Reviewer 1

The authors have identified an emergent relationship between the optimum temperature of photosynthesis and the projected change in atmospheric CO2 between 2100 and 1900, using a combination of global climate-carbon cycle modeling and local eddy-covariance measurements. Results of the analysis show that the larger Topt could further generated a lower △CO2 at the end of the century than the original model predictions. Overall this is a well-written and solid study. The findings are also of broad interest to the community and offer an important constrain on the magnitude of the carbon cycle feedback. I have just a few questions about the data processing procedure and would like to see more discussion about the Topt in the manuscript.

We would like to thank the reviewer for taking the time to read and comment on the manuscript - the added discussion around Topt will definitely strengthen the manuscript.

Please specify the meaning of the red dots in figure 2, which will help readers who have not read Booth et al (2012) to have a clearer understanding of the emergent constrain in your manuscript, at least providing the details of the simulations (red dots) in the appendix.

The red dot in Figure 2 shows the results from Booth et al., i.e., the relationship between different Topt values and the resulting change in CO_2 by the end of the century. We have expanded the caption of the figure to include this description and added the table of Topt vs delta CO_2 adapted from Booth et al (2012) to the appendix.

> "Contours of probability density for the linear regression adapted from Booth et al., 2012. **The red dots show the relationship between different Topt values and the resulting change in CO_2 by the end of the century from the parameter perturbation experiment of Booth et al., (2012) (see appendix for a table of these values).** The thin black dashed-line shows the best-fit linear regression...."

I suggest the authors better explain the concept and calculation of Topt as well as the optimization process. Also, please provide more details about the utilization of the GPP and LE data in the analysis.

We have added the following text to better explain the concept of T_{opt} in our study (L81):

> One of the parameters perturbed in Booth et al., (2012) was T_{opt}, which corresponds to the optimal temperature for non-light limited photosynthesis for broadleaf forests. **In JULES, non-light limited leaf-level photosynthesis is controlled by the carboxlylation rate following the models of Collatz et al. (1991, 1992) with T_{opt} representing the temperature at which the carboxlylation rate reaches a maximum.**

We have also added more on T_{opt} in the discussion (see the following response).

The optimisation is currently described in Section 2.2. We have expanded as follows:

These results are no doubt model and scenario dependent. Nevertheless, this study highlights a new methodology to use should future models show strong emergent relationships between model parameters and future climate change.

3. Data assimilation is a good tool for optimizing parameters from different processes. The nonlinearity of the terrestrial ecosystem models can have few parameters that are interacted and this would result in the joint-distributions of parameters from different processes. While in the data assimilation we seldom considered that or put little focus on the parameter interactions. So how can we properly obtain the relationships between paramters and variables that can be projected to futures? As the authors mentioned soil moisture and other variables. Why do not we use the emergent relationships between optimized variables instead?
Our apologies, it seems that we may not have been clear enough about the nature of the Data Assimilation in this study, which is used to constrain internal model parameters rather than state variables. We will add the following text to clarify this:

"**Unlike the more orthodox application of Data Assimilation (DA) in weather forecasting, the Raoult et al. (2016) study used DA to derive optimum JULES parameters to fit FluxNet observational data, rather than to nudge state variables. The paper shows that the resulting constraint on the optimum temperature for photosynthesis (T_{opt}) in turn provides an emergent constraint on the increase in atmospheric CO_2 by 2100 in a coupled climate-carbon cycle model (Booth e al., 2012). Although this clear link is very likely to be model dependent, we present it here as a first example of how local model calibration and the emergent constraint technique can be used to constrain global climate-carbon cycle projections.**"