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Biogeosciences Discussions

Interactive comment on "Effects of drought – altered seasonality and low rainfall – in net ecosystem carbon exchange of three contrasting Mediterranean ecosystems" *by* J. S. Pereira et al.

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Biogeosciences Discuss., 4, 1–35, 2007

Below we list the changes made in the discussion paper. Most of them resulted from the suggestions made by the referees. We appreciated their comments and suggestions, which contributed to clarify many points and improve our writing. We also introduced some improvements in the text and figures and changed somewhat the structure as suggested by the referees. We believe that the new version has improved substantially in relation to the original submission and we hope that it is now acceptable for publication.

03 August 2007

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Interactive Discussion

Discussion Paper

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Comments by Ref # 4

1. Discrepancy between title and conclusions and major objectives

   (a) Title: we agree with comments and changed the title to "Net ecosystem carbon exchange in three contrasting Mediterranean ecosystems. Effects of drought"

   (b) Conclusions: we agree with comments and changed the text to address both objectives: (i) comparison of the net ecosystem carbon exchange in three ecosystems characteristic of southern Portugal; (ii) the effects of extreme drought on NEE.

2. In the present study we processed data from three different ecosystems, where different equipment was used. In general, post-processing was standardized as much as possible, given the ecosystem and the equipment used. The coordinate rotation was applied following the recommendations of the Carboeurope IP project (2D for grasslands and planar fit for forests). This explains why we used a 2D coordinate rotation for the Tojal, the grassland site. In Tojal, storage was not added, but as previously verified by us (and advanced by the referee) the storage term was insignificant, thus not considered. A frequency response correction was performed for the fluxes of Mitra site, only correcting the flux loss due to tube attenuation of the closed-path analyser. The open-path analysers of both Tojal and Espirra sites were placed according to Kristensen et al. (1997), minimizing the flux loss due to sensors spatial separation. Based on this, we consider that the flux loss of the systems comprising open-path analysers, due to the lack of any frequency response correction, should be similar to the flux loss of the system using the closed-path analyser. Although the lack of frequency response corrections may produce some change in the absolute annual carbon balances, it is not expected to alter the inter-annual differences in carbon balance. In this study we performed the u* filtering. As mentioned by the referee, the choice of

the u* threshold can be a source of systematic uncertainty. However, because we used advanced quality tests, such as the stationary and integral turbulence tests, the uncertainty associated with the choice of the u* threshold is expected to be rather low. The use of such tests tend to reduce significantly the role of the u* filtering (see Wohlfahrt et al., 2005) by eliminating most of the fluxes that are usually removed by it. That was confirmed after checking our data sets, using different u* thresholds below the determined u* threshold. As a consequence, using a u* threshold below the determined u* threshold, where the uncertainty usually lies, will not produce significant changes in the annual carbon balances. For these reasons, we felt that conducting systematic uncertainty analysis would be redundant. When relevant, some of the above information was added into the text.

3. Soil water availability. We introduced the data in page 1719, l.9 and info on data collection in "2.2 Field measurements" (page 1708, l. 24). Note, unless stated otherwise the page and line numbers refer to the discussion paper.

Detailed comments

1. We agree, it was changed

   Land use : cork- & holm-oak (33%), eucalypts (19%), grasslands (24%) - % Forest area

   Land use : cork- & holm-oak (13%), eucalypts (8%), grasslands (21%) - % Non urban area

   Source: Inventário Florestal Nacional 2005/2006, DGRF; Anuário Estatístico de Portugal, 2005, INE; Inquérito à Estrutura das Explorações Agrícolas, 2005, INE.

2. We agree, it has been changed

BGD

4, S1105–S1114, 2007

Interactive Comment

EGU

3. We agree, it was removed

4. Both contentions are right because Mitra and Tojal are in Évora and the eucalypt plantation near Pegões – Espirra, but we deleted the phrase to avoid confusion. Lines 21-23 of page 1708, should read, (. . .) time steps for all localities: Évora (Mitra and Tojal) and Pegões (Espirra). In page 1712, section 3.1., we introduced, "In Évora, during the experimental period, and in terms of hydrological-years, the mean air temperature varied between 15.8°C and 16.1°C and the solar radiation (. . .)

