

We would like to thank all reviewers for taking the time to read the manuscript and make many useful suggestions that we will use to make this a strongly improved version of the manuscript. We are grateful for the overall positive assessment and will incorporate the advice to improve the narrative, increase the quantitative nature of the text and improve figures.

Response to Anonymous Referee #2

Van Gorsel et al explore the sensitivity of Australian woodlands and forests to an extreme heat wave. Results are interesting but a number of minor steps could be taken to make the results less qualitative. The Discussion section should be expanded somewhat to create a more explicit comparison with other heat waves such as those studied by Ciais, Teuling, and many others. The Discussion section ends on a disappointing note with little in the way of synthesis of results to advance current knowledge.

We will expand this section in the revised manuscript with the following references (amongst others). We will come the effects on energy and carbon fluxes in our study to other heat waves (at a minimum):

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, AD, Friedlingstein, P, Grunwald, T, Heinesch, B, Keronen, P, Knohl, A, Krinner, G, Loustau, D, Manca, G, Matteucci, G, Miglietta, F, Ourcival, JM, Papale, D, Pilegaard, K, Rambal, S, Seufert, G, Soussana, JF, Sanz, MJ, Schulze, ED, Vesala, T, and Valentini, R: Europe-wide reduction in primary productivity caused by the heat and drought in 2003, *Nature*, 437, 529-533, 10.1038/nature03972, 2005.

Reichstein, M, Ciais, P, Papale, D, Valentini, R, Running, S, Viovy, N, Cramer, W, Granier, A, Ogee, J, Allard, V, Aubinet, M, Bernhofer, C, Buchmann, N, Carrara, A, Grunwald, T, Heimann, M, Heinesch, B, Knohl, A, Kutsch, W, Loustau, D, Manca, G, Matteucci, G, Miglietta, F, Ourcival, JM, Pilegaard, K, Pumpanen, J, Rambal, S, Schaphoff, S, Seufert, G, Soussana, JF, Sanz, MJ, Vesala, T, and Zhao, M: Reduction of ecosystem productivity and respiration during the European summer 2003 climate anomaly: a joint flux tower, remote sensing and modelling analysis, *Glob. Change Biol.*, 13, 634-651, 10.1111/j.1365-2486.2006.01224.x, 2007.

Teuling, AJ, Seneviratne, SI, Stockli, R, Reichstein, M, Moors, E, Ciais, P, Luysaert, S, van den Hurk, B, Ammann, C, Bernhofer, C, Dellwik, E, Gianelle, D, Gielen, B, Grunwald, T, Klumpp, K, Montagnani, L, Moureaux, C, Sottocornola, M, and Wohlfahrt, G: Contrasting response of European forest and grassland energy exchange to heatwaves, *Nat. Geosci.*, 3, 722-727, 10.1038/ngeo950, 2010.

Trigo, RM, Garcia-Herrera, R, Diaz, J, Trigo, IF, and Valente, MA: How exceptional was the early August 2003 heatwave in France?, *Geophys. Res. Lett.*, 32, 4, 10.1029/2005gl022410, 2005.

van Heerwaarden, CC, and Teuling, AJ: Disentangling the response of forest and grassland energy exchange to heatwaves under idealized land-atmosphere coupling, *Biogeosciences*, 11, 6159-6171, 10.5194/bg-11-6159-2014, 2014.

The following minor comments are designed to strengthen what I feel is an interesting manuscript that is of interest to the readership of *Biogeosciences*, but that needs to stake its claim to novelty.

Many qualitative statements can be avoided; for example what constitutes 'exceptional' on line 31?

It is difficult to explain 'exceptional' in the abstract but we quantify it quite clearly in the section "heat wave characterisation". Having said that we understand that this is a more general comment and will make changes in the abstract (and throughout the manuscript) to be more quantitative.

The abstract would be more powerful and citable with qualitative statements instead of quantitative ones.

We will add more quantification throughout abstract.

Define 'recover quickly' on page 3 line 16.

Will do

I'm confused, the end of the abstract says that CABLE was used but the end of the introduction says that BIOS2 was used.

Will change CABLE to BIOS2 in the abstract.

I understand what is meant by 'relevant fluxes' but others outside the eddy covariance community might not.

Thank you, we will change the term to "latent and sensible heat as well as carbon fluxes"

Why is 'BGH' an acronym and how does it abbreviate 'reference period'?

We will change the describing sentence to 'We used the hourly data of a background period (BGH)'

Avoid all acronyms that can be avoided. Please also state the actual name of the flux sites used rather than just the fluxnet acronym at first mention to provide a more complete description of the sites.

We will do so.

The sentence beginning line 16 page 4 includes the classifiers i, ii, iii, and then i again in a single sentence.

Will change, thank you.

Sometimes the common name for each species is in parentheses, and sometimes the scientific name is.

Will tidy up, thank you.

Occasional minor typographical issues like the space between 33 and m on page 5 line 3.

