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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Retrieval of aerosol parameters from the oxygen A band in the presence of chlorophyll fluorescence" *by* A. F. J. Sanders and J. F. de Haan

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The manuscript deals with the retrieval of aerosol parameters and terrestrial chlorophyll fluorescence from spectrally-resolved measurements in the O2 A-band. Given that a number of spaceborne instruments measuring in O2A are currently operating, and that several others are planned for launch in the coming years, the topic of exploiting the O2 A-band for improved atmospheric and surface retrievals is of relevance to a wide community. In particular, the retrieval of fluorescence from space is evolving rapidly in the last couple of years, which is further supported by new studies in the line of the one presented in this manuscript.

My opinion is that the manuscript is timely and addresses an important field of research, and also that it is well written and presented. However, I think that the authors should address several critical points before the manuscript can be accepted for publication:

1) Representativeness of the simulations

As the authors discuss in the text, their precision estimates are significantly better than the ones provided by other authors (Frankenberg et al) dealing with a similar problem. In my opinion, this might be explained by an over-simplified simulation and retrieval set-up. For example, the effect of uncertainties in e.g. the temperature profile, surface pressure, aerosol optical properties, polarization or the direct/diffuse radiation ratio could change the precision estimates substantially through cross-correlation with the state vector parameters. Also, at least 2-3 parameters should be added to the state vector in order to account for the non-linear spectral shape of surface albedo (normally modeled by an n-order polynomial). Even in this simplified case, the authors mention "exceptions to the overall trends described in Sect. 4 exist" (p3199, L19).

The question is then to what extent the precision estimates achieved in this work would hold for a more realistic retrieval scenario including more state vector elements and uncertainties in the forward model parameters. I consider that the authors should extend their simulation set-up so that their conclusions can really be considered representative of a real retrieval scenario. Simulations with only 4 free parameters and a flat and constant surface reflectance cannot recreate the complexity of the problem.

2) Accuracy vs precision

Related to the previous point, non-expert readers might be confused by the small errors reported in Fig. 4. Apart from the potential over-simplification of the retrieval approach described before, systematic errors are not considered in the error budget. Even though the authors state clearly that those figures are only precision estimates from the propagation of instrumental noise, they also refer to comparisons of those

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precision errors with "scientific user requirements" which at least in the case of fluorescence will always include systematic errors. Actually, we know that biases can become very important when fitting wide spectral windows (>5-10nm) due to cross-correlation of fluorescence with the state vector parameters describing surface albedo. In fact, the formulation of surface reflectance in the forward model is critical for such wide fitting windows, and more sophisticated approaches than polynomials in wavelength are necessary (this is not the case for narrow spectral windows containing only Fraunhofer lines).

In my opinion, providing precision errors for a fluorescence retrieval method dealing with a relatively broad fitting window, as it is the case here, is misleading. In this case, precision errors may be significantly smaller than biases. The authors should consider to perform realistic end-to-end simulations in which both accuracy and precision are properly evaluated.

3) O2 vs Fraunhofer lines

The first part of Section 5 presents a critical analysis of other works (Frankenberg et al 2011, 2012) also dealing with the retrieval of fluorescence from O2A measurements. In particular, the authors put a lot of emphasis on the discussion of the information content provided by Fraunhofer lines for fluorescence retrievals, and state e.g. in the abstract "we also show that most of the fluorescence signal is provided by in-filling of the O2A band and to a lesser extent by filling-in of Fraunhofer lines".

On the one hand, I think that this O2A/Fraunhofer discussion is unnecessary for this work, especially with such a direct language as the one used in Section 5. On the other hand, I was surprised by the findings in Fig.5 showing the apparent lack of impact of the Fraunhofer lines in the retrieval of fluorescence. This contradicts our own results using end-to-end retrieval simulations. I am attaching some figures from our own analysis. In short, I ran end-to-end simulations with the forward simulation data set and the statistical retrieval approach described in Joiner et al AMTD, 2013 (doi:10.5194/amtd-6-3883-

2013). The end-to-end simulations were performed with and without a solar spectrum as the authors did to produce their Fig.5. Forward simulations comprise >200,000 case including different observation and illumination angles, atmospheric conditions (different values of surface pressure, T profile, aerosol optical thickness, model and height), and surface reflectance and fluorescence (from combinations of leaf area index and chlorophyll content). A constant SNR of 2000 is assumed. The mean and standard deviation of this test data set for the cases with and without solar irradiance are displayed in the Figs.1-2 of this review. Our end-to-end simulation results for the entire test data set are shown as a scatter plot in Fig.3 of this review. Diamond symbols and error bars show the mean and the standard deviation, respectively, derived from all the retrievals performed for the same surface state (reflectance and fluorescence spectra) under different atmospheric conditions and observation/illumination angles. Despite the almost identical fit residual obtained with and without the Fraunhofer lines (Fig.4 of this review), a very different retrieval performance is found, which contradicts the findings presented in this manuscript.