5. We agree, it has been changed

6. We agree: done

7. We agree: done

8. LUE was calculated as described in Gilmanov et al. (2007) as monthly averages. The reasons why we use these indicators are given also in the discussion. In fact, GPP is linearly related to APAR and the slope of the relationship between the two gives a measure of the efficiency of the canopy level photosynthesis to use light. Using incident PAR we integrate the efficiency of light capture by the canopy. Furthermore, LUE was minimal in summer due to water stress and light in excess to what leaves could use for photosynthesis but it was maximal in winter even though temperatures were limiting because the percent diffuse light was greater. However there was an important difference between the oak savannah, which has to reconstruct the canopy (herbaceous) and the eucalyptus stand that display leaves the year long. Regarding rain use efficiency, it tends to be maximal under limiting water supply (Huxman et al., 2004). The variability results from differences and plant metabolism, in plant nutrition and soil properties, and rainfall seasonality. At high water supply the non-productive fluxes of water become more important than.

9. To a certain extent we agree that Fig. 2 is not necessary. The figure was removed as well as section 3.2., as it was. Nevertheless, we consider relevant that the dynamics of the oak savannah was indeed similar to that of the grassland.

10. We changed the structure a bit and merged sections 3.3 and 3.4 into a new section 3.2. (former section 3.2. was deleted), entitled "inter-annual variation and differences between vegetation types".

11. We agree, it has been changed

12. We added the r^2 value = 0.76 to figure 3 (new number).

13. We changed p. 1714, l. 28 to discuss the seasonal changes in LUE.

14. Our aim in this paper was to focus on carbon fluxes and drought. As we mention further down we are preparing companion papers on different tpics.

15. It has been changed: The monthly e values calculated are generally lower than the $\varepsilon_{wk,max}$ presented by (Gilmanov et al. 2007). In the European grasslands, the gross ecological light use efficiency varied greatly from maximum weekly mean of $\varepsilon_{wk,max}$ = 7.2 mmol mol^{-1} in the dry semi-natural grassland Bugacpuszta to $\varepsilon_{wk,max}$ = 43.0 mmol mol^{-1} in the intensively managed Carlow grassland. In Tojal $\varepsilon_{wk,max}$ was 10.9 mmol mol^{-1} in 2005 (dry) and 22.2 mmol mol^{-1} in 2006.

16. P. 1716, l. 24 – p. 1717, l. 4: modified according to comments of referee #2.

17. Moved to the section dealing with seasonality, 3.3 (see our comment # 4-13), page 1717, line 27, but see also comments from referee # 5.

18. Merge tables 1 and 3: Done and text changed accordingly.

19. Tab. 2 eliminated. Precip values per hydrological year are in Tab. 2.

BGD

4, S1105–S1114, 2007

20. Information related to the footprint was improved and added into the section 2.2. Footprint results, in Table 1, were presented for Z/L = 0.2. This information was added.
21. Precip values added to Table 2.
22. Fig. 2 deleted
23. Overlapping bars corrected
24. We had only two years of data for Tojal. The data are presented in the text (see our comment 4# 13).
25. We kept the figure - see our comment 4# 17, above.

Biogeosciences Discuss., 4, 1–35, 2007

Comments by Ref # 2

1. Although we consider that closure error of energy balance equation cannot be used as a criterion to assess data quality (for further information see Foken et al., 2004), information on the magnitude of the error has been added on the text. Closure error was estimated for the Oak Woodland and Grassland sites using valid data, to assess the quality of the measurements. We also calculated the closure error after gap filling, for all the sites, to check the overall performance. However, whereas for the grassland and Eucalypt sites we could analyse the whole study period, for the Oak woodland it was only possible to analyse the year of 2006 due to G measurements availability. Results for both the cases showed that closure error fell within the normal range (0-30%). The Oak Woodland had the highest closure error, which may have been partly a result of the inherent difficulty in obtaining representative measurements of Rn and G, in such heterogeneous landscape."

2. We tried to follow a consistent procedure

3. In fact, the percentage of gaps was relatively high, manly for the Mitra and Espirra sites, due to system failures and electrical cuts. Nevertheless, similar gaps were reported for other forests (Falge et al. 2001). We learnt from Falge et al. 2001 that gap-filling errors are relatively small when gaps are lower than 40%. Thus, for our case, errors may be relatively high. However, we used the algorithm of Reichstein, which tend to reduce the errors by using the same methods as in Falge et al. (2001) but taking into consideration the temporal correlation of the fluxes. At the moment we are unable to estimate the potential effects on analysis and/or conclusions.

