Response to referee comment RC1:

We thank the referee for reviewing our work. We place the referee's comments as "C" and provide our response in italic as "R".

C1: Overall, this is a well written manuscript with some interesting insights. Not only the in-situ observations, the authors also use a multi linear regression model in this study. The authors aim to investigate the impacts of ENSO events on an oil palm plantation from the aspects of CO2, water and energy exchange. The manuscript contains a clear and concise title. However, I do feel the information are overloaded in the manuscript in which the readers may find it difficult to explicitly articulate the key points.

> *R1: We will adapt the manuscript with a clearer storyline to ensure better readability and better articulation of the key points.*

C2: The authors also discussed the response of oil palm (NEE) to drought and haze conditions solely on the productivity aspect. It is however not clear about the relative contribution of GPP to the NEE. I find it is a bit misleading – was the ecosystem respiration also affected by drought and haze?

> *R2: In an earlier stage of the data analysis we tested two approaches to partition NEE into respiration and GPP. In the first step we used the method developed by Reichstein et al., 2005 (online flux partitioning tool: http://www.bgc-jena.mpg.de/~MDIwork/eddyproc/index.php) where NEE can be modelled and separated into GPP and respiration. Although modelled and measured NEE showed a relatively high R^2 of 0.82, modelled NEE was on average, 58% lower as compared with measured NEE. The flux partitioning generally fails in other ecosystems as well.*
>
> *We also tested flux partitioning of NEE into GPP and respiration using CLM-Palm (Fan et al., 2015). CLM-Palm was developed for simulating oil palm physiology, such as growth, yield, carbon, water and energy exchange. CLM-Palm is a sub-model within the framework of the Community Land Model (CLM4.5) (Oleson et al., 2013). CLM-Palm has proven capacity to accurately simulate the site-level and regional water fluxes (Meijide et al., 2017; Fan et al. 2019) as well as growth, yield and carbon fluxes (Fan et al., 2015) during non-ENSO periods. In comparison with measured NEE, CLM-model has fairly good performance in pre-drought and post-haze periods but it struggled to represent daily average NEE during the non-haze drought and haze drought periods (see Fig. 1 below). We speculate that the model is oversensitive to extreme meteorological events, such as drought and haze, due to the model's soil water stress function (Sellers et al., 1986) and missing plant hydraulic processes in the overarching CLM4.5 (Oleson et al., 2013). CLM5, which has been released recently, has implemented plant hydraulic functions which allow to simulate the utilization of trunk water storage by oil palm during dry periods but CLM-Palm has not been adapted to the CLM5 framework yet.*

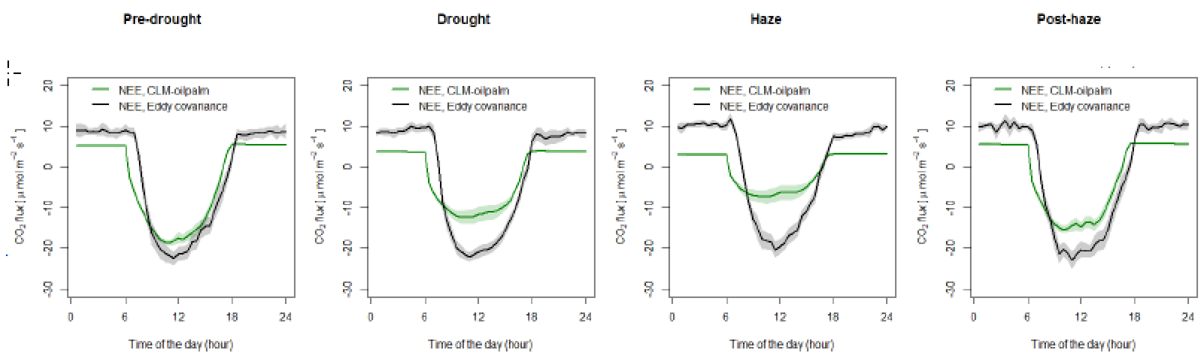

Figure 1. Comparison between diurnal trends of net ecosystem exchange (NEE) from eddy covariance (EC) measurements and CLM4.5-Palm model output during pre-drought, drought, haze and post-haze period. Shaded areas represent 95 % confidence limits.

Therefore, we decided to solely focus on NEE since our main focus in this manuscript lies on the overall CO_2 flux behaviour of the oil palm plantation during the extreme events of drought and haze. We also present night time ecosystem respiration and we were able to disentangle the driving parameters of night time respiration with our multiple linear regression model (MLRM). In the updated version of the manuscript we will add more information on the expected and possible behaviour of day time respiration affected by non-haze drought and haze drought.

- *Reichstein, M., et al. (2005): On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm, global Change Biology 11, 1424-1439.*
- *Meijide, A. et al. (2017): Controls of water and energy fluxes in oil palm plantations: Environmental variables and oil palm age, Agricultural and Forest Meteorology 239, 71-85.*
- *Fan, Y. et al. (2015): A sub-canopy structure for simulating oil palm in the Community Land Model (CLM-Palm): phenology, allocation and yield, Geosci. Model Dev. 8, 3785-3800.*
- *Oleson, K., et al. (2013): Technical Description of version 4.5 of the Community Land Model (CLM), NCAR/TN-503+STR, NCAR Technical Note, National Center for Atmospheric Research, Boulder, Colorado, 434 p.*
- *Fan, Y. et al. (2019): Reconciling canopy interception parameterization and rainfall forcing frequency in the Community Land Model for simulating evapotranspiration of rainforests and oil palm plantations in Indonesia, Journal of Advances in Modeling Earth Systems, 11, 732-751.*
- *Sellers, P. et al. (1986): A simple biosphere model (SiB) for use within general circulation models, J. Atmos. Sci. 43 (6), 505-531.*

C3: There are in fact several publications on the effect of ENSO events on the ecosystem productivity either in oil palm plantation, forest or other ecosystems. However, I did not see the authors discussed or compared their results with that of the published findings.

