We thank the reviewer for their constructive comments and we address their various concerns below. Referee comments are highlighted in bold, with our response below in each case.

Recent findings on a leaf and tree level indicated that during heatwaves the photosynthesis (A) may decouple from the stomatal conductance (gs). In line with gs, transpiration (E) may increase while A does not which impacts instantaneous water use efficiency (WUE). De Kauwe's et al paper aims to extend this evidence on the ecosystem level analyzing eddy covariance data from mostly Australian forested ecosystems. Because the topic is novel and because the correlation between A and gs became central to many models the topic may be in a scope of a large audience.

Generally, the paper reads well. Data are demonstrated on figures which are mostly clear to understand.

We thank the reviewer for this positive summary of our work.

But I do not think that the research questions stated in the last paragraph of the introduction section fit the rest of the paper. That means, the paper focuses more on changes in instantaneous WUE (A/E) that on a decoupling of the gs from A. Of course, both may be described in the same paper but the reasoning in the introduction and in a discussion as well as the structure of results should be adjusted accordingly.

The reviewer is correct that whilst we do talk about a decoupling between A and g_s, our analysis is focussed on the response of ecosystem-scale quantities: flux-derived GPP and the flux of latent heat. However, we do not see that the question as stated, was inconsistent with our analysis - the transpiration (or latent heat flux) is in part an outcome of the leaf-level stomatal response, which we feel this was clearly articulated: "*In this paper we therefore explore eddy-covariance measurements to examine whether there is widespread field-based evidence that during heat extremes, trees decouple photosynthesis and g_s, leading to increased transpiration. We chose to* *focus on wooded ecosystems as the capacity to maintain transpiration throughout a heat extreme most likely requires deep soil water access and is in line with previous experimental evidence from trees (Drake et al., 2018; Urban et al., 2017)*".

To further clarify this, we now also add to the above: "*In contrast to previous experimental studies (e.g. Urban et al. 2017), our focus is on the ecosystem-scale and so we analysed the photosynthetic decoupling between photosynthesis and transpiration.*"

Further, I suggest a few points to work on: 1. Is it E or gs which decouples from A during heatwaves?

We agree with the reviewer this is an important point to clarify and we will do so in our revised manuscript. We have changed our sub-heading in the methods 2.1 from "*Evidence of photosynthesis-canopy conductance decoupling*" to "*Evidence of photosynthesis-transpiration decoupling*".

We have also added text to this section to explain our approach: "*A number of previous studies reporting photosynthetic decoupling experimentally, have focused on the coupling between A and* G_s *(Weston and Bauerle, 2007; Ameye et al. 2012; von Caemmerer and Evans, 2015), as opposed to A and E (Drake et al. 2018). At the ecosystem-scale (eddy-covariance), coincident measurements of* G_s *and LE (or transpiration) are rarely available. Whilst it is possible to estimate the canopy* G_s *by inverting the Penman-Monteith using measured LE, such an approach necessitates additional assumptions related to the canopy boundary layer conductance (Jarvis and McNaughton, 1986*; *De Kauwe et al. 2017), the canopy net radiation and the ground heat flux (Medlyn et al. 2017). Here we avoid these assumptions by focusing our analysis on the measured LE flux, as opposed to an estimate of the canopy* G_s."

Both are interlinked but for the modeling purposes, I believe that A/gs (i.e. intrinsic WUE) is more important than A/E (i.e. instantaneous WUE). On the other hand, increase in E while A does not change or decline during the heatwave is the important issue, too.

We agree with the reviewer; however, outside of an experimental setting we do not have access to measurements of g_s. Here we are seeking to examine the evidence at the ecosystem-scale and as such, our focus is on the response of E. We agree, that a decoupling of A/g_s may not translate to A/E at the canopy/ecosystem-scale due to the level of control stomata have on transpiration ("decoupling", Jarvis and McNaughton, 1986) and environmental drivers (net radiation, wind speed, VPD). In our revised methods (see above) and discussion text we explain this point more fully.

