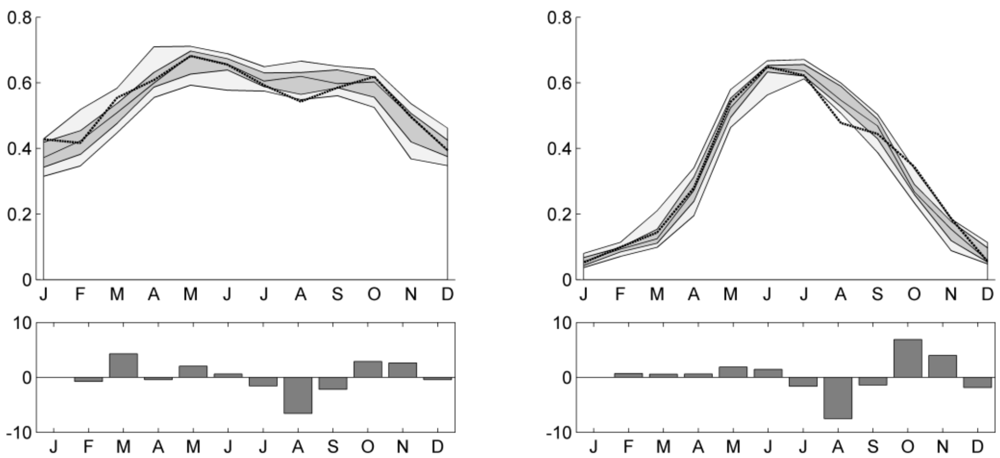
Response to Referee #2

RC 1: Like acknowledged, in the core of the remotely sensed PsN data is a radiation use efficiency model driven by phenology dynamics and modeled instantaneous responses of photosynthetic activity and respiration to changes in climate. How much of the observed response can be seen in changes in phenology (more observation based) or attributed to instantaneous responses to changes in climate (sensitive to model parameterization)? Are the responses in the fraction of absorbed photosynthetically active radiation (FPAR) consistent with PsN and NPP? What is the contribution of the environmental stresses in to anomalies in NPP? Exploring the effects on FPAR should be shedding some light on these differences.

AR1: It is true that since NPP and PsN are computed using a light efficiency model driven by meteorological data, part of the response observed to the heatwaves may be due to sensitivity to the model parameterization, rather than to the phenological response. Reichstein et al. (2007) have very thoroughly addressed this problem comparing ecosystem productivity and respiration during the summer of 2003 assessed by flux towers, remote sensing and modelling, including MOD17. They report an agreement between the models, which are shown to be able to capture the large-scale spatial patterns of vegetation response to the climate anomalies registered in 2003. Furthermore, their flux data analysis indicates that reduction in carbon uptake by vegetation in 2003 was also not only due to the heatwave event, but also due to persistent dry conditions, which is consistent with our results for HW03.

However, we acknowledge that fPAR provides additional information about the physiological response of vegetation to the heatwaves, which increases robustness to our results. Therefore, we have analyzed monthly fPAR anomalies in both years (see figure below):



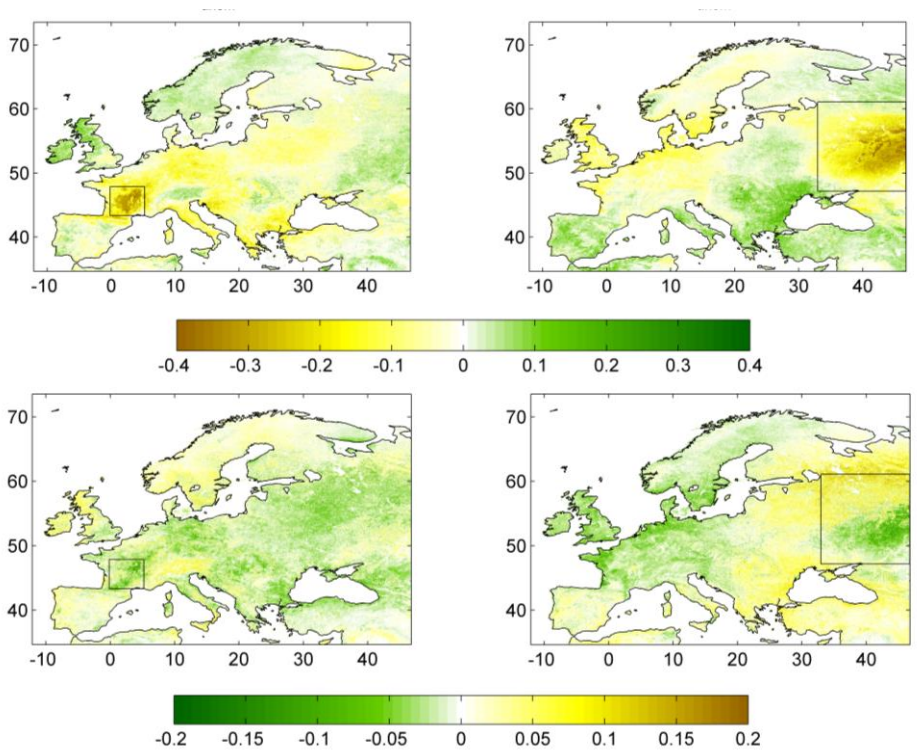
As in Fig. 2 but for fAPAR.