Of course the retrieval precision depends on the particular forward model configuration, state vector definition and associated assumptions. In this sense, the larger number of parameters inverted in our forward model (see Joiner et al) than in the one proposed in this manuscript makes our retrieval to be potentially more sensitive to instrumental noise. But nevertheless the improvements achieved with the the Fraunhofer lines seems concluding enough to challenge the authors' statement that most of the information is provided by the oxygen lines. I could provide the authors with the data base we generated to develop and test our own fluorescence retrieval algorithms so that they can test some of the assumptions they are making in their approach.

Other minor comments:

Title: it may be due to a personal bias, but my impression is that the manuscript is more focused on fluorescence than on the aerosol retrieval part, which is not clear in the title. Critical surface albedo (p.3199, L24): I think this concept was developed for

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multispectral data (MODIS-like). I am not sure that it applies to high spectral resolution data in which each spectrum samples very different atmospheric optical thickness for a relatively constant surface albedo).

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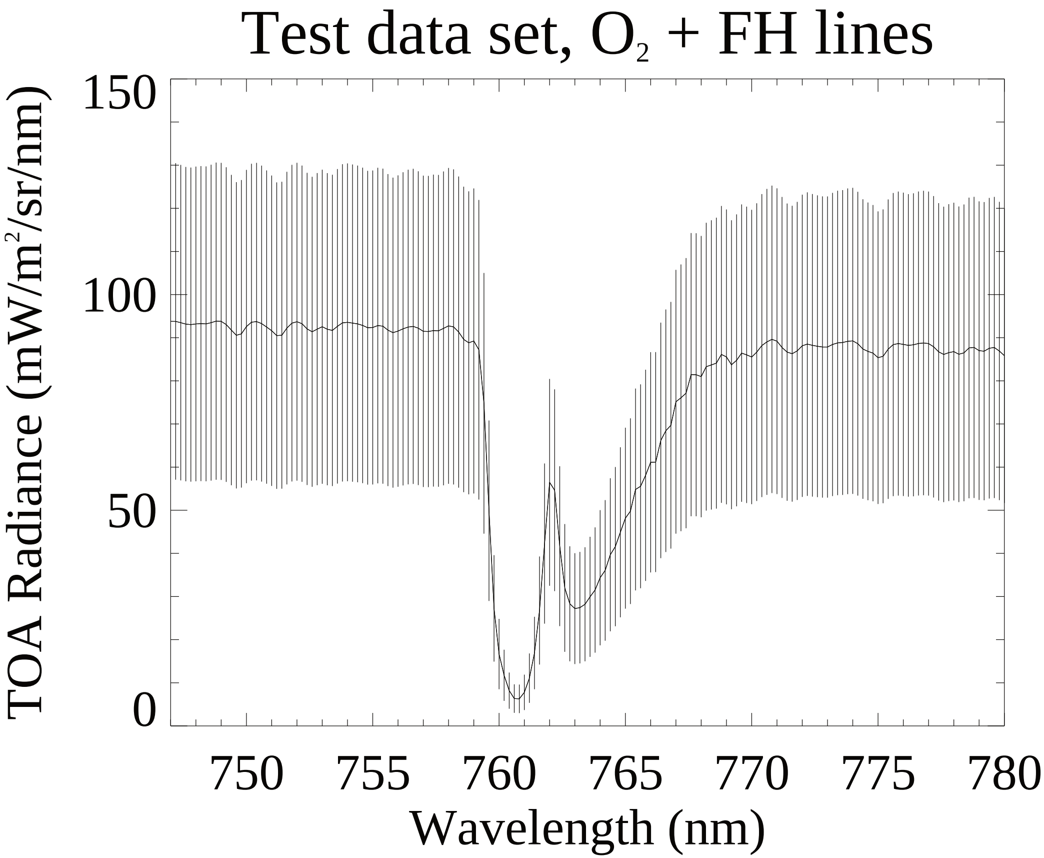

Fig. 1.

