Atmospheric
Measurement
Techniques

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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.

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We thank Dr. Stammes for his thoughtful and thorough review and suggestions to improve the paper. We respond to specific comments (repeated here for clarity) in bold below.

Main comments

- The fluorescence retrieval algorithm is not very clearly presented in Sect. 3. Please

clearly present all the steps in the algorithm, e.g. in a flow diagram; the best place would be in Sect. 3.4 or 3.5.

We have added a flow diagram as suggested (see Fig. 1 below) to Sect. 3.5 along with a paragraph that more clearly outlines all the steps of the algorithm.

- A first error estimate is needed, although the authors state that it is difficult to assess because of the nature of their algorithm.

We have significantly revised the paper with respect to the error analysis. We estimated errors following a linear unconstrained approach as outlined in the paper. We compared results with those from the full simulation study and they compared quite well (to within about 4%). We then estimated errors for GOME-2 data and describe the results in Sect. 5.

Specific comments

Abstract: Please shorten the introductory text (lines 1-14), do not emphasize the O2 A-band, and instead add specific and quantitative results from the paper. Mention that the algorithm is based on a simplified radiative transfer model, applied to a wide spectral range, and that the PCA approach to solve for atmospheric absorption is an empirical approach.

We have made the suggested changes.

p. 3889: - l. 8/9: add: : : :, on Metop-B launched : : :. - l. 18-19: remove the word 'flux'

done

p. 3890: - l. 1: remove: "In the absence of atmospheric scattering or", since in the NIR spectral range there is always atmospheric scattering (Rayleigh).

done

- l. 19: remove "and scattering", since the assumption was to neglect scattering. These

three terms are in line with p. 3891, l. 6.

done

p. 3894: - l. 17 ff: The DOAS approach does not hold for the deep parts of the O2 A-band, where many lines are optically thick. So why include this absorption band if DOAS does not apply? What would happen if the O2 A-band would be skipped? What is the resulting error if it is included?

We added more detail to this section and provided a forward reference to simulations shown later in which the O2 A-band is skipped or included. Those simulation show the resulting errors. "Because this law does not strictly apply to the O_2 A-band where individual lines may become optically thick and absorption is temperature dependent, simulations are needed to evaluate how well our simplified approach will work in this spectral region. Our approach is flexible in that different fitting windows may be utilized. As will be shown below, the O_2 A-band can in fact be completely removed from an extended fitting window without much if any loss of information content."

- l. 25: remove "as well as the effects of RRS", since neglecting RRS was addressed earlier.

done

p. 3895: - l. 27 ff: Please try to explain the differences in behaviour of PCs 2, 3 and 4 between the simulations (Fig. 5 and 7) and the GOME-2 measurements (Fig. 6 and 8). It seems that some PC's are reordered in number and/or inverted in sign between simulations and data. A possible related question is: do the simulations represent the same conditions as the GOME-2 data, namely bright scenes: snow/ice, Sahara, clouds?

We reordered the sentences in this paragraph and added "The PCs for simulated and real data are expected to be different as PCs from the real data may con-

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tain information related to instrumental artifacts and processes not included in the simulated data (e.g., rotational-Raman scattering). In addition, the simulated data may not represent all of the conditions or the distribution of conditions that are present in the GOME-2 data, particularly bright scenes that occur over heavily clouded conditions. The training data set does include bright soils and snow, however."

p. 3897: - l. 3-9: please shorten this too long sentence. What is the conclusion of this paragraph? What is the resulting error in the fluorescence retrievals?

We broke up this sentence and moved and expanded this part in Section 4.1. We now provide error estimates for both simulated and GOME-2 retrievals based on the linear approach.

p. 3898: - Sect. 4.1: please give the relation of this subsection with the model scenarios described in Sect. 3.2.

We added an introduction to Section 4 and reorganized to clarify: "In this section, we retrieve fluorescence using the simulated radiances for the 230 400 different conditions contained in the testing data set described in Sect. 3.2. We conduct retrievals for a number of different scenarios. We then compare the retrieved fluorescence with that of the truth as specified in the testing data set for the entire sample. Table 1 provides statistical results of those comparisons for the scenarios described below."

p. 3900: - l. 16: why is the resolution 0.3 nm relevant? Why not another resolution, e.g. 0.1 nm? What would be the expected effect of a higher resolution? Is it to better resolve the Fraunhofer line filling-in of fluorescence?