As in PsN, summer months are characterized by negative anomalies in photosynthetic activity. However, for both episodes, only in August is observed an extreme response by vegetation, reinforcing our conclusion that the extreme ecological response was mainly due to the heatwave event in both years. The authors consider that it is worth comparing the seasonal cycle of fPAR and PsN, and will, therefore, include further analysis on this topic in the revised version of the paper.

Reichstein, M., Ciais, P., Papale, D., Valentini, R., Running, S., Viovy, N., Cramer, W., Granier, A., Ogée, J., Allard, V., Aubinet, M., Bernhofer, Chr., Buchmann, N., Carrara, A., Grünwald, T., Heimann, M., Heinesch, B., Knohl, A., Kutsch, W., Loustau, D., Manca, G., Matteucci, G., Miglietta, F., Ourcival, J.M., Pilegaard, K., Pumpanen, J., Rambal, S., Schaphoff, S., Seufert, G., Soussana, J.-F., Sanz, M.-J., Vesala, T. And Zhao, M. (2007), Reduction Of Ecosystem Productivity And Respiration During The European Summer 2003 Climate Anomaly: A Joint Flux Tower, Remote Sensing And Modelling Analysis. Global Change Biology, 13: 634–651. Doi: 10.1111/J.1365-2486.2006.01224.X.

RC2: The interpretation of effects in autotrophic respiration is not straightforward from using PsN or NPP. For an intention to derive implications in vegetation behavior in this regard would be important to distinguish between NPP and GPP (Jung et al., 2011).

AC2: We agree with the referee that to assess autotrophic respiration (AR) behavior in response to the heatwaves, both GPP and NPP should be computed and compared. Therefore, we have used annual GPP fields (MOD17A3 dataset), and computed AR as the difference between GPP and NPP:



Annual GPP_{anom} (top) and AR(bottom) fields for 2003 (left) and 2010(right) in $kgC.m^{-2}.year^{-1}$.

Although the spatial patterns of GPP_{anom} are generally similar to the ones obtained in NPP_{anom} fields, the spatial analysis of AR allows uncovering interesting features, particularly in HW10. Our analysis is focused in the same regions (boxes) over France (HW03) and Russia (HW10) that were used in the manuscript.

In HW03, the decrease in GPP over France is accompanied by a negative anomaly of AR, rather than an enhancement due to high temperatures. Results are consistent with the analysis in Ciais et al. (2005), which relies on an ecosystem model to compute total ecosystem respiration and indicates a drop in both autotrophic and heterotrophic respiration during 2003. However, HW10 presents a marked difference in AR anomalies between the northern Russian sector, with high marked increases in AR, and the southern sector, where AR is decreased during 2010. Such clear cut north-south differences in AR impact (under similar climatic conditions) may result from the effect of different land-cover response to the heatwave. In fact, when comparing the spatial pattern with GLC2000 (figure below), the regions with increased autotrophic respiration (north) correspond to forested areas (mainly broad-leaved and mixed forests), while the area dominated by negative AR_{anom} corresponds mainly to croplands and other cultivated areas (south).

We consider that this topic is worth to be discussed in further detail in the revised version of the manuscript and will, thus, include a figure comparing GPP, NPP and AR fields, and Table1 will be accordingly changed to summarize the results for each land-cover type in the two regions.

