Hydrol. Earth Syst. Sci. Discuss., 2, S930–S938, 2005
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Hydrology and Earth System Sciences Discussions

Interactive comment on "Stratified analysis of satellite imagery of SW Europe during summer 2003: the differential response of vegetation classes to increased water deficit" *by* A. Lobo and P. Maisongrande

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Received and published: 14 November 2005

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In order to structure our answer, we summarize comments by Referee K. Caylor as follows:

1. Authors should demonstrate that the period 1999-2002 used as the reference period for the summer values of NDVI in the article is appropriate to establish a natural range.
2. P-PET includes both rainfall and temperature effects which could affect NDVI independently. Why not simply use a P anomaly?

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3. NDVI anomaly should be defined more clearly and some inconsistency in the NDVI scales is observed in the figures.
4. Captions of figures 1 and 2 are inconsistent with the figures themselves and with the text. Values and signs of P-PET must be clarified.
5. If the NDVI of herbaceous vegetation in the northern part of their study area peaks in spring, why expect any effect of summer drought on NDVI in August?
6. Trees have little ability to adapt their LAI (or NDVI) to changes in prevailing climate conditions within a single year.
7. A historical analysis of the baseline sensitivity of each landcover type to changes in the chosen drought index would be necessary to make any strong inference regarding the specific responses to the 2003 event.
8. Mention of the article by Ciais *et al*. (Europe-wide reduction in primary productivity caused by the heat and drought in 2003 *Nature* **437**, 529-533 (22 September 2005), which was published after author's submission.

We provide here answers to these comments:

1. Authors should demonstrate that the period 1999-2002 used as the reference period for the summer values of NDVI in the article is appropriate to establish a natural range.

And,

7. A historical analysis of the baseline sensitivity of each land cover type to changes in the chosen drought index would be necessary to make any strong inference regarding the specific responses to the 2003 event.

As Europeans, the fact of the extreme exceptionality of summer 2003 was so evident that, by reference to summer 2003, the period 1999-2002 was obviously "normal". We now realize our Euro-centrism and apologize for it. While we do make reference to the work published by Black et al. (2004) and Chuine et al. (2004), we do not mention the key fact in those articles: summer of 2003 was probably the hottest in Europe since at latest AD 1500, and the hottest since 1370 in Bourgogne (France), with an anomaly of temperature that was 43% higher than that of the second hottest year (1523).

The above paragraph is not sufficient to fully answer comments #1 and #7, as those comments refer to NDVI values, therefore we explain this issue. We use NDVI data derived from images acquired by the VEGETATION instrument, launched in April 1998. Thus, we use the longest available period to calculate the reference annual course of NDVI with this instrument. As Referee K. Caylor states, other instruments provide longer series. Unfortunately, while NDVI time series derived from different sensors have been compared (i.e, Morisette et al. 2004, www.vgt.vito.be/vgtapen/ pages/fullpapers/Morisette_full.pdf, Berges et al. 2005, www.isn-oldenburg.de/projects/ earsel-abstracts2005/ABS_Berges_lacaze.html), no specific transfer functions are yet available (although work described by Brown et al. 2004 www.agu.org/meetings/fm04/fm04-sessions/fm04_B33D.html indicates that we are not far from this point now). A solution would have been using AVHRR (with a longer time series) instead of VEGETATION imagery. Nevertheless, VEGETATION imagery has a higher quality, essentially because its superior geometric accuracy let us take advantage of its full resolution of $1km^2$, and because of its atmospheric corrections. As landscapes in W Europe are very complex and the stratified analysis according to a fine-resolution land cover map (CORINE 2000) was an essential component of our approach, the finest possible resolution for the imagery was required, hence the choice of VEGETATION.

