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Atmospheric
Measurement
Techniques
Discussions

# *Interactive comment on* "Chlorophyll fluorescence remote sensing from space in scattering atmospheres: implications for its retrieval and interferences with atmospheric $CO_2$ retrievals" *by* C. Frankenberg et al.

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Suggested Full Title: Remote sensing of NIR chlorophyll fluorescence from space in scattering atmospheres: implications for its retrieval and interferences with atmospheric CO2 retrievals

Suggested Short Title: Remote sensing of NIR chlorophyll fluorescence from space

I would like to add a few comments to the dialogue on this very solid contribution to atmospheric chemistry and, potentially, to the vegetation sciences. The technical as-



pects of the paper related to atmospheric processes retrievals appear to be rigorous, and clearly demonstrate that chlorophyll fluorescence in the near-infrared region between 750-775 nm emitted from large regions of vegetation at the Earth's surface can be detected in the Fraunhofer lines that bound the O2-A oxygen absorption feature centered at ∼760 nm. Because chlorophyll fluorescence primarily occurs in the red and far-red wavelengths, with peaks at ∼680 and 740nm, the evaluation and use of this low fluorescence signal detected at longer wavelengths must be carefully stipulated as coming from non-optimal wavelengths (e.g., 750-775 nm). This will likely limit usefulness in predicting vegetation processes. This point should be clarified in the Goals of the paper (Page 2489, lines 18-25): the Fs retrievals addressed here are those in the 750-775 nm range, only a subset of the full chlorophyll emission range (650-800 nm). Therefore, the full and short titles for the article should indicate that the fluorescence topic discussed is limited to this region, not the entire emission region. Suggested titles are given at the top.

The authors should cite the recently published paper by Joiner et al. (2012) in this same on-line journal, AMT, throughout the paper as appropriate. This should be cited on Page 2489 (line 24), Page 2491 (line 3), Page 2498 (line 16), and Page 2504 (lines 1 & 8). The citation is:

Joiner, J., Yoshida, Y., Vasilkov, A. P., Middleton, E. M., Campbell, P. K. E., Yoshida, Y., Kuze, A., and Corp, L. A.: Filling-in of near-infrared solar lines by terrestrial fluorescence and other geophysical effects: simulations and space-based observations from SCIAMACHY and GOSAT, Atmos. Meas. Tech., 5, 809-829, doi:10.5194/amt-5-809-2012, 2012.

My comments address the more tangential issues raised and discussed by others: 1] the characterization of the "true" (aka, ideal) condition against which the results are compared; 2] the presumed usefulness of the retrieved NIR fluorescence signal in this region (∼750-775 nm) for describing photosynthetic function in vegetation regionally and globally; and 3] the statements made about the FLEX mission.

My first suggestion, in support of an earlier posted comment, is to replace the term "full-physics retrievals" with "realistic-physics retrievals" or "optimized physics retrievals" or similar term throughout. This is because the simulations, although accounting for many effects, are still lacking "full-physical descriptions" in some important ways. The term Fs is defined on p 2489 (line 14), and could thereafter by used in place of the words "chlorophyll fluorescence".

Another issue involves terminology and overstatement of capability. One example is found in the second sentence of Section 2 (Chlorophyll fluorescence, page 2490, lines 13-15). ["During photosynthesis, visible solar energy absorbed by chlorophyll can either be used for carbon fixation, be dissipated into heat, or be re-emitted via fluorescence at longer wavelengths in the 660–800nm window. This so-called solar-induced chlorophyll fluorescence (Krause and Weis, 1991; Baker, 2008, and references therein) thus offers 15 a very direct measure of photosynthetic activity."] To be correct, this should be re-written. I suggest this: Shortwave energy obtained from a laser or a visible light pulse with laboratory or field instruments, or by the sun, is collected within vegetation by chlorophyll. Under optimal conditions, most of this energy is routed through photosynthesis, but typically some energy is dissipated as heat or re-emitted via fluorescence at longer wavelengths in the 660-800 nm window. When determined under natural conditions outdoors, the fluorescence obtained is referred to as solar-induced chlorophyll fluorescence. Fluorescence intensity is an indicator of photosynthetic activity."

