337, L20-28: for soil moisture, I would say that there are some effects from soil water flow between outside and inside the plots.

Answer: We do only partially agree with the referee here. We did not detect any (nocturnal) replenishment of soil moisture at our soil moisture probes and we kept our experiments at an adequate distance to the borders of the roofed area. We agree, that in close vicinity of the borders exchange effects might occur. (Please see also the answers to comment no. 1 and 11 of referee#1, comment no. 1 of referee#2, and comment no. 3 of referee#3).

11.Referee: P14338, L1-5: We knew this problem for long time. How did you address this issue?

Answer: The referee is referring to the problem of adult trees rooting inside and outside of the roofed area, and therefore possible extract water outside the roofed area and release it via hydraulic redistribution inside. We did not detect any rise in our soil moisture data, which can be associated with hydraulic redistribution. We focused in our study on understory vegetation and not on adult trees. Any water that is extracted from adult trees outside the roofed area (and is not redistributed) is consumed by the tree itself and therefore not changing the soil moisture budget. (Please see also the answers to comment no. 1 and 10 of referee#1, comment no. 1 of referee#2, and comment no. 3 of referee#3).

12.Referee: P14338, L15-28: These conclusions are not support by the results at this stage.

Answer: As written above we have now focused on the short-term effects and avoided speculations about potential reactions of the ecosystem under longer drought periods. We do think that we have now better focused on these short-term responses but still

relate them to effects observed in other studies and to the general mechanisms of drought responses of ecosystems.

Conclusion

13.Referee: P14340, L1-4: The conclusion cannot be 'expected'.

Answer: We have now focused on the effects supported by our results and have omitted the expectations.

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/11/C7685/2014/bgd-11-C7685-2014-supplement.pdf>

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Interactive comment on Biogeosciences Discuss., 11, 14319, 2014.

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