We added a few sentences to this section to explain why we conducted experiments at a higher spectral resolution than GOME-2. The choice of 0.3 nm was arbitrary. At the beginning of this section, we added "In order to show the sen-

sitivity of the results to spectral resolution, we performed a similar set of experiments at a higher spectral resolution (FWHM = 0.3 nm, sampling of 0.1 nm) as compared with that used in the above subsections." Later, we added more explanation of the results. "This improvement results from 1) More spectral samples within the fitting window and 2) A larger filling-in fluorescence signal in the cores of the deeper Fraunhofer lines that are better resolved at the higher spectral resolution as shown in Fig. 9. Further improvements can be made by making measurements with higher spectral resolution and/or increased sampling."

p. 3901: - l. 10: What could be the reason of these large residuals ? Are they due to the simplified radiative transfer model?

We added more detail to this section and speculate as to the cause of these residuals (note that they are of the order of 0.5% of a very small radiance level, so not sure they should be called large). "Note that relatively larger residuals (larger than instrument noise but well below 1%) are produced at the very low radiance levels found within the deep O_2 A-band. These residuals are seen in both the simulated data as well as real GOME-2 data as will be shown below and could be the result of non-linear behavior of the O_2 A-band that the PCA method is not able to capture."

p. 3902: - l. 2: please clarify: "referenced to 737 nm"?

We have clarified this. Please see response to Reviewer 1.

p. 3903: - l. 7: times > time

done, thank you.

p. 3904: - l. 10: singal: signal

done, thank you.

- l. 12: SSA > SAA

done, thank you.

p. 3905: - l. 11-12: : : : derived from data free of fluorescence ..: what is meant? Please clarify this part of the algorithm in the paper's main text; in the conclusions it causes confusion. - Please add to the Conclusions an estimate of the error in the retrieved fluorescence.

We removed this part from the conclusions and clarified in the main text. We added an estimate of the GOME-2 fluorescence retrieval error in the conclusions section.

p. 3906: TROPOspheric

done, thank you.

p. 3911: O'Dell paper belongs before the P papers

done, thank you.

Table 1: Please specify all the quantities tabulated in the header or in table footnotes. Clarify the differences (sign), and specify which quantities are fluorescence quantities.

done, thank you.

Fig. 4: Which spectral resolution is used here? Please give a color bar for the water vapour variation.

All information is now given in the caption.

Fig. 12, caption: - the testing - fit > fitted (2x) - I in italics

fixed, thank you.

Fig. 16: - which grid cell size was used for binning?

added the grid cell size (0.5 x 0.5 degrees)
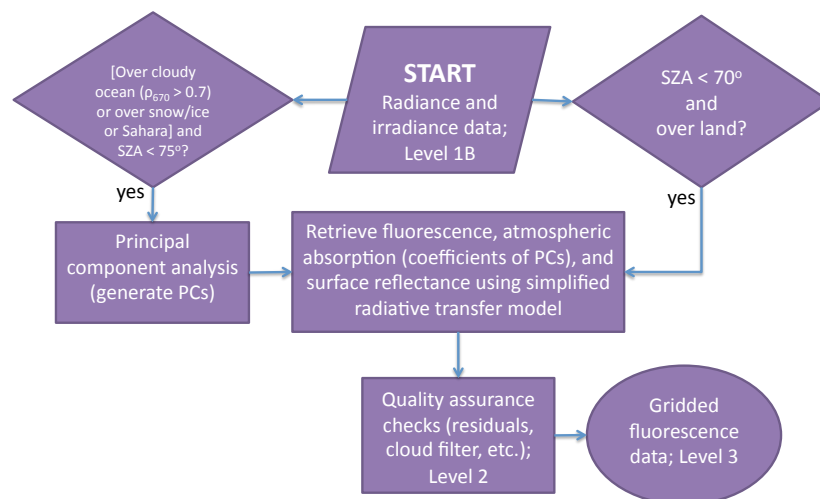
- betwen > between

fixed, thank you.

Fig. 1. Flow chart showing end-to-end processing of GOME-2 data