On Page 2492, please clarify the spectral locations of the two Gaussian A1 and A2.

References to the FLEX mission should be stated correctly. For example, a rewrite is provided here for Page 2498 (lines 18-19). "These are typically used in ground-based studies and suggested for inclusion in the FLEX mission retrieval scheme along with fluorescence and reflectance information to be acquired in additional spectral regions. That broader approach is necessary because TOA retrievals that rely solely on the O2 bands are problematic, as will be corroborated in the following section."



Furthermore, it should be noted (e.g., Page 2499, lines 27-29) that the FLEX mission will measure Fs at more optimal regions of the emission spectrum than can be obtained with the GOSAT or similar NIR instruments, and will make vastly improved spatially explicit measurements at $\sim$300m that can be validated against ground-based measurements. So, please also correct the reference to FLEX (incorrect statement about only using O2 bands for Fs retrievals) on page 2505 (lines 6-9). I suggest that you do not delete references to the FLEX mission, as stated in one of the posted online comments in reply to those of W. Verhoef, but rather that correct information be substituted.

Edits Page 2489, lines 14-16: Frankenberg et al. (2011a) found that NIR chlorophyll fluorescence (Fs) between 750-775 nm cannot be unambiguously distinguished from the effect of scattering on the depth and shape of atmospheric O2 absorption features in the 0.76 $\mu$m range.

Page 2490 (lines17-18): . . .in the two emission peaks around 680 and 740 nm, the latter which encompasses the strongly saturated O2A-band around 760 nm. (line 27) . . .retrievals cannot be readily applied if only the O2 A-band is measured and a ground reference value is unavailable.

Page 2491 (line 9): . . . resembles vegetation patterns associated with optimal GPP. [Note: The GPP patterns provided in Beers et al. and GOSAT publications (Frankenberg et al., 2011; Joiner et al., 2011, 2012) describe very low spatial resolution (e.g., 0.5 x 0.5 deg).

Page 2492 (line 1): retrieved is mis-spelled. Page 2495 (line 14): . . .where when Page 2497 (line 13): . . .as well as. . . (line 27): Please clarify what parameter (for which energy units are given) are related to the error in XCO2 of 0.55ppm.

Page 2499 (line 11): The inclusion of fluorescence as fitting parameters caused some outliers in retrieved XCO2 at low simulated Fs values though. Why do you call these "true" Fs values? (line 19) . . .because for interferences are introduced.

Page 2500 (lines 4-12): This is vague. Please rewrite this. (line 19): Are you referring to operational retrievals of O2 or CO2?

Page 2503 (lines 2-4): Please give a better justification for re-using Aeronet data for the same months (but different year) that these data were not collected or available. Fig. 13. shows that inter-annual variation is apparent. (lines 6 & 15 ): change "to" to "with"

Page 2504 (line 6): Refers to Fs?

Page 2505 (lines 21-23): Please limit this claim to the NIR Fs (two places in one sentence).

Figure Captions: RMSEs for linear fits would be useful. Figs. 3, 4, 5, & 6. Captions should include— NIR Fs at 755 nm. Fig. 5. “known” Figs. 6, 7, 8, & 10: what are the units for Y axis of bottom panel? Fig. 7 & 8: Clarify second sentence. Fig. 9: zero level offset in XCO2? Fig. 11: True Fs values? Or, expected values with model conditions X? Fig. 12: Red lines (plural) Fig. 13. These are simulated surface and TOA NIR Fs at 755 for 0.5 x 0.5 deg areas. Instead of ‘Goddard’, put Greenbelt, MD (middle). Fig. 14: The plot only shows X axis to 759 nm, but caption says 760 nm.

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 2487, 2012.