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Atmospheric Measurement Techniques Discussions

Interactive comment on "Global monitoring of terrestrial chlorophyll fluorescence from moderate spectral resolution near-infrared satellite measurements: methodology, simulations, and application to GOME-2" *by* J. Joiner et al.

Anonymous Referee #1

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General comments

The proposed manuscript introduces a new statistical approach to retrieve chlorophyll fluorescence from moderate spectral resolution GOME-2 satellite data. After a description of the underlying methodology, comprehensive assessments are presented to evaluate the performance of the method considering instrumental effects (i.e., spectral resolution, sensor noise) and method specific aspects (number of principal components, width of the fitting window). The work adds to and complements recent and

promising efforts to measure FS from satellite data to improve global estimates of photosynthesis and the carbon cycle.

The manuscript can be considered as innovative as it provides a new strategy to retrieve FS from moderate spectral resolution satellite data by exploiting atmospheric absorption bands (H2O, O2-A) and Fraunhofer lines. More important, the proposed approach provides an alternative FS retrieval bypassing the difficult atmospheric correction by approximating atmospheric absorption and scattering processes from the image data itself using principal components.

Results of the presented work will increase the evidence that satellite based FS retrievals are possible but also highlights related difficulties. The work is definitely worth publishing after the consideration of the few aspects listed below.

Specific comments

P3885/L6: The only way to contribute to the carbon cycle using fluorescence is via GPP. Please rewrite: “as well as assessment of the terrestrial carbon budget by providing more accurate estimates of gross primary productivity (GPP)”

P3885/L11: Photosynthesis is GPP and can be (in a simplified way) approximated by two components: light absorption (APAR) and the utilization of it (LUE). FS is known to be strongly related to its excitation energy (APAR) and was found to be sensitive to changes of photosynthetic activity (LUE). Please rewrite: “fluorescence is correlated to the amount of absorbed photosynthetic active radiation (APAR) and the efficiency of the plants to utilize this light to drive photosynthesis (LUE).”

P3885/L13-...: Please clarify your argumentation by specifying why FS is complementary to reflectance based vegetation indices? You might use these aspects in your argumentation: - Greenness bases indices are linked to the chlorophyll content and indicate potential photosynthesis, but FS is supposed to be an indicator for actual photosynthesis - PRI is sensitive to the de-epoxidation state of xanthophyll pigments within

AMTD

6, C1415–C1419, 2013

the xanthophyll cycle, a protection mechanism evolved in parallel to FS to dissipate excessive energy.

P3887/L18-20: You mention that the proposed approach does not require nearby non-fluorescing targets. But, as far as I understand, you need observations on a daily basis to do the principal component analysis. Please update the statement made in the introduction accordingly.

P3887/L21-22: Please rewrite: "Our methodology is similar to approaches developed for ground-based instrumentation (Guanter et al. 2013) in that. . ."

P3888/L10-15: I would recommend replacing the summary with some statements highlighting the implications of your work for the research community.

P3888/L17-24: I am wondering if the discussion of SCIAMACHY is relevant here – you might consider moving it to the discussion section.

P3889sqq: Why do you introduce new abbreviations for FS (IF) and extraterrestrial solar irradiance (F) rather than using the ones more or less established in RS and used in your previous work?

P3890/L18-P3890/L5: I would recommend moving this paragraph in front of P3890/L1. Currently, it is difficult to understand why you are doing all these mathematical reformulations.

P3892/L1: It was unclear for me – until the next page – how you could simulate at sensor radiance without having a vegetation model. You could consider rewriting the first sentence: "To quantify retrieval errors, we conduct detailed simulations using combined atmospheric and vegetation models over a wide range of conditions."

P3893/L25: Radiative transfer in the O2-A band is indeed complex and the reasons are comprehensively listed. You are proposing a retrieval scheme which also exploits the H2O band around 720nm. A similar listing and discussion on disturbing factors is required.

AMTD
6, C1415–C1419, 2013

P3895/L27-P3896/L8: Please briefly indicate why the PCA's differ for the simulated and the real data.

P3897/L11: Please extend the description of your method. How exactly and where do you select data to run the PCA? What are required characteristics of these data used as input for the PCA?

P3897/L22: Please specify the limits you tested for cloud contamination.

P3902/L15: Are the negative values an effect of data noise, or a result of one of the assumptions made, or caused by less representative data used to calculate the PCA's? Please give a short indication.

P3903/L3: Why do you not sample FS at the same wavelength as the GOSAT FS retrieval (755nm) does? This would make the comparison much easier.

Please include or extend a discussion on the following aspects: - Problems related to the retrieval of FS in highly variable H2O absorption bands. Does it complicate the retrieval or is the complexity comparable to retrieval in O2 bands?

- Impact of the distribution and sampling frequency of data used to calculate the PCA on the retrieval accuracy. Can it be that the selected spectra do not cover the variability introduced by the SAA, leading to higher uncertainties in South America?

- Validation of results. Right now the validation only relies on a visual comparison of GOSAT and GOME-2 FS retrievals – which is fine as these results are published and its plausibility was evaluated using various approaches. However, the papers describing the GOSAT retrieval (Joiner et al. 2011, Frankenberg et al. 2011, Guanter et al. 2012) indicate that, because of the coarse spatial resolution, validation is impeded for these data and only indirect strategies can be applied (e.g., using simulated data, methodology checks, plausibility checks). A validation of the satellite based FS (aggregated over many kilometers) is still challenging and would require alternatives which have to be developed (e.g., scaling approaches using field, airborne, small footprint satellites,

AMTD
6, C1415–C1419, 2013

etc.). Please include a short discussion on validation problems.

- You retrieval relies on some assumptions, including: i) atmospheric scattering is small and was not considered (P3890/L1; ii) the radiative transfer equations are only valid for monochromatic light (P3890/L17); iii) distinct spectral structures of e.g., FS were assumed (P3891/L6); no rotational Raman scattering modeled (P3892/L22); iv) no consideration of directional effects (P3892/L26). Please discuss potential impacts on the retrieval accuracy.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 3883, 2013.