Ciais, P.; Reichstein, M.; Viovy, N.; Granier, A.; Ogee, J.; Allard, V.; Aubinet, M.; Buchmann, N.; Bernhofer, C.; Carrara, A.; Chevallier, F.; De Noblet, N.; Friend, A. D.; Friedlingstein, P.; Grunwald, T.; Heinesch, B.; Keronen, P.; Knohl, A.; Krinner, G.; Loustau, D.; Manca, G.; Matteucci, G.; Miglietta, F.; Ourcival, J. M.; Papale, D.; Pilegaard, K.; Rambal, S.; Seufert, G.; Soussana, J. F.; Sanz, M. J.; Schulze, E. D.; Vesala, T. & Valentini, R. (2005), Europe-wide reduction in primary productivity caused by the heat and drought in 2003 Nature, 437, 529-533

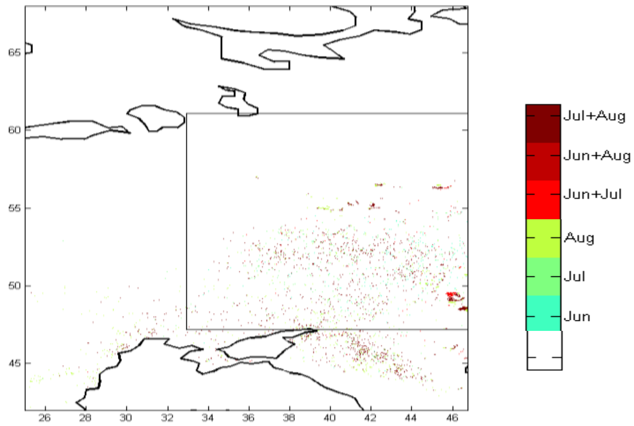
		Forests		**Cultivated**		**Total**	
		HW03	**HW10**	**HW03**	**HW10**	**HW03**	**HW10**
GPP_{anom}	(kgC.m-2)	-0,25	-0,13	-0,15	-0,15	-0,21	-0,13
	Tg	-6,5	-30,1	-7,6	-48,9	-20,8	-90,1
NPP_{anom}	(kgC.m-2)	-0,25	-0,18	-0,13	-0,13	-0,19	-0,14
	Tg	-6,7	-40,7	-6,6	-42,5	-18,9	-93,6
AR_{anom}	(kgC.m-2)	0,01	0,05	-0,02	-0,02	-0,02	0,01
	Tg	0,17	10,5	-1,00	-6,4	-1,90	3,4
Δ PsN	(kgC.m-2)	-0,30	-0,24	-0,22	-0,18	-0,23	-0,19
	Tg	-7,2	-55,1	-14,9	-56,0	-23,0	-125,0
% of area		26	37	73	47	-	-

RC3: These two years were particularly intensive also in terms of fire activity, as the authors also acknowledge. Significant losses in PsN and NPP can also be attributed to reductions in FPAR caused by fire activity. This impact cannot be disentangled in the current analysis. The isolation of burned areas could help: 1) attribute losses in vegetation activity due to fire activity; and 2) interpreting the changes in productivity based on phenological and physiological responses to climate. Clarifying these aspects would lead to a better understanding of the differences between Eastern and Western responses of vegetation to heat waves. Addressing potential implications would significantly improve the discussion and conclusion sections.

AC3: The authors agree with the referee that this is an important question to address. Since MOD17 relies on a light efficiency model to compute GPP from FAPAR measurements obtained by satellite imagery, fires will have an impact on GPP and NPP values by decreasing absorbed radiation due to total or partial combustion of the canopy. It is worth, thus, assessing how much of the decrease in NPP is due to the loss of vegetation by fire.

Therefore, we have used MODIS MCD45 fire database (Roy et al., 2005) to identify the pixels burnt during summer for each region and integrated the observed NPP anomaly over the corresponding burnt area. In the case of HW03, as expected, fires during the heatwave months have an insignificant contribution to the decreases in vegetation activity. In HW10, the widespread fires that affected Russia during summer led to decreases in PsN of 1.8TgC, which corresponds to more than 1% of the total losses over the region. We must stress that these values only reflect the contribution of fires to the reduction in NPP observed; they do not account for the carbon emissions due to combustion or for the losses in carbon uptake over the following years before the ecosystem recovers, which would lead to much larger values of carbon flux anomalies.

Roy, D. Jin, Y.; Lewis, P. & Justice, C. (2005) Prototyping a global algorithm for systematic fire-affected area mapping using MODIS time series data Remote Sensing of Environment , 97, 137 - 162



Burned pixels in summer 2010 from MODIS MCD45, HW10 is highlighted in the box.

RC4: P15895, L23: “withing” -> within?