The point the reviewer highlights speaks to the novelty of our approach, which considers responses at the ecosystem-scale and attempts to contextualise previous experimental work (e.g. Drake et al. 2018 and Urban et al. 2017).

Many papers were published on E/gs which assumed stomatal regulation to maximize the A for a fixed amount of water transpired over the long time period. This idea was recently challenged (i.e. Wolf et al. 2016, PNAS; Sperry et al. 2017, PCE) and De Kauwe et al. may want to work with this evidence, should they decide to aim their paper this way.

In our revised discussion (4.2 Implications for models), we have addressed the point raised by the reviewer: "*The implications for modelling studies that focus on heat extremes are clear, particularly for studies in Australia. None of the current generation of land surface models have the capacity to decouple transpiration from the down-regulation of photosynthesis with increasing temperature. Instead models assume photosynthesis and g_s (and consequently transpiration) remain coupled at all times. As a result, climate models will underestimate the capacity of the vegetation to dampen heat extremes in simulations for Australia. This is also true of more sophisticated plant hydraulic models (Williams et al. 2001) and profit-maximisation approaches (Wolf et al. 2015; Sperry et al. 2016) that hypothesise the cost of water is not fixed in time, but instead increases with increasing water stress. For these latter approaches to account for a photosynthetic decoupling they would need to prioritise maintaining an optimum canopy temperature above a net carbon gain. However, mechanisms to capture this within models should likely wait for further supporting evidence of photosynthetic decoupling.*"

Furthermore, I do not believe that trees should keep a fixed A/E ratio in a short time (i.e. a few days of a heatwave). That said, imagine the temperature is fixed to a specific value (i.e. 25 oC) and vapor pressure deficit (VPD) increases from near zero to a couple thousand Pa (scenario unlikely to happen in nature but good to demonstrate the change in WUE). Photosynthesis would decline due to stomatal closure as a response to the increase in VPD, but the transpiration would increase.

This is why we also analysed the eddy-covariance data from the perspective of WUE, to attempt to disentangle any decoupling from the response to increasing VPD.

2. Should authors want to focus more on A/gs relationship, I believe the analysis which clearly demonstrates the change in (or lack of) the response should be presented.

As mentioned above, it is not possible to show the A/g_s relationship from eddy-covariance data. To do so would require inverting the Penman-Monteith equation from measured LE flux. Whilst this approach has been used, it requires a series of assumptions related to the canopy aerodynamic conductance, it is far clearer to analysis the measured flux. See added text above.

While I do not challenge the approach of GPPxD^0.5 here, I do not think it is enough illustrative. Many readers, including me, are not familiar with this approach.

We agree that we were not clear enough in our explanation of this approach, a point that the other reviewer also highlighted. In our revised methods, we now explain why we took this approach: "*As temperature increases, vapour pressure deficit (D) also increases, which will drive an increase in LE unless there is stomatal closure, but this effect is unrelated to the decoupling mechanism we seek to find. To disentangle the potentially contributing role of D, we also explored these data based on the theoretical* *expectation (Lloyd et al. 1991; Medlyn et al. 2011; Zhou et al. 2014) that transpiration (E) is approximately proportional to GPP* $\times D^{0.5}$ *(g C* $kPa^{0.5}$ m^{-2} d^{-1}*; Eqn. 7). This expectation is based the idea of optimal stomatal behaviour proposed by Cowan and Farquhar (1977) that stomata should be regulated so as to maximise photosynthetic carbon gain less the cost of transpiration. Medlyn et al. (2011) derived the optimal stomatal behaviour as:*

