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 the figures.

Response to Anonymous Referee #1

This study details the 'Angry Summer' of 2012/2013 in Australia from a FLUXNET perspective. I have a few sundry comments (listed below) but my main issue is one of narrative. I am missing some grand notion of what we've learned from this that we did not already know.

Australian ecosystems are generally known for their resilience to dry and hot conditions. Large-scale droughts and heat waves in Europe during 2003, in Canada during 2000 to 2003 and in the US during 2012 caused substantial reductions in summer carbon uptake, and vegetation-climate feedbacks were found to contribute to warmer temperatures. However, direct observations of the ecosystem response to large-scale extremes in Australia have been lacking so far and this manuscript provides new insights into such response based on direct flux measurements from several sites that has only recently become available. We will point this out much more clearly throughout the manuscript, will have a better emphasis on 'take away messages' and will change the abstract by adding "ecosystems known for their resilience towards hot and dry conditions." to "In this study we synthesised eddy-covariance measurements from seven woodlands and one forest site across three biogeographic regions in southern Australia. These observations were combined with model results from BIOS2 (Haverd et al., 2013) to investigate the effect of the summer heat wave on the carbon and water exchange of terrestrial ecosystems." in the abstract to reflect this earlier on in the manuscript.

We already knew, as an example, that extreme events alter the energy balance.
Yes, we do. However, our results provide novel insights into a range of heat wave responses across different ecosystems that have been previously unreported. Furthermore, as we point out in the discussion there is a fundamental difference in this Australian heat wave to what has previously been observed in Europe and US. In contrast to these other studies, incoming radiation and available energy were unaffected by the heat wave in Australia.

We might have guessed that AU-Tum, as a forest with relatively deeper roots, would have a different LE response.
Similar to reply 1) there have been no direct observations of ecosystem responses to large scale extremes in Australia. This is also true of studies characterising root distributions of these trees, thus we cannot confirm (nor deny) the assumption that AU-Tum has trees with deeper roots than the other sites. However, it seems unlikely that the Mediterranean woodlands would not have equally deep or deeper roots

because they are more strongly water limited than AU-Tum. This manuscript uses direct measurements to quantify this response beyond guessing and makes a contribution towards understanding the ecosystem response to heat waves in Asutralia.

Removing some of the verbosity might help polish the storyline, e.g., the site characteristics can be readily outsourced to a table in the appendix.

We will rework the storyline and cite characteristics for clarification. We do think, however, that describing the sites in detail is crucial for the interpretation of the results in this manuscript.

Also, with your HW1 and the HW2 you are set up to talk about legacy (or memory) effects, but that word appears nowhere in the study.

We chose to split the heat wave period into two parts to make it possible to see if the ecosystem sink / source behaviours would recover after a rain event. We will revise our argumentation for making this clearer in the revised version of the document (e.g. abstract).

The authors did not have any intent to investigate legacy effects which would require a different analysis altogether.

Finally, your "Although all observed ecosystems remained carbon sinks through the duration of the heat wave" bit in the Conclusions is different that the expectation that extremes flip carbon status (sink to source).

This aspect of the manuscript will change most during the revision. This sentence will be changed to “The woodlands turned from carbon sinks into carbon sources and while the temperate woodlands recovered quickly after rain, the Mediterranean woodlands remained carbon sources throughout the duration of the heat wave.” We will adjust the conclusions and results/discussion accordingly. We will also contrast this finding to ecosystem responses in the European 2003 heat wave (Ciais et al. 2005 *Nature*; Bastos et al. 2014 *Biogeosciences*; van Heerwaarden et al. 2014 *Biogeosciences*), China (Bauweraerts et al. 2014 *Agricultural and Forest Meteorology*) and the 2013 summer drought in central Australia (Cleverly et al. 2016, *Agricultural and Forest Meteorology*).

Using that as a framing piece would help the narrative I believe. In any event, as is I am at a loss as to what the main take-ways of this study are (other than different sites responded slightly differently, which is a given a priori).
The authors don’t think that previous to this study one could have safely guessed what the impact of extreme heat is on the different ecosystems across Australia and hope that the reviewer agrees that after the revisions made to the paper it is worth publishing this novel material that shows that the carbon sink of the the moisture limited, drought adapted woodlands is generally more vulnerable to heat extremes.

Please use unique line numbering (do not reset to 1 every page). L5 is rather ambiguous here.
Lines will be re-numbered throughout.

Re: "While climate change generally increases the sink strength of terrestrial ecosystems through carbon dioxide and nitrogen fertilisation" The authors need to rethink this. There have been several recent papers that read as an active debate on this assertion. See e.g., van der Sleen et al 2014 & Smith et al 2015. Plus there is more to climate change than C and N fertilization.
We will reduce the text and the references for carbon fertilisation as we feel discussion of this aspect distracts from the main topic, the impact of heat waves on the south Australian ecosystems, and is poorly supported by our data.

Re: "BIOS2" comes out of the blue here. In the abstract you mention CABLE?
Thanks, we will change CABLE to BIOS2 in the abstract.

Re: "Discussion" But you have not done anything with BIOS2 as of yet? Or if you have it is not clear what? Was it just to gapfill meteorological time series? In the appendix you have skill metrics for various fluxes but I cannot find a reference in the paper that these were ever used?
We refer to the climatology, derived from BIOS2 output in several places throughout chapter 3 (e.g. last sentence 3rd paragraph in 3.2.1 and last sentence of 3.2.1, last paragraph of 3.2.2).

Figure 2: Why is precip different by panel? The same sites and times are shown in each one? Also, what of the background shading? I would put the legend outside of the plot as well.
Graph will be changed also taking Referee3's comments into account

Figure 3: This needs a legend for the symbols that is not in the caption.
Thank you, adding a legend will improve readability.

Figure 4: What are "Flier points"?
Flier points are points that represent data extending beyond the whiskers (which represent the most extreme not outlier points). I.e. flier points are outliers. We will add this information to caption.

Figure 5: (And this applies to the other figures as well.) Could you look into visually more distinct colors?
The colour scheme is to a certain degree a matter of taste. The colours are either complementary colours or have a very distinct difference in grey scale to distinguish between them.

Figure 7: BHG? Why not show the differences wrt the background to declutter?

The reason for not showing the differences is that we would prefer not to lose the information on the magnitude of the fluxes.

Table 1: Is it not Plains?
It is indeed. Thank you.