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Biogeosciences Discussions

Interactive comment on "First observations of global and seasonal terrestrial chlorophyll fluorescence from space" *by* J. Joiner et al.

Anonymous Referee #1

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The manuscript presents a significant contribution towards a regional and global characterization of actual plant photosynthetic rates. Results of such observational approaches are essential to better understand and to improve the quantification of interactions between the biosphere and the atmosphere (e.g. carbon cycle). The authors use an existing satellite based observation system (GOSAT) and suggest a novel approach to retrieve sun-induced chlorophyll fluorescence (Fs). In result, the authors provide a first global map of Fs and compare the results to traditional Earth observation (EO) products. Although the results are preliminary, the work provides interesting insight into differences between potential and actual photosynthetic rates of plant ecosystems.

The authors exploit the potassium (K) I Fraunhofer line near 770nm to retrieve Fs.

This approach seems to bypass (or at least to minimize) the impact of the atmosphere on the Fs retrieval, a problem of commonly used approaches exploiting atmospheric absorption bands (e.g. O2-A). The main criticisms I have belongs to a) the simplistic radiative transfer formulation (Eq. 1) and b) the limited discussion of the retrieval accuracy.

a) Equation 1 formulates the top-of-canopy radiance. The investigated signal, however, was measured with a space-borne sensor. Even though the atmospheric impact in terms of absorption is minor and the spectral dependency of scattering is constant for the investigated spectral range, both terms should be included in this equation (and the following ones).

b) Remotely measured Fs is a complex signal and reflects i) the physiological response of the plant, ii) the amount of green biomass in the sensors field of view (FOV), iii) the amount of absorbed photosynthetic active radiation (APAR), and iv) effects related to the retrieval and the measurement itself. The calculation of FSyield (it's your "scaled FS") compensates for variations of APAR (for the "scaled FS", there must be a stronger link between EVI and FS due to the remaining structural relationship). Remaining variations of FSyield can be attributed to i, ii and iv. Assuming that the EVI reflects the structural component (or the potential photosynthesis) (ii), then, I agree with your statement (page 8296, line 10-19) that a 1:1 relationship shouldn't be necessarily exist. So, the obvious scattering in your graphs (Fig. 13-15) can be partly! attributed to the existing difference between potential and actual photosynthesis.

But, the observed scattering is also caused by uncertainties of the retrieval itself!! The evaluation of the methods reliability and the retrieval precision requires a proper discussion of this aspect. Such a discussion might be important as well to continue the development of this promising approach!

The text already includes several short statements about the potential impact of assumptions made for retrieving Fs. So, please summarize all these aspects and discuss your results again considering the different aspects potentially causing variations in your retrieved Fs signals:

- difference between potential and actual photosynthetic rates (as already done)

- the variability of the K I line filling-in in dependency on surface albedo

- variable measurements per grid box (ranging from 1-39)

- the low contrast between emitted and reflected radiation and the (comparatively low) instrument SNR of 300

- effects of atmospheric scattering: scattering is constant over the investigated spectral range. Due to the different signal level, however, scattering leads to a proportional different filling-in of the line and, consequently, to an offset in the retrieved Fs signal. This effect should have implications on the spatio-temporal variability of Fs...

The calculation of the FSyield (your "scaled fluorescence") seems difficult. Can you suggest some strategies to provide more reasonable fAPAR values in the near future?

Please discuss strategies for a validation of the results (e.g. a comparison of the MODIS GPP product and FS (not FSyield!!) or the evaluation of seasonal signals using tall eddy-covariance towers).

A couple of small comments:

- page 8284, line 3-13: Please include a short argumentation related to approaches linking space-borne PRI observations and LUE (e.g. Drolet, RSE 98, pp 212-224 or Hilker, RSE, 114, pp 2863-2874)

- Page 8284 – line 16: Please, rephrase "reflectance effect" to e.g. "reflectance signal"

- page 8285, first sentences: Please, rephrase to "In air- and space-borne applications, one must additionally account for atmospheric absorption and scattering..."

- page 8285, line 4: Measured radiance signals of non-fluorescent surfaces of the

same image can be used and to separate Fs from R and to account for path scattered radiance. This approach does not allow the correction of FS re-absorption due to atmospheric transmissivity. You should not "say atmospheric correction" in this context. Please rephrase to "a measurement of a non-fluorescensing surface can be used to separate both the emitted and reflected radiation fluxes"

- page 8287, line 24: You could refer Guanter et al. 2010. They investigated the dependency of the O2 line depth and surface pressure.

- page 8288, line 26: You already introduced F as abbreviation for fluorescence, please remove either the abbreviation of the written word.

- page 8289, line 11: Please, rephrase to "We could also account for atmospheric scattering..."

- page 8289, line 11-12: Please indicate the used radiative transfer model and how the model was used to account for atmospheric interaction.

- page 8289, line 11-12: You state that the spectral dependence of atmospheric scattering is constant over the investigated spectral range. But, scattering leads to a proportionally different filling-in of the line and, consequently, to an offset in the retrieved Fs signal. Could you provide a short statement about the impact of atmospheric scattering on the in-filling? For my understanding, this should have implications on the spatio-temporal variability of Fs as the aerosol load may change significantly over time and between different parts of the Earth.

- page 8292, line 10, 11: You introduced F as abbreviation for fluorescence, please replace Ff with F.

- page 8293, line 10: Please, rephrase to "a widely used reflectance-based vegetation index"

- page 8297, line 1: Please correct "Fluorescence"

- page 8297, line 8: Please, rephrase to "The FLEX mission plans to utilize the O2-A and O2-B band"

- Please consequently use introduced abbreviations.

- The quality (text size and resolution) of some figures is sub-optimal (e.g. figure 6 or 16). Please improve the quality.

Interactive comment on Biogeosciences Discuss., 7, 8281, 2010.