R3: We will update the manuscript with a discussion on the effect of ENSO events on the ecosystem productivity in other ecosystems such as forests and plantations.

C4: It is also interesting to note that oil palm plantation was a net sink of CO2 during the ENSO year. Please find the specific comments below.

R4: ENSO in 2015 was characterized by a distinct drought period which lasted in our study region from May until October 2015. During the haze drought period, the oil palm plantation was carbon neutral due to the dense smoke and overall reduction in available PAR. After the end of the haze drought period towards the beginning of the wet season we observe a short transition period where carbon uptake is relatively low compared to the rest of the wet season. However, except for the two months of the haze drought period, the oil palm plantations remained a sink of atmospheric CO_2. Our study site is a well-managed commercial oil palm plantation where fertilization and pest control is applied on a frequent basis. Other oil palm plantations, with less developed management practices might have lower ability to adapt to the drought and haze conditions compared to our study site.

C5: Page 2 line 17: The life cycle of oil palm is about 25 years.

R5: We agree with the referee. We will update the paragraph. The life cycle of oil palm is about 25 years (Woittiez et al (2017).

- *Woittiez, L. et al. (2017): Yield gaps in oil palm: A quantitative review of contributing factors, Euop. J. Agronomy 83, 57-77.*

C6: I see NEE is first written on Page 3 line 2 in the manuscript, please define NEE or what does NEE stand for.

R6: We will update the manuscript and define NEE (net ecosystem exchange).

C7: Page 3 line 26: The superscript should be put for -1 (2235 mm yr-1).

R7: We will update the paragraph.

C8: Page 3 line 25-26: I don't understand the use of climatic data from the meteorological station. If it is to show longer term data, then it is probably necessary to compare meteorological data from the site and that of the station even though they are only 29km apart. This is to show that the longer term data is relevant to the site.

R8: We will update the wording. The only station which has such long-term climate data available is Sultan Thaha Airport Jambi. Therefore, in the current version of the manuscript we use this data to show the overall long-term climate characteristics of the region where our meteorological tower is located. Measurements at our tower started in 2013 and we do not find any significant differences in daily average air temperature ($P<0.001$) or in monthly sum of precipitation ($P<0.001$).

C9: Page 3 line 30: The superscript should be put for m2 m-2.

R9: We will update the manuscript.

C10: Page 3 line 30: The LAI was very low for the palm age. Could this be due to the large gaps because of palm leaning?

R10: We will update the manuscript with information on how LAI at the study site was derived. In this study we did not investigate the impact of oil palm leaning on LAI. We use LAI which was estimated by Fan et al. (2015) based on the number of expanded leaves (35-45) per palm. The planting density at the site is 156 palms per ha (8x8 m horizontal density). Sample measurements of LAI (unpublished data), using LAI-2200 Plant Canopy Analyzer (LI-COR Inc. Lincoln, USA) at 12 oil palm plantation plots in the Jambi province in June 2018 show average LAI of 2.7 ±0.57 SD m^{-2}. Oil palm age at the measured plots is ~18 years and horizontal density varies between 8x8 m or 9x9 m. Awal & Wan Ishak (2008) report LAI of 3.05 ±0.119 m^{-2} m^{-2} and 4.05 ±0.343 m^{-2} m^{-2} for two oil palm locations with 16 years old palms and a density of 148 palms per ha. Breure (2010) reports mean LAI of 5.97-5.51 m^{-2} m^{-2} for three 8 years old plantations with 135 palms per ha.

- *Fan, Y. et al. (2015): A sub-canopy structure for simulating oil palm in the Community Land Model (CLM-Palm): phenology, allocation and yield, Geosci. Model Dev. 8, 3785-3800.*
- *Awal, M.A. & Wan Ishak, W.I. (2008): Measurement of oil palm LAI by manual and LAI-2000 method, Asian Journal of Scientific Research 1 (1), 49-59.*
- *Breure, C.J. (2010): Rate of leaf expansion: A criterion for identifying oil palm (Elaeis guineensis Jacq.) types suitable for planting at high densities, NJAS – Wageningen Journal of Life Sciences 57, 141-147.*

C11: Page 4 line 13: The superscript should be put for...m s-1.

R11: We will update the manuscript.

C12: Page 8 line 6-9: The monthly oil palm yield does not make sense as the values are extremely high. Annual fresh fruit bunch yield can rarely achieve more than 40 t/ha on average.

R12: We agree with the referee. We reanalysed our harvest data and found an error in the calculation of monthly yield. We apologize for the error. The wording of the paragraph will be changed with the correct monthly harvest: "From August 2015, monthly oil palm yield declined continuously from 3.93 t ha^{-1} to its minimum of 1.05 t ha^{-1} in May 2016. Compared to the same period (Nov.-May) in the two years before and the year after the ENSO event, average yield affected by 2015-drought and haze was 32% (0.70 t ha^{-1}) lower. Considering the 2015-haze drought only, average oil palm yield 6-9 months after the beginning of the haze drought was even 50% (1.1 t ha^{-1}) lower compared to the non-ENSO years."

C13: Page 9 line 16: The word 'NDH+ should be 'NHD+

R13: We will update the manuscript.