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Interactive comment on "Unravelling the physical and physiological basis for the solar-induced chlorophyll fluorescence and photosynthesis relationship" *by* Peiqi Yang et al.

Anonymous Referee #1

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Review of "Unravelling the physical and physiological basis for the.." by P. Yang et al.

In this study Peiqi Yang and co-authors analyze observations from corn field during one growing season, where chlorophyll fluorescence (ChlF) has been measured both actively (MONIPAM) and passively (SIF) and relate the timeseries of these variables to gross primary production (GPP) measured from a flux tower. As the title says, they aim to study the relationship between GPP and the ChlF, a very important topic for a wider research community that now is using the novel SIF observations to estimate GPP. I find this manuscript very suitable for this journal and of interest to many.

The authors find out, that the correlation between GPP and SIF is small, once the

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effect of absorbed PAR in canopy has been removed from the relationship. At the leaf level they found that the role of thermal dissipation was important factor influencing the relationship between fluorescence and photosynthesis yields. Also, they show the different functionalities of sunlit vs. shaded leaves in these respects and bring up the need to take them into account in the modelling efforts.

Major comments

I find the manuscript well-written and the figures clear. At times the text was a bit unspecific and challenging to understand (most of my comments are requirements for clarifications) and in the Discussion it was at times difficult to know, whether it was the leaf-level or canopy-level results being discussed. I'm sure the authors can overcome these issues with a bit more work on the text.

Of the things that were not discussed, I had few issues coming to my mind, that the authors might want address in the revised version. The title is very general, but the only plant being studied is corn, that is a C4 plant and might have a more linear relationship between SIF and GPP than C3 plants. Is this something worth mentioning somewhere and the possible differences related to C3 plants?

In the discussion of light environment, it is not mentioned that the tree canopies etc will have a more complex radiative transfer. Is the sunlit-shaded -separation something that is being recommended for crop canopies or is that something you consider sufficient also for more complex canopy structures?

You mention, that the correlation between photosynthetic and fluorescence yields estimated from canopy level had no correlation between the variables in the leaf level. The passive and active measurements anyhow differ in the very basics, i.e. in the passive you use just one wavelength, while MONIPAM gives you a spectrally integrated signal. Maybe you could also mention this?

Minor comments

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l. 20: You mention, that the link between GPP and SIF is much weaker after taking into account iPAR and fAPAR. The correlation is below 0.30, so it is maybe even negligible. Maybe you could write this number here (because now it sounds, like there would still be definitely a functional link).

l. 20-22: Actually the positive correlation was present for sunlit leaves in well-illuminated conditions, whereas it was negative in the low-light conditions, was it? Maybe you could add that here.

l. 32: Eddy covariance measures the net flux, not GPP. This is not now obvious from the text.

l. 83: Sorry, what is 'fluorescence quenching'? And what maximum level are you referring to here? Maybe this sentence could be rephrased.

l. 116: Should it be 'carbon fluxes' instead of 'crop fluxes'?

l. 138: Not exactly clear, how the interpolation goes above the maximum observed value.

l. 144: Sometimes 'MoniPAM', few times 'MONIPAM'. The writing could be uniform throughout the text.

l. 161, section 2.4: Later you use PRI also, but you don't introduce its calculation.

l. 215: Maybe you could show the equation for photosynthetic LUE here. It is not necessarily clear to which variable you're referring to here, so that would help. This is unclear, because in line 223 you say you calculate variables using only leaf temperature and radiation intensity as input, but here you say that this variable is dependent on many different input variables.

l. 224: Would you have a reference for the crops Vcmo value? Which temperature response are you using for it?

Section 3.1. Are there changes in the LAI values during the growing season and is

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there an increase in the senescent material in the field of view during the last development stage? The seasonal cycle of the observations is not shown. Therefore it is a bit difficult to judge, from which time period certain points in the e.g. Fig. 1 are.

Fig. 3: I miss having ticks in this figure. Especially, as the subplots don't have numbers. Adding ticks would help readability.

l. 278: "an order of magnitude improvement of 13%" - just wondering, if a higher correlation between SIF and GPP is necessarily 'an improvement', I'd tend to think it is just a higher correlation. Also, is increase of 13% 'an order of magnitude' size?

Fig. 4: A suggestion for this figure would be to make the panels bigger and include both sunlit and shaded in the same figure, shaded e.g. in dashed line. This would make comparison between the two easier (if it doesn't get far too busy plot).

l. 298: Is this midday dip of FiiN more occurring only in the sunlit leaves? Overall, when discussing Fig. 4 you don't mention differences between sunlit and shaded leaves. If they are similar in their dynamics, that's also maybe worth noting. There anyhow seems to be differences, that might be interesting, e.g. FiiPshade maybe goes lower fast during senescence, FiiFshade has lower values than FiiFsunlit, even though other components are perhaps on pretty similar levels.

l. 305-306: Maybe you can share some numbers about nighttime FiiF, as I find it difficult to see 'clear' decrease in these values. Is your sentence referring to this picture or the whole timeseries? For the sunlit leaves, it seems that during the young and mature stages there are nights with some higher values, but the overall level (at least as far as I can try to read the figure) is not that different. I'm not arguing your claim, but maybe you can back that up a bit.

l. 313: So, is the Fig. 5 for the sunlit or shaded leaves?

l. 314: 'evident. . . increased through the growing season': to me this sentence sounds that there is increase between all young – mature – senescence -stages. For the

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nighttime, yes, there is a definite change during senescence compared to other stages. But the daytime values during senescence don't then seen lower, and then if there is a change in daytime values between young and mature stages is not so clear, as there is daily variation. For the Fig. 5 you chose 'representative' day for the pie chart. Could you tell on what conditions you chose this day? Did it have certain meteorological conditions or was it just similar as most other days?

