Atmos. Meas. Tech. Discuss., 5, C83–C87, 2012
www.atmos-meas-tech-discuss.net/5/C83/2012/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Filling-in of far-red and near-Infrared solar lines by terrestrial and atmospheric effects: simulations and space-based observations from SCIAMACHY and GOSAT" *by* J. Joiner et al.

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Received and published: 20 February 2012

The authors build on previous work on the exploitation of satellite measurements in solar Fraunhofer lines for the retrieval of non-solar electromagnetic signals (as opposed to reflected solar radiation). The basic idea is that surface or atmospheric emitted signals superpose to solar-reflected radiation at the TOA in an additive way, which makes both emitted and reflected signals can be decoupled by the modeling of the fractional depth of solar lines. In a previous work, the same authors demonstrated the feasibility of using this concept for the retrieval of terrestrial chlorophyll fluorescence

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(Fs) from GOSAT-FTS measurements in the Fraunhofer line in 770.1 nm (Joiner et al., Biogeosciences, 2011).

In this new manuscript, they extend this approach to a Fraunhofer line in 866 nm which is sufficiently resolved by SCIAMACHY coarser resolution measurements. The authors find an additive signal in 866 nm which correlates spatially with vegetated areas as indicated by satellite-based vegetation indices and with GOSAT-based Fs. Despite only a very low Fs signal could happen at that wavelength (most of the Fs emission is expected to happen in the 650-800nm range, with a steep decrease towards the edges of this interval), it can be speculated it is the most likely reason to explain the observed in-filling of the 866 nm line. As a secondary objective, the authors report on the improvements performed on their GOSAT Fs retrieval scheme, which now includes a time-dependent set of reference spectra to model Fs in-filling.

The manuscript tackles a rapidly rising field of research, to which the authors have considerably contributed. The methodology and sensitivity analyses proposed for the retrieval of in-filling signals in 866 nm seem sound, and the results strengthen the confidence on the feasibility of Fs retrieval from space. Although I consider some points concerning the introduction, methodology and results must be addressed (see comments below), I recommend the manuscript for publication in AMT. The following comments and suggestions might help to improve the manuscript.

1) Statement of the problem:

Almost no experimental evidence supports the existence of a non-negligible Fs signal for wavelengths >850 nm, where any Fs appears to be below the NEdL of standard lab and field instruments. The possibility of a measurable Fs signal of ~0.1-0.2mW/m2/sr/nm under natural illumination conditions and the leaf-level is discussed in Section 2, without a clear conclusion as to whether those Fs levels in 866 nm are realistic for the SCIAMACHY spatial and temporal scales. The authors choose then a conservation position and only refer in the remaining of the paper to the detection

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of a general in-filling signal, "chlorophyll-a fluorescence being a plausible candidate". Some points concerning this:

- Sections 1-Introduction and 2-Laboratory measurements are solely dealing with the description of the Fs signal and its detection from space. This does not seem to be consistent with the rest of paper, which only proposes Fs as one of several possible candidates for the observed in-filling. "we make no assumption about the source of the additive signal" is stated in Section 4.1. Fs is not mentioned in the title either. It is appreciated that the authors do not want to over-sell the point of Fs measurement in 866 nm in view of the mentioned concerns about the signal levels. But the introduction does not seem to show this, which is confusing to the reader at the first glance. Please, consider to rewrite some parts of the text according to this.

- Concerning section 2, I feel it is crucial for this work to make as much a solid statement about Fs emission in wvl>850nm as possible. Although it is understood that it might be rather difficult to find experimental evidence on this, the paper might greatly benefit from extending section 2 with more information, references and discussion. In particular, some lines about the effect on Fs levels of morning rather than afternoon illumination (SCIAMACHY and GOSAT, respectively) would be important. The title "Laboratory measurements" could be extended to include fluorescence.

On the other hand, the relatively important updates of the older GOSAT Fs retrieval approach by Joiner et al (2011) are not mentioned in the introduction. Considering this is not a negligible point of this manuscript, a brief discussion of this (e.g. why the approach needed to be updated) could be added to the statement of the problem.

2) Methodology

- As in Joiner et al (2011), Fs retrieval is performed over narrow spectral fitting windows ($\sim$0.35nm) containing one single Fraunhofer line. However, as discussed by Frankenberg et al (2011), the use of wider spectral windows with several lines (e.g. 756-759nm and 769-774nm) should lead to a much lower sensitivity to noise, which is the main

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error source in GOSAT retrievals. Why is the retrieval approach not making use of wider fitting windows, at least for GOSAT? There seems to be nothing in the current narrow-window approach which prevents it to be extended to wider windows. The reason to keep using those narrow fitting windows should be discussed in the manuscript, maybe including simulations of single-retrieval 1-sigma error for the narrow and wide fitting windows. Apart from this, please give an explanation of where the 0.696 scaling factor (3 decimal places?) comes from.

- No much information is actually given on uncertainties in section 5.7, which might be particularly relevant for the new retrievals with SCIAMACHY. For example, on single-retrieval errors. Could this be added to the text? In particular, what is the random error in Fs due to noise? How many retrievals are normally available for each 0.5° cell of the SCIAMACHY maps, and how is this affecting the standard error? It is also mentioned that both SCIAMACHY channel 4 and 5 are used. How are retrievals from each channel combined in the final scaled-F product? Is the same 1-sigma uncertainty to be expected from each channel? Also, please give more information on the effect of the South Atlantic anomaly (?) on the measurements.

3) Results

The Results section might be too short with respect to the rest of the manuscript. Some potential extensions/modifications could be:

- Updated GOSAT retrievals: the use of time-dependent reference spectra accounting for both instrument degradation and zero-level offsets are expected to greatly improve the results with respect to those in Joiner et al (2011). Given the fact that that pioneering work has become a reference in these emerging field, it might be useful to discuss in this manuscript why that approach had to be improved, and what the impact of these changes is on the results presented in Joiner et al. (2011). In particular, the Fs levels in Figs.8-9 (scaled at 770nm) are higher than those described by Frankenberg et al (2011) (scaled at 755nm) and lately by Guanter et al (2012, RSE in press), and there

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is some trace of non-negligible negative values over some desert areas. Please, add some discussion along this direction.

- Assuming the retrieved scaled-F signal can be interpreted as fluorescence, it would be very interesting to see long temporal series of scaled-F from the SCIAMACHY product over e.g. the regions of interest in Fig 11. It could also help to discard instrumental effects on the in-filling signal (e.g. instrument degradation).

- It would be helpful for the GOSAT community to see plots of the temporal dependence of the GOSAT reference spectra referred to in section 5.3.

- Fig. 12-6. High levels of SCIAMACHY scaled-F are shown in June, when EVI is lower than 0.3. This seems unfeasible, and suggests effects other than fluorescence are accounting for the reported in-filling, at least over the India site. Please, comment.

- Figs.9-10:

- I think 9 & 10 could be merged into one single figure showing 4 months, either the central months of each season or the seasonal means. Not much extra information seems to be added by the 12 months.

- TOA radiance instead of reflectance should be displayed if this is to show a potential correlation between Fs retrievals and instrumental effects, as at-sensor radiance would be the parameter driving potential instrument-related in-filling.

4) Other comments:

- Title: 'far-red' could be omitted (near-infrared sufficient for 755-866nm?), whereas it could be considered to add 'fluorescence' as a keyword despite the "conservative" position chosen with respect to the nature of the detected F signal.

- @AMTD Editorial office: the dates of manuscript receive and acceptance in AMTD must be wrong (2011 rather than 2010)

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 163, 2012.