

## ***Interactive comment on “A double peak in the seasonality of California’s photosynthesis as observed from space” by Alexander J. Turner et al.***

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The manuscript by Turner et al. presents a study of the potential of sun-induced fluorescence (SIF) derived from the S5P/TROPOMI mission to track spatial and temporal variations of photosynthesis within California’s ecosystems. The authors first downscale the original TROPOMI SIF retrievals from  $\sim 3.5 \times 7 \text{ km}^2$  to 500 m and then compare the resulting signal with gross primary production (GPP) estimates derived at flux towers as well as with MODIS vegetation indices for the entire California area. They find that the seasonality of SIF at the state level shows a double peak which is not found in equivalent time series from MODIS indices.

In my opinion this is an interesting study with some potentially important messages.

C1

First, it presents a simple methodology to downscale the new SIF data from TROPOMI to MODIS like spatial sampling, which I can imagine it will be reproduced by many others in the future; second, it takes advantage of this novel data set to show that the spatio-temporal variability of photosynthesis in California is driven by that of two groups of biomes for which photosynthesis peaks in different times of the year. This finding is used to illustrate the superior sensitivity of SIF to actual photosynthetic processes than reflectance-based indices, which are good proxies of photosynthetic potential.

The manuscript is very well written and presented, methods and data are innovative and the results are interesting, so I recommend it for publication in Biogeosciences. Before that, however, I would appreciate if the authors could address the following two points in their revision of the manuscript:

1. Double peak, PAR and/or physiology? The authors acknowledge that the different seasonality in SIF and vegetation indices may be due to a clear-sky bias in the vegetation indices, but also claim that “SIF can detect the downregulation of photosynthesis even when plants appear green”, which seems to hint that it is not only the reaction to solar irradiance which makes SIF to show the double-peaked seasonality. To substantiate this claim, it would be interesting to see a plot of  $\text{NIR}_v \times \text{PAR}_{\text{ground}}$  (with  $\text{PAR}_{\text{ground}}$  the at-surface PAR for all-sky conditions), and evaluate to what extent its seasonality resembles that of SIF. The difference between SIF and  $\text{NIR}_v \times \text{PAR}$  could be attributed to physiological effects captured by SIF.

2. GPP scaling - The authors scale SIF to GPP as  $\text{GPP}^* = 18.5 \times \text{SIF}$ . However, I think we know better. There have been a number of papers in the last years showing that factors such as a canopy structure, photosynthetic pathway or observation geometry affect the SIF-GPP relationship making the use of a global scaling factor to be questionable. On the other hand, this study is based on the analysis of time series and no quantification of GPP is performed, so I don’t see why the authors need to scale SIF to GPP values. I would therefore recommend the authors to simply use SIF rather than both SIF and  $\text{GPP}^*$  in the analysis (Figs. 6 to 8).

C2

Other comments:

- p1, L3 “oversampling and downscaling” → simply “downscaling” would probably be more clear for most of the readers.
- p2, L3 “more direct methods” than what methods?
- p2, L24 Several SIF downscaling methods have been published in the last years which are actually not based on machine learning nor intended to produce spatially-continuous SIF data sets from OCO-2 SIF retrievals. In particular, the method by Duveiller et al. to downscale GOME-2 SIF to 0.05° (last implementation here <https://www.earth-syst-sci-data-discuss.net/essd-2019-121/>) could also be adapted to TROPOMI. Please, discuss pros and cons of the oversampling/downscaling method presented in this manuscript with respect to that by Duveiller et al. and any other comparable downscaling method.
- p4, L10 “near-infrared and shortwave infrared”.
- p4, L19 “The TROPOMI SIF retrieval uses...” I don’t think the average reader will understand this sentence without any further introduction to PCA-based SIF retrievals.
- p4, L 25 I can’t find any information on cloud filtering, so I assume that the authors are simply not applying any. Please, discuss this here, e.g. whether no cloud filtering could/should applied globally when using SIF as a proxy for GPP (which would be somewhat scary...).
- Fig 8. Panel C?

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