Biogeosciences Discussions

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Reply on RC2

Mark Pickering et al.

Author comment on "Sun-induced fluorescence as a proxy for primary productivity across vegetation types and climates" by Mark Pickering et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-354-AC4, 2022

- *Other comments*
  Abstract: I would shorten the description of the implemented methodology and would add 2-3 lines summarizing the main results

We agree that it could be made more concise and will rewrite the text for the next version (including removing reference to 'environmental stress' here, as discussed in other comments).

- *L64, 2nd equation (I miss equation numbers): please, state that this equation applies to instantaneous GPP and SIF, but a temporal sampling factor should be applied to account for the different temporal sampling in GPP and SIF (daily & all-sky for GPP, instantaneous & clear-sky for SIF). Related to this, one could wonder to what extent some of the features under analysis (SIF:GPP slopes, IAV, response to environmental factors) are not driven by this temporal sampling mismatch (see https://www.sciencedirect.com/science/article/pii/S0168192321001222).*

1) Thank you, I will add 'instantaneous' to line 64:
'Rearranging the equations for instantaneous SIF and GPP fluxes:',

2) It is possible to add a temporal sampling factor (e.g. e_{samp}) to the equation, but as the discussion is somewhat theoretical at this point, it is assumed the SIF and GPP are occurring simultaneously and therefore it is not required

3) Throughout the manuscript we are referring to daily averaged SIF and GPP values (see our response to Reveiwer 1's comments on this theme also, this will be made clearer in the revised text). Therefore, and feel free to correct, shouldn't this principally result in an extra uncertainty in the measurement of the features, rather than being a driver of the features? We agree that there is going to be a significant clear sky bias however in these (and most) SIF studies however, and this may also explain some of the divergence seen in the tropics though.
We agree that the recommended paper shows the value in correcting for all-sky conditions in the future studies and will discuss further in the next manuscript.

4) We will add equation numbers

- *L76 "FLEX, scheduled for launch in 2023" – I think it will be at least 2025*

https://www.esa.int/Applications/Observing_the_Earth/FutureEO/FLEX

We agree with this comment, and will update it in the revision.

- *L258 "Downscaled FLUXCOM SIF" □ "Downscaled GOME-2 SIF"*

Thank you for spotting this typo

- *Sec. 4.4 and Fig. 6: I think the "No climate zone" case (only vegetation types, without segmentation by climate zone) should be added, as this would represent the usual "PFT-based" scaling of other studies. It could include a test of how the SIF-based GPP differs if only the two clusters proposed by Turner et al. are used (see major comment above).*

Currently we provide the 'no climate zone' linear relationship parameters in figure 5 (these are the values on the left side - but these are for the vegetation types). However we can also apply these to Fig. 6 in order to add an 'each vegetation category'. As you say, this would be useful for comparison with other papers, as well as comparing for comparing with our suggestion of 2-3 categories within a climate zone.
We add the figure to the next version as well as text on the additional panel and a short description . Note - we find that removing the climate zone grouping results in less agreement between the FLUXCOM GPP and the GPP estimated from the SIFDS-GPPFX vegetation relationships. The agreement is better than the case where only the climate zones are considered (and not the vegetation cover), suggesting that vegetation cover is more important than these broad koppen geiger climate groupings, but there is still a noticeable decline in agreement (compared to a full PFT-KG breakdown or the breakdown suggested by the ANCOVA analysis).

We propose adding the following line that discusses this to the text:
L409 When only the vegetation covers are considered, and no climate grouping is proposed, there is less difference between the estimated GPP and the FLUXCOM GPP than in the case of the climate groupings alone, suggesting that differences between vegetation covers are more important in determining the SIF-GPP relationship than the climate zone grouping. However there are still noticeable differences compared to the relationships that include a breakdown by climate grouping, as can be seen in the width of the inset histograms.

- *Fig. 6, funny red line in the leftmost vertical label of the bottom left panel*

Thank you for noticing this. We will adjust the future revision

- *L453 (and elsewhere): "Strong correlation is noticeable in the SIFDS response to meteorological fluctuations, as can be seen clearly in equatorial rainforests". - I think the rainforest case should be handled with caution, as a large fraction of the observed trends could just be due to signal issues and retrieval artifacts*

This response also incorporates similar comments from Reviewer 1, and so it is worth seeing this comment also.

