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Interactive comment on "Investigating the usefulness of satellite derived fluorescence data in inferring gross primary productivity within the carbon cycle data assimilation system" *by* E. N. Koffi et al.

Anonymous Referee #4

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The present study attempts to evaluate the usefulness of space-borne measurements of solar-induced fluorescence (SIF) data in constraining GPP within a Carbon Cycle Data Assimilation System (CCDAS). The recent available satellite SIF data has provided a new perspective on monitoring broad-scale vegetation photosynthesis as chlorophyll fluorescence is central to photosynthesis. In the current study, the authors used CCDAS as an additional tool to investigate the potential of SIF as a complementary to some recent work. The results are quite meaningful. However, there are some major issues which are needed to be addressed.

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General comments

In this study, they found that fluorescence is not sensitive to the key parameter (Vcmax) of a coupled photosynthesis-fluorescence model, which directly contradicts with a recent work by Zhang et al. (2014) as they stated in their conclusion. They also found that fluorescence is more sensitive to chlorophyll concentration (Cab) but GPP not. These findings also contradict with the results from FLEX/Sentinel-3 Tandem Mission Photosynthesis Study – FINAL REPORT (Mohammed et al., 2014) in which they showed that fluorescence is more sensitive to Vcmax than Cab both for C3 and C4 plants. The reason for such a difference between the current study and Zhang et al. (2014), in my opinion, is due to the following:

(1) Under light saturation conditions (high light illuminations), plants photosynthesis is limited by Rubsico maximum carboxylation rate (Vcmax) in the Faquahar et al. model, and hence for fluorescence in the model. In the Figure 2a of their study, the authors show the sensitivity of SIF to Vcmax at an incoming radiation level of 500 W/m2 (Rin). In the study of Zhang et al. (2014), they focused the analysis during the growing season at crop sites. The Rin in these crop sites (e.g., Mead sites) can be more than 900 W/m2 (generally larger than 700) around noon during July and August. Hence, the radiation level in the current study may be too low as they stated in their manuscript in P726, Line 3-4. This level of radiation may be still in light-limited conditions for plants. In the study of Zhang et al. (2014), they also pointed out that the sensitivity of SIF to Vcmax is not high during the early or late growing season.

This is the most important factor why the simulated Fs is not sensitive to Vcmax. As stated in the study of van der Tol, et al., (2015), ' When light is in excess or stress develops there is a reduction in the fluorescence yield and the slope of the dependence of SIF on light intensity declines. This is the basis for inversions to obtain Vcmo [Zhang et al., 2014]. With increasing stress or reductions in Vcmax at constant light (as would occur with repeated sun synchronous satellite observations), SIF would be observed to decrease. The extent of this decrease may depend on the severity and type of stress.'.

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(2) The study of Zhang et al. (2014) focused on the cropland, especially for C4 crop (corn). The authors need to mention this when making the comparisons.

(3) The current study used monthly observed climate data including incident radiation to drive SCOPE which gave smaller radiation values as they mentioned. While Zhang et al. (2014) used field instantaneous meteorological and other measurements (e.g., LAI etc) which represent more actual conditions. As they stated in P731 Line 1-3, if they optimally chose temperature and LAI, they could reproduced a sensitivity about 2/3 that shown in Zhang et al. (2014). This means that the data set they used to drive SCOPE has given some uncertainties for the sensitivity analysis. This raised the concern whether they can used mean monthly observed data for SCOPE since it need instantaneous driver especially for radiation. This should be discussed carefully.

In summary, the authors need specify and mention the different conditions when they compare with other studies.

The Abstract is not clear at the current stage. They should clearly state their main findings.

Their Fig.3a is similar to the Figure 12 (lower left) in the study of van der Tol, et al., (2015), but with lower sensitivity of Fs to Vcmax. This needs to be discussed and explained.

For the diurnal simulations, they could use other FluxNet sites to make the comparison with the SIF and GPP measurements. This would make the diurnal simulations more meaningful.

LAI is a more important parameter for both SIF and GPP simulations. In the sensitivity analysis in 3.1, why don't they provide the sensitivity analysis for LAI?

Specific & minor points (reference is made to page P and line L numbers):

P708 L7-8: Need specify the result is for low-light conditions within the CCDAS.

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P708 L14: The natural terrestrial carbon flux

P708 L14: This sentence is not clear.

P709 L17: 'their estimates' means what?

P709 L18: '. . . larger GPP in the tropics .." compare to what?

P709 L21: '. . . plant fluorescence (hereafter Fs) . . .' . Please consider ' sun-induced fluorescence (SIF)' and revise through the manuscript.

P709 L24-25: ' They showed . . . GPP at the global scale'.

P710 L3-4: Not really well understood, especially with the stead state fluorescence. Need reference here.

P715 L14-15: Not summation of fluorescence yield Φft, but florescence flux.

P716 L2: should be ' canopy radiative transfer'?

P717 L21-24: SCOPE need instantaneous driver, especially for radiation input, are the mean monthly observed climate data OK for the simulations?

P719: Are the sensitivity running of SCOPE at hourly step?

P720 L19-21: I would say, C4 vegetation is more sensitive.

P720-721: Need point out the sensitivity analysis is under light-limited conditions. P721 L25-28: This contradicts with well-known and many published studies. Need specify why.

P723 L10-11: In my opinion, Vcmax impacts the values of SIF and GPP, but not their relationship.

P724 L4-6: Should include negative retrievals of SIF.

P726 L3-4: How smaller is the Rin in the CCDAS than actual values? The radiation level determined the relationship between SIF and GPP, and their sensitivity to Vcmax.

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P729 L16-18: should be ' . . . is unlikely to work within the CCDAS'.

P730 L18-19: You need mention that the work of Zhang et al. (2014) was at light saturation state for cropland.

P730 L19-20: How the 4 times differences come from? In their work of Zhang et al. (2014), they showed different sensitivity of SIF to Vcmax for different period of the growing season for the cropland. If you compared the sensitivity of SIF to Vcmax for the early growing season (e.g., early June) with that in the middle of growing season (e.g., July), there are also differences especially for C3 crop. Please also check the general comments.

P731 L1-3: This is good point. Need discuss more.

P732 L8-9: Need mention the illumination condition (light limited or light saturated).

Interactive comment on Biogeosciences Discuss., 12, 707, 2015.