Will change and review the manuscript for corrections to symbols and text.

With respect to the GIMMS3g FPAR product, what product was used before this update?

We will change this section to read:

In this work, we updated BIOS2 to use the GIMMS3g FAPAR product (Zhu et al., 2013) instead of MODIS and AVHRR products (Haverd 2013b) for prescribed vegetation cover. The reference period used, BGC, is 1982-2013, the period over which remotely sensed data is available.

More qualitative statements enter the results sections where they should be avoided at almost all costs. What is 'high' VPD and 'very low' soil water in section 3.1? See also: 'less pronounced', 'similar', 'decreased throughout the heat wave' (by how much?), and 'unusually high'. A nice statement follows 'unusually high': During HW1 they were generally more than 1.5-2 standard deviations (\Leftrightarrow) higher than during the same time during the 32 years mean from the background period (BGC). More passages should look like this.

We will quantify these statements now throughout the results section.

Comma after 'Due to increased surface temperatures' on page 7. (Note 'moreso' following this passage doesn't say much. By how much?)

Comma will be added with quantified statements.

Superlatives like 'remarkably' and 'even' throughout the manuscript suggest surprise, but should be avoided.

We will mostly remove these words.

The reader knows the heat wave was big.

I don't understand 'daily latent heat flux (Fe)'. Is Fe a new abbreviation for latent heat flux on the daily time scale?

This new variable (Fe) was introduced in error and will be removed.

In the discussion section on page 9 it is re-defined as F3. Wasn't the first usage of this common term somewhat sooner? Following the re-definition of Fe, the authors abbreviate sensible heat flux as 'Fh', then proceed to immediately not use this new

definition in the next line. I recommend removing all abbreviations that are not necessary in this abbreviation-heavy manuscript.

We will tidy this up

On page 10 note that latent heat flux is also controlled by VPD in addition to soil heat flux and this stomatal control is discussed in the next paragraph. Please define 'With temperatures clearly above an optimum temperature'. Plants can surprise. What is the optimum leaf temperature range for Eucalyptus?

We will more clearly point to the reference for the optimum temperature and provide ecosystem scale site specific numerical values.

Also, how did photosynthetically active leaf area potentially increase over such a short time period of the heat wave? I feel that this argument should be thought through a bit more.

Agreed. We will remove this because it is not fully documented

How do results agree or disagree with recent manuscripts by Poulter et al. (2014) and Ahlstrom (2015) on the role of dryland ecosystems in the global C budget?

Poulter's study specifically focused on the response of ecosystems in the Southern Hemisphere to very wet, favourable conditions (in contrast to heat waves or droughts). However, when taken together with Zhao and Running (2010, *Science*), Ahlström (2014) and Cleverly et al. (2016 *Scientific Reports*), the extraordinary resilience of Australian ecosystems that dominates patterns of global productivity is a consequence of the extraordinary fluctuations in climate (from very wet to droughts and heat waves) to which the flora is adapted. This is in striking contrast to the 2003 heat wave in Europe, which was historically unprecedented (Schar et al. 2004 *Nature*). We will address in the Discussion how these results are consistent with previous findings on the role of dryland ecosystems on the global C budget.

The end of the Discussion section is a bit vague and waves briefly at numerous diffuse threats yet doesn't synthesize results in any of these contexts.

The end of the Discussion section will be revised to clarify and emphasise the difference of the responses of Australian ecosystems during the 2013 Angry Summer heat wave to observations made previously and elsewhere.

The choice of red and green together in Figure 2 is a bit unfortunate. The legend says that some of the lines are meant to be blue but they appear green in my copy.

We will change Figure 2 so that the blue lines are no longer applicable. We expect that providing stronger quantification in the text will improve the readability of the figures and mean that red/green is less of a problem in this graph. In all other graphs there is a good grey scale separation through the lighter green.

I'm not really sure what Figure 4 is telling us; I'm not accustomed to seeing things like incident radiation presented as a boxplot. Figure 5 is more useful. Is Figure 6 just for one day? The smoothing/averaging treatment of Fig. 5 (and 7) would look nice here too.

Figure 4 shows the radiation balance and the partitioning of the energy terms during background conditions. We have added “Average” and a reference to Figure 5 to the caption of Figure 6 to emphasise that the lines are for the whole period of BGH, HW1 or HW2.

Some thin vertical lines would help the multiple box plots be a bit more readable. It's hard to ascertain what corresponds to what.

Will do

A table of abbreviations would help.

Will add

I feel that Ray Leuning should be included in the Acknowledgements section.

Absolutely. We initially were going to dedicate the whole special issue to Ray (and therefore did not acknowledge him in this manuscript) but given current uncertainties around funding for a preface to the special issue we will add an acknowledgement to the manuscript. Furthermore, the introductory paper for the special issue (Beringer et al.) is dedicated to Ray Leuning.

Many thanks again for a very constructive review (which we will also acknowledge in the manuscript)!