A full and formal answer to the question mentioned by Reviewer K. Caylor (“To what extent were observed anomalies in NDVI during summer of 2003 significant compared to the natural variation of NDVI for each of the vegetation types during the historical NDVI period of record?”) would be extremely involved and the matter of a different article. Also, we are convinced that current efforts by large programs from space agencies to generate multi-sensor products (i.e., the mentioned Cyclopes program) will include producing an inter-calibrated NDVI “climatology” that we will be able to use in the future to answer such a question with a reasonable effort. Meanwhile, we think that we can take the four-years (not 3, 1999-2002) as a temporary estimate of the “climatic” NDVI, in particular considering the large abnormality of summer of 2003. Our present analysis needs to be taken with caution, but it does deserve being reported.

An intermediate solution to carry out “some attempt to demonstrate that 1999-2002 NDVI data are ‘normal’ enough to use this limited period as a reasonable comparison to the 2003 data”, would be by using the NDVI series from GIMMS (8 km x 8 km resolution, from 1988 to 2003) and show, for some selected locations for each land cover type, the position of the annual course of NDVI for the period 1999-2002 compared to the annual course of NDVI for the 1988-2002 period and its confidence intervals. In this way, we would keep comparisons within the same data sets. As this solution implies a significant additional work, we expect feed-back from Reviewer on this issue.

Finally, the point raised by K. Caylor “. . . particularly since one may expect that the NDVI of 2003 to be correlated to the 1999-2002 NDVI patterns regardless of the 2003 P-PET anomaly,. . . ” is certainly interesting and take advantage of this notes to comment on it. We would say, a priori, that such “memory” would be very short for herbaceous vegetation, except in the case of catastrophic events: for a given pixel p, an anomaly decreasing NDVI in August of year y from a normal value of 0.7 to 0, would imply a total elimination of vegetation cover in that pixel. This would certainly imply that NDVI in p in year $y+1$ would be low regardless of temperature and precipitation. But for anomalies caused by meteorological conditions, NDVI in year $y+1$ is probably independent of year$y$ for herbaceous plants. This is not the case of trees: it is expected that some trees would still show in year $y+1$ the results of adverse conditions in year y. We are currently paying attention to this question of the different “memories” shown by different vegetation types.

2. P-PET includes both rainfall and temperature effects which could affect NDVI independently. Why not simply use a P anomaly?

Environmental factors are seldom independent for organisms, which must provide integrative responses. For our problem, the same P deficit is more severe if T is higher, as plants must overcome the increased PET. Perhaps for a climatologist, using P and T would make more sense. But considering drought "from a plant's point of view", P-PET is what really matters. A different problem is the effect of T by itself (not as a part of the water demand), which is visible in the higher mountains. This fact is mentioned in lines 1-6 on pg. 2032.

3. NDVI anomaly should be defined more clearly and some inconsistency in the NDVI scales is observed in the figures.

We propose the following text in the Methods section:

Lines 28-29, Pg. 2029 and Lines 1-2, Pg. 2030:

We computed an average annual series of monthly mean NDVI images for the period 1999 to 2002, which we use as the "normal" reference, and an annual series of monthly mean NDVI images for 2003:

$$\bar{V}_m = mean(V_{m,a})$$

where V stands for NDVI, m for month, $\bar{V}_m$for the reference NDVI value of month m, and a for the year, ranging from 1999 to 2002. Also, we calculated the images of the NDVI anomaly of June, July and August 2003, as the difference between the monthly 2003 images and the monthly images of the reference period:

$$\Delta V_m = V_{2003,m} - \bar{V}_m$$

where ΔV_m stands for the anomaly of NDVI of month m in 2003.

Regarding the inconsistency of values in the color bars:

NDVI values are often scaled to the 0-255 range because of computer storage and display reasons. We attempted to convert all values in the article to the |-1, 1| range (actually, in practice, |-0.1, 0.9| range) but we obviously kept the wrong scale in figs. 8, 9 and 11. We do apologize for this mistake, which certainly confuses the reader. NDVI values in these figures have to be multiplied by 0.004. We append to this text the correct figures. Note that the range of values of the anomaly of NDVI in Fig. 11 is shorter, because they are averages (and their standard errors) for each vegetation type.