I find it a bit annoying that you show days 193-197 in Fig. 4 and 192-196 in Fig. 5. It doesn't help in comparison. Was there a special reason you chose to show differing time periods?

l. 325-327: Are these numbers for the contributions correct? Based on numbers on the pie chart, I'd say different (but as mentioned below, I cannot read them clearly).

l. 341: Sorry, what does your 'seasonally averaged' means?

l. 345: A bit confusing, that you are here referring to subplots 6a and b, but the values are from the averaged plot 6c (and your point also).

l. 349: Should this be 6a (for FiiP and FiiF relationship)?

l. 350: You write in response to incoming light, but the color code here is for FiiN? If you want to emphasize 'to incoming light', maybe you can say something about that how it is related to this.

l. 351-353: Actually the arrow for the shaded leaves doesn't necessarily show the response to sustained heat dissipation so well, as the highest FiiD levels are not on the lowest levels (Fig. 7b). Also, yes, the responses between sunlit and shaded seem pretty similar, but just by looking, maybe the slopes (FiiP vs FiiN) in sunlit leaves change between the colored groups and not so in shaded leaves.

l. 363: Do you get the value 65% from the Fig. 7c? If so, you could clearly state which value you are referring to. (These larger variations in FiiP are also more present in lower FiiN values, logically. . .)

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l. 376: Sorry, not clear what you mean by ‘these trends’. The mentioned values were from half-hourly values and you mean that similar behavior is visible in seasonal and diurnal values?

l. 391: So, did you exclude measurement points from drought conditions from the dataset? Based on what conditions was that made? Or was the plot irrigated to start with, and you didn’t have to worry about drought?

l. 394: So, did you find any ways that you could parameterize sustained heat dissipation, so that you could model it during the growing season?

l. 454: Your point here is that heat dissipation is more directly connected to photosynthetic lue than fluorescence emission to what.. heat dissipation? This sentence is a bit unclear, please rephrase. Are you here referring to Fig. 7a or 7b, are you talking about leaf or canopy level? Earlier you mentioned that give some doubt to PRI and show its correlations with a question mark. So this would be more about leaf level?

l. 456: ‘photosynthetic energy’, what do you actually mean by this? Is this the absorbed light energy in the photosynthetically active region?

l. 456: So are you now only referring to the study be Heber et al, or what did you see in your diurnal results? Or is the diurnal scale visible in 6c (but the relationship is not positive for shaded leaves)? To my understanding the review by Heber concentrates on mosses and lichens, quite different plants than corn. Maybe you could better clarify what is the meaning for you of this reference and how it related to your results?

l. 482: Sorry, what is the LUE-GPP relationship mentioned here?

l. 502: Often, when a model separates the canopy into sunlit and shaded fractions, it is called a two-leaf model (such a BEPS, e.g. Qiu et al 2019). Not ‘two-big-leaf’, even though to my understanding the idea is pretty much the same as you’re here proposing.

l. 504: Sorry, is the a word missing in this sentence? Was shown what?

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l. 502-509: In this paragraph you talk about LUE models and then mention SCOPE as an example of a more detailed model, but there are also large scale models of with varying degree of complexity (e.g. Parazoo et al, 2020), located between SCOPE and LUE models. Just mentioning, since now this paragraph offers maybe a quite narrow view.

l. 521: You mean that they (sunlit FiiF and FiiP) are more tightly connected than the FiiFshaded and FiiPshaded?

l. 560: So, you mean that the physiological traits of shade/light -adapted leaves would be good to be taken into account in SCOPE and other such models? It is not that clear how the above examination about the sunlit fraction depending on LAI and zenith angles really ties with the discussion. Could you maybe tie that better to the context?

Technical/typos

l. 68: 'improved the correlation', the correlation of SIF?

Table 1: Also add here how you measure the PRI.

Fig. 1: The a) and b) seem to be flipped.

l. 279: Why do you talk about 'mid-morning'? Your morning seems to end at midday, not to 'late morning'. . .

Fig. 4: Maybe change some y-axis labels for the right side for better readability?

Fig. 5: At least in my version the numbers in the pie charts are challenging to read. Could you improve the figure in that respect?

Fig. 6: Would you like to add a legend box? At first, the dot belonging to the legend might seem to be in the plot. Please, add ticks to subplots a and b.

l. 348: 'linear relationship'?

l. 355: Is 'expressed' the best word to use in this context?

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Fig. 8c : The plotted symbols are below the subpanel name.

Fig. 10 caption: Do you mean in the second last sentence, that the values of FiiN-canopy are unknown or what?

Fig 10: Show the values with the same number of decimals, even if 0.1 is 0.10.

Fig. 11. In my copy it is not easy to differentiate the lines with zenith angle 30 and 0. At least in subpanel c) the legend also looks suspicious. If you want to have a w/b -figure here, could you maybe differentiate the lines with different widths or styles?

l. 444: So, are these now leaf level values?

References:

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