4. The reasons to choose the indicators are given in M&M and in the discussion.

5. We improved the conclusions. Done

6. The phrase “water year” has been changed to “hydrological year”

7. LUE is a function of LAI and this last is a function of soil moisture and root depth basically but other factors also affect their functioning like:

    (a) Diffuse/direct radiation, see p. 1716, line 24 – p. 1717, line 4. Data presented and discussed.

    (b) Specificity of rubisco – although important, e.g., if we consider the grass vs. oak or eucalyptus vs. herbs and the C3-C4 contrast in Tojal, but it is too specific and somewhat speculative.

8. The question “the dimensions of LUE are in mmolCO2/PAR mol which is affected directly by LAI and LAD. Why was LUE (not) taken in mmolCO2/Chlorophyll mol? Would these dimensions not tell us more about the real strategies of the species in adapting to such conditions?” The referee is right but we did not have the data.

BGD

4, S1105–S1114, 2007

Interactive Comment

That may be critical – having contemporary data – in the case of the herbaceous communities which change in species composition along the season and from season to season.

9. RUE was calculated as the ratio of GPP *versus* gross precipitation in gC per litre, as in Lauenroth et al. (2000) and Huxman et al. (2004). For the sake of comparing gross rainfall was taken at stand level per unit of ground area. The objective was to quantify rain use efficiency with all inefficiencies characteristic of each system. We are aware that in a similar oak savannah stand (crown cover fraction 0·39) the precipitation interception loss was 8% of gross rainfall and 28% of tree evapotranspiration (David et al. 2006) and that in the Espirra eucalyptus stand the interception loss is around 15% (Valente et al. 1997), but we decided to follow the ecosystem level approach instead of a more analytical plant species approach. In that case WUE based in real transpiration should have been chosen

Biogeosciences Discuss., 4, 1–35, 2007

Comments by Ref # 3

1. Concerning the first figures, Figure 2 was eliminated

2. The partition between transpiration and evapotranspiration is being analysed in detail for a companion paper under preparation. The data collection is extensive and it would not be feasible to include it in the present paper, with an appropriate discussion.

3. We have included soil water data, in relative terms, to discard soil different characteristics and made them comparable in water content terms. To try to close the soil water balance with soil moisture data is difficult to do, especially for Mitra site, as calculating the soil volume used by trees is quite impossible. The trees

have a long rooting system and access the underground water level during part of the year. The lower border of the soil volume used by trees is diffuse and may be quite different from one individual to the next.

Biogeosciences Discuss., 4, 1–35, 2007

Comments by Ref #5

1. We made clear our statement of hypothesis in introduction (page 1706)

3.1. Results – The figure has been modified as suggested.

3.2. Fig. 2 was deleted (see reply no. 22 to ref. #4)

3.3. We corrected the figure

3.4. We moved the correction and change the text. We hope to have simplified it.

3.5. We made the correction and change the text. See comment 13 ref. #4. The similarity between Mitra and Tojal resulted also from the fact that a deep routed C4 plant is Tojal had some degree of summer gas exchange. We are preparing a companion papa dealing specifically with these comparisons in detail.

3.6. Changes done as suggested

3.7. We improved the discussion of fig. 8 (now... in all cases LUE increased dramatically in 2006 as compared to 2005 due to the improvement of moisture conditions after the autumn rains in 2005. It is also clear that the second year (...)

3.8. We have improved the discussion of fig. 10 /now 6) which consider a very important feature of seasonally dry environments.

In addition

We included one more co-author, **T.A. Paço** and the acknowledgments were added on page 1721 (l. 26).

Refs.

Foken, T., Göckede, M., Mauder, M., Mahrt, L., Amiro, BD and Munger, JW, 2004. Post-field data quality control. */in/* Lee X., Massman W, Law B.: Handbook of Micrometeorology: A Guide for Surface Flux Measurement and Analysis, Kluwer, Dordrecht, 181-208.

David, T.S., J.H. Gash, F. Valente, J.S. Pereira, M.I. Ferreira and J.S. David 2006. Rainfall interception by an isolated evergreen oak tree in a Mediterranean savannah. Hydrological processes. 20:2713-2726.

Valente, F., J.S. David and J.H.C. Gash 1997. Modelling interception loss for two sparse eucalypt and pine forests in central Portugal using the reformulated Rutter and Gash analytical models. Journal of Hydrology. 190:141-162.

Interactive comment on Biogeosciences Discuss., 4, 1703, 2007.