4. Captions of figures 1 and 2 are inconsistent with the figures themselves and with the text. Values and signs of P-PET must be clarified.

We also have to apologize for this mistake:

Caption to Fig.1 should be:

Figure 1. Difference between Precipitation and Potencial Evapotranspiration (P-PET) in summer (June to August) in mm. Left, average summer; right, summer 2003.

Caption to Fig. 2 should be:

Figure 2. Anomaly of P-PET in summer 2003.

Clarification regarding the signs:

Let the normal summer P-PET value be -100 mm and the summer 2003 P-PET value be -250 mm, the anomaly of summer P-PET would be -250 - -100 = -150 mm.

We have modified the appropriate paragraphs in the Methods section to avoid confusion:

After Line 13 on Pg. 2028:

The anomaly of summer 2003 P-PET is defined as the difference between P-PET in summer 2003 minus the value of P-PET in the summer of the reference period:

$$\Delta(P - PET)_s = (P - PET)_{s,2003} - (\underline{\qquad P - PET \qquad})_s where$$

s $stands for summer.$

5. If the NDVI of herbaceous vegetation in the northern part of their study area peaks in spring, why expect any effect of summer drought on NDVI during August?

This is only trivial for people used to seeing NDVI annual courses (or after reading the article). We just point out the fact that the impact of exceptionally dry and hot summers like 2003 on NDVI for this type of vegetation is expected to be lower because of its current annual course. We are now considering an article on the impact of spring droughts in the same region.

Also, please note that herbaceous vegetation with green (NDVI) peak in spring is located towards the South of our area of study: normal summer drought prevents a summer peak.

6. Trees have little ability to adapt their LAI (or NDVI) to changes in prevailing climate conditions within a single year.

Please note that we do make the distinction between deciduous and evergreen broadleaf forests. There is no contradiction between comment #6 and our text: one of the reasons deciduous trees can have little ability to adapt their LAI within a single year compared to herbaceous plants, is that they have access to more water resources in the soil, at least for some forests. Nevertheless, we do agree that this is a complex matter, not central to our discussion, and which could actually distract the reader from the point we want to stress: the importance of the fact that we do detect an NDVI anomaly for deciduous trees in summer 2003, despite the fact that deciduous trees tend to have more stable LAI phonologies than herbaceous plants. This can only happen for very severe droughts. (Our work with the simulation model is now finished: for

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some deciduous forests in the region, three consecutive summers like 2003 would kill 80% of the trees. But this is a subject of another article). We change lines 18-20 in pg. 2040 to just say: "Compared to herbaceous plants, LAI phonologies of deciduous trees are more stable. The NDVI anomaly…"

We use the term *robust* (line 23, pg. 2037) in a statistical sense to refer to the certainly unexpected fact that some NDVI anomaly is observed for evergreen broadleaf (Mediterranean) forests. It is small but significant, and causes due to inaccuracies in the NDVI signal are unlikely because of the reasons explained in the text.

8. Mention of the article by Ciais et al. (Europe-wide reduction in primary productivity caused by the heat and drought in 2003 Nature ***437****, 529-533 (22 September 2005), published after author's submission.*

We think that the date of submission should be the line defining which references should be included, but if the Editor also agrees with comment #8, there is no problem from us.

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Interactive Comment

Figure 8. Plot of the P-PET in summer 2003 vs. P-PET in the average summer (1999-2002). Colors indicate the anomaly of NDVI in August 2003.

TRIAL RESTRICTION

Figure 9. Most negative NDVI anomalies in August 2003 across P-PET in the average summer (1999-2002).

TRIAL RESTRICTION

Figure 11. Plot of the mean values and standard errors (p=0.95) of the anomaly of NDVI in August 2003 *vs*. the anomaly of P-PET in summer 2003 for the four vegetation classes considered. Dec: deciduous forests; Brev: broadleaf evergreen forests; Spr: spring herbaceous vegetation; Sum: summer herbaceous vegetation.