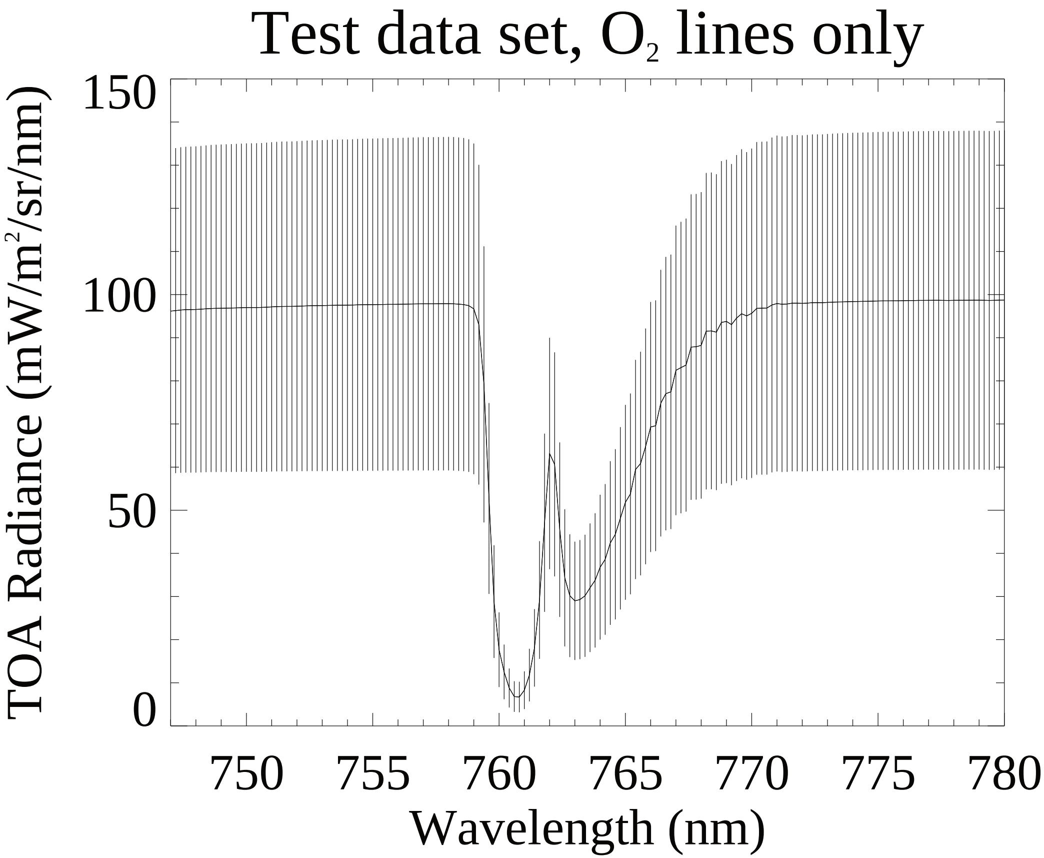

Fig. 2.

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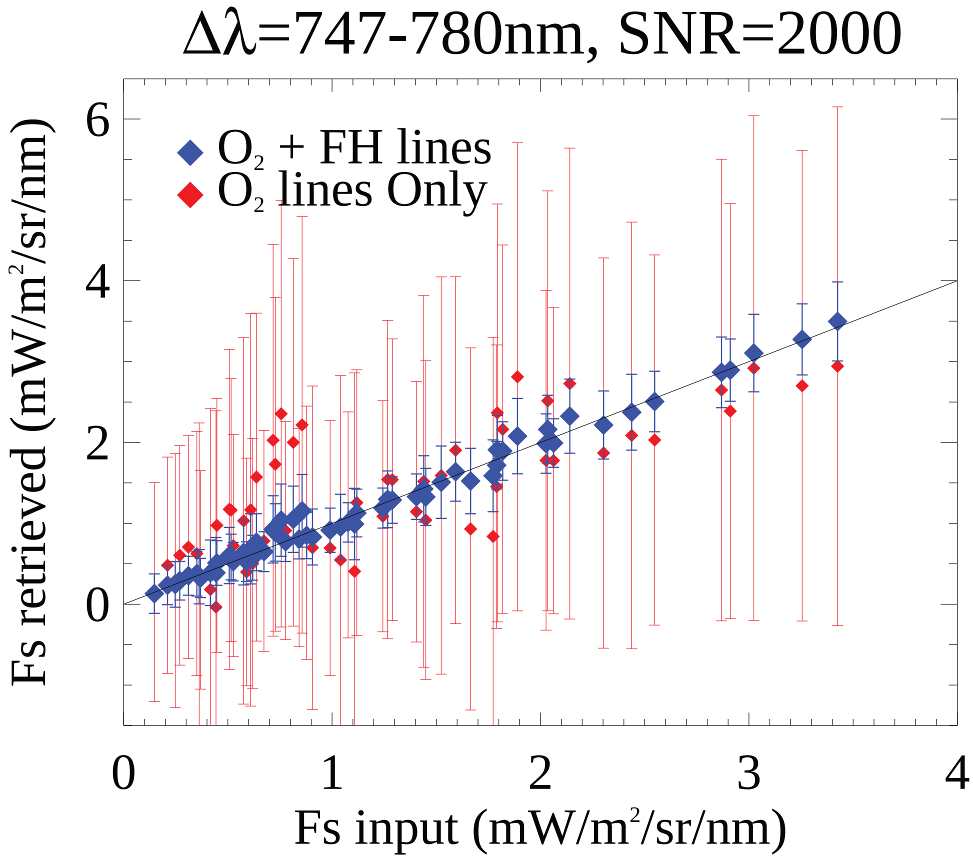

Fig. 3.

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