We agree that equatorial rainforests are a special case. The main aim of the comment was to give an example of where there is co-dependence in the meteorological variables, however it is a complex example, and the wording was confusing. We will instead substitute this line with:
'Codependence between the atmospheric variables means that it is difficult to directly explain fluctuations in SIF via individual meteorological variables in isolation, for example, the correlation between warmer temperatures and high VPD, results in a similar SIFDS response…'

- *Sec 4.5: the authors refer to this part of the analysis as an assessment of the response of SIF to "environmental stress". However, I am unsure that the tiny signal of stress (subtle changes in LUE or photosynthetic pigments) can be captured by a downscale SIF product with a monthly sampling. Also, the acquisition time of the SIF data (morning for GOME-2, it would be midday for TROPOMI) will also play a role of their ability to indicate stress. I would recommend the authors to discuss these issues in the text.*

We agree, and get the general impression though that we are perhaps over-stating the results with the use of the words 'measure of environmental stress' and 'measure of resilience' and should perhaps tone down the language a little. The aim is simply to convey that SIF may be useful as an indicator of plant growth in response to fluctuations in meteorological drivers and that lack of growth might indicate environmental stress. The results show that downscaled SIF responds to meteorological fluctuations in a similar manner to FLUXCOMGPP (which is dependent on the meteo-variables, whilst SIF is independently observed). Therefore we believe the results to be valuable.

Resilience is likely also the wrong word to use, and therefore we will remove reference to it and replace 'environmental stress' with less strong terms. I note the following changes for the updated version:

L20 With the demonstration of downscaled SIF as a proxy for GPP, the response of SIFDS to short-term fluctuations in several meteorological variables is analysed, and the utility of SIFDS as a measure of environmental stress explored.
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With the demonstration of downscaled SIF as a proxy for GPP, the response of SIFDS to short-term fluctuations in several meteorological variables is analysed and the most significant short-term environmental driving and limiting meteorological variables determined.

L27 and demonstrates the utility of SIF as a measure of environmental stress.
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and explores the similarity of the SIF and GPP responses to meteorological fluctuations.

L94 If downscaled sun-induced fluorescence is to be used as a proxy for ecosystem productivity or as a measure of environmental stress, it is important to understand the spatial and temporal relationships
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Removed 'or as a measure of environmental stress,'

L106 the paper investigates the potential of downscaled SIF as a global measure of environmental stress to fluctuations in several meteorological factors,
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the paper investigates the response of downscaled SIF to fluctuations in several meteorological factors,

L270 In order to explore the potential capabilities of SIF as an early indicator of stress across different type of vegetation type, the response of downscaled SIF to anomalies in a number of meteorological variables is analysed.
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The response of length-of-day corrected downscaled SIF to anomalies in a number of meteorological variables is analysed.

L469 In this context the study suggests that it is possible to use high-resolution SIF as a near-real time measure of the resilience of ecosystems to climate fluctuations

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In this context the study suggests that it may be possible to use high-resolution SIF as a near-real time measure of the response of vegetation productivity to climate fluctuations

L468 In this context the study suggests that it is possible to use high-resolution SIF as a near-real time measure of the resilience of ecosystems to climate fluctuations.
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L468 In this context the study suggests that it is possible to use high-resolution SIF as a near-real time measure of vegetation change in response to climate fluctuations, as well as demonstrating where vegetation may be resistant to certain fluctuations.

L490 This suggests the possibility of using SIF in the near-real-time monitoring of vegetation stress in reaction to environmental conditions
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This suggests the possibility of using SIF in the near-real-time monitoring of vegetation reaction to environmental conditions

L580 Proving this technique at a global scale provides evidence for the use of high-resolution SIF in monitoring the resilience of local ecosystems to environmental fluctuations, an area of growing importance as extreme weather events become more frequent and more severe
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Proving this technique at a global scale demonstrates that high-resolution SIF responds to meteorological fluctuations in a similar way to FLUXCOM GPP. As such it has potential as a near real-time indicator of vegetation status that, unlike FLUXCOM GPP, is independent of meteorological variables.

Note, some comments also relate to Reveiwer 1's comments on the wording overstating the results somewhat, so please see the responses to these comments. On the point about the acquisition time, noting other reviewer comments, we will explicitly and clearly state that the SIF is length-of-day corrected in the next version .