AC4: The text will be corrected accordingly.

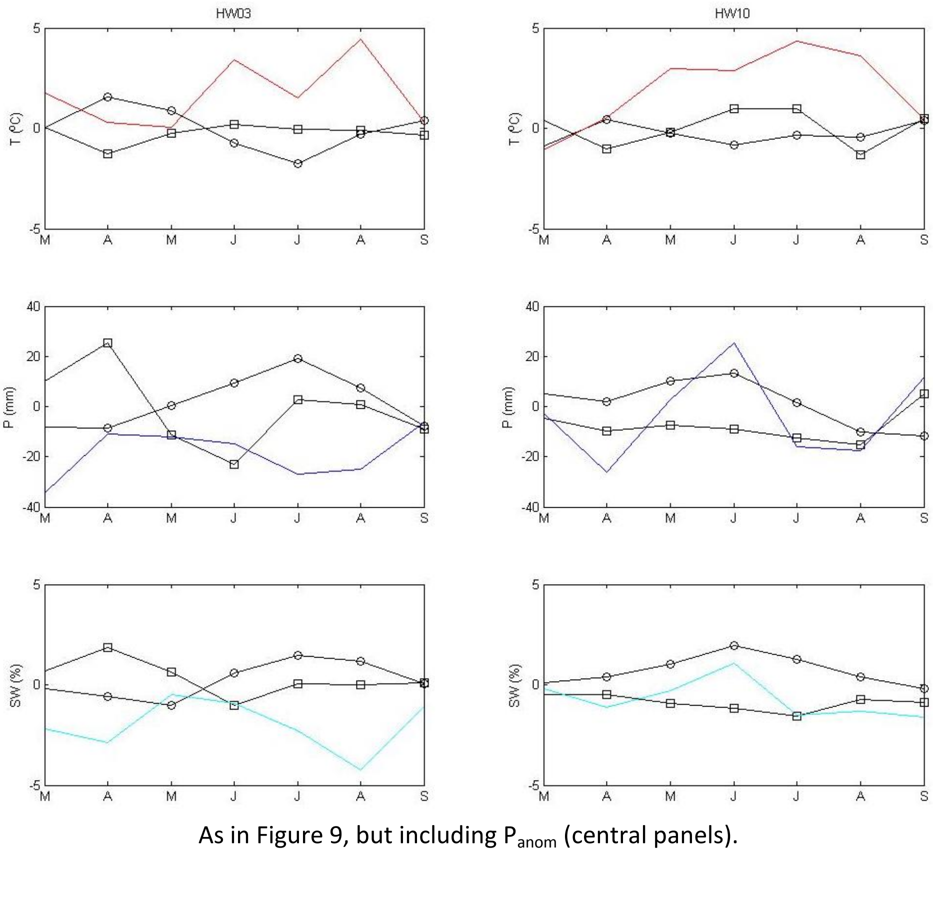
RC5: Figure 2: In this plot indeed seems that the relative effect of the heat wave of 2003 is lower than the relative loss in PsN in 2010 at the annual scale. This difference appears much smaller if only looking at the period between June to August. Is this the case?

AC5: That is the case. As mentioned in page 15888, l14-21:

> *In magnitude, the difference between the curves corresponding to the cumulative PsN in the year of the heatwave and the median is quite similar for both regions (about 0.25 kgCm^{-2}), however, relative to the corresponding standard deviation, the impact of the heatwave on PsN in HW10 was slightly higher, reaching -2.8σ in August 2010, while in HW03 the departure in August 2003 was -2.4σ. Following summer, cumulative PsN curves for the two extreme years follow a similar trajectory as the respective climatologies, thus the negative balance is mainly due to the decrease in PsN rates during JJA.*

RC6: Figure 9: "P_anom" is not shown in the figure, although would be very interesting.

AC6: In this analysis we are more interested in disentangling the response of vegetation to (a) high temperatures and (b) water stress. In that regard, water stress in vegetation is better assessed by soil moisture, which reflects water available for vegetation functioning, than by precipitation alone. Furthermore, and as mentioned in the introduction, several works have shown that soil moisture dynamics is influenced by the combination of precipitation and temperature and radiation flux, which affect evapotranspiration. In a preliminary version (please see figure below) we had included P_{anom} in Fig. 9. However, we decided not to include it because it does not add more information about water stress conditions to the information provided by plot of SW_{anom}.



As in Figure 9, but including P_{anom} (central panels).