$$G_s = 1.6\left(1 + \frac{g_1}{\sqrt{D}}\right)\frac{A}{C_a} \tag{1}$$

where G_s *is canopy stomatal conductance to* CO_2 *(mol* m^{-2} s^{-1}*), A is the net assimilation rate (µmol* m^{-2} s^{-1}*),* C_a *is the ambient atmospheric* CO_2 *concentration (µmol* mol^{-1}*), D is the vapour pressure deficit (kPa), the parameter* g_1 *(*$kPa^{0.5}$*) is a fitted parameter representing the sensitivity of the conductance to the assimilation rate and the factor 1.6 is the ratio of diffusivity of water to* CO_2 *in air. Assuming that transpiration is largely controlled by conductance, this relationship can be rearranged to show that water-use efficiency (A/E) is approximately proportional to* $1/\sqrt{D}$*. This dependence has been remarked by many authors (e.g. Lloyd et al. 1991, Katul et al. 2009). Based on this dependence, Zhou et al. (2014, 2015) proposed an "underlying water-use efficiency" (uWUE) for eddy covariance data:*

$$uWUE \approx \frac{GPP\sqrt{D}}{E} \tag{2}$$

Zhou et al. (2014) argued that the $D^{0.5}$ *term provided a better linear relationship between GPP and E. Thus, to probe the effect of D, we focused on heatwaves (i.e. approach 2) and plotted LE expressed as evapotranspiration (mm* day^{-1}*), as a function of* $GPP \times D^{0.5}$*.*"

It would be much better to demonstrate directly how A changes with a change in gs (or canopy conductance, gc). There are approaches to calculate gc from sap flow measurements (which I use). I do not know how reliable are approaches to calculate gc from eddy covariance data but if gc can be somehow derived I would be in favor of using it.

See response above.

3. The timescale of the temperature vs. GPP data. Why did the authors decide to use the maximal daily temperature and compare it to the daily sum of the GPP? Would not it be more appropriate to work with half an hour (or hour) resolution in both temperature and GPP?

The suggested approach is of course a viable analysis framework; however, it would increase the time-resolution (and so the noise in the data) without necessarily adding any additional insight. Our approach analysed multiple heat-extreme events, across multiple site, this would not be possible (or would be harder) if we disaggregated this into diurnal, 4-day events. Here, we are seeking to see the broader patterns at behaviour at the ecosystem-scale.

4. What is the temperature optimum of photosynthesis for the plants in studied ecosystems? The temperature of 37oC for a part of the day may not be high enough to visibly affect the daily GPP. 5.

The temperature optima for leaf and canopy photosynthesis in Eucalypts in southern Australia are well below 30 degrees (see Duursma et al. 2014; Drake et al. 2016; Kumarathunge et al. in review), suggesting that days above 37 degrees should induce a decline in GPP. We also analysed heatwave events (defined as least three consecutive days where the maximum daily temperature exceeded 35°C).

We have addressed this point in our new discussion sub-section (4.1 Why did we not find supporting evidence for ecosystem-scale photosynthetic decoupling?), specifically: "*One could ask whether our analysis considered hot enough temperatures (> 37 °C) to trigger a photosynthetic decoupling mechanism. For example, during an imposed heatwave, Ameye et al. (2012) probed the decoupling mechanism at daily maximum temperatures between 47 and 53°C. Similarly, Zhu et al. (2018) found that most of the 62 species sampled across Australia exhibited maximum critical temperatures near 50°C. However, the temperature optima for leaf and canopy photosynthesis in Eucalypts in southern Australia are well below 30 degrees (see Duursma et al. 2014; Drake et al. 2016; Kumarathunge et al. in review), suggesting that days above 37°C should induce a decline in GPP. Our analysis also* *included events with daily maximum temperatures of greater than 40°C and consecutive heatwave days > 35°C. Therefore, we would argue that insufficiently high temperatures are unlikely to explain why we did not see clear evidence when looking at eddy covariance data.*"

Is there any information available how much trees and understory (grasses) contribute to the LAI and to the GPP?

Across all of these flux sites we analysed, the simple answer is no. We have now added a statement on this issue of leaf area adjustment to our new discussion: "*Finally, although Drake et al. (2018) did not find evidence of increased litterfall during their heatwave experiment, it is of course possible that at our sites, there was some reduction in leaf area in response to high extremes. Any leaf area reduction would in turn reduce transpiration and thus may offset ecosystem-scale estimates of a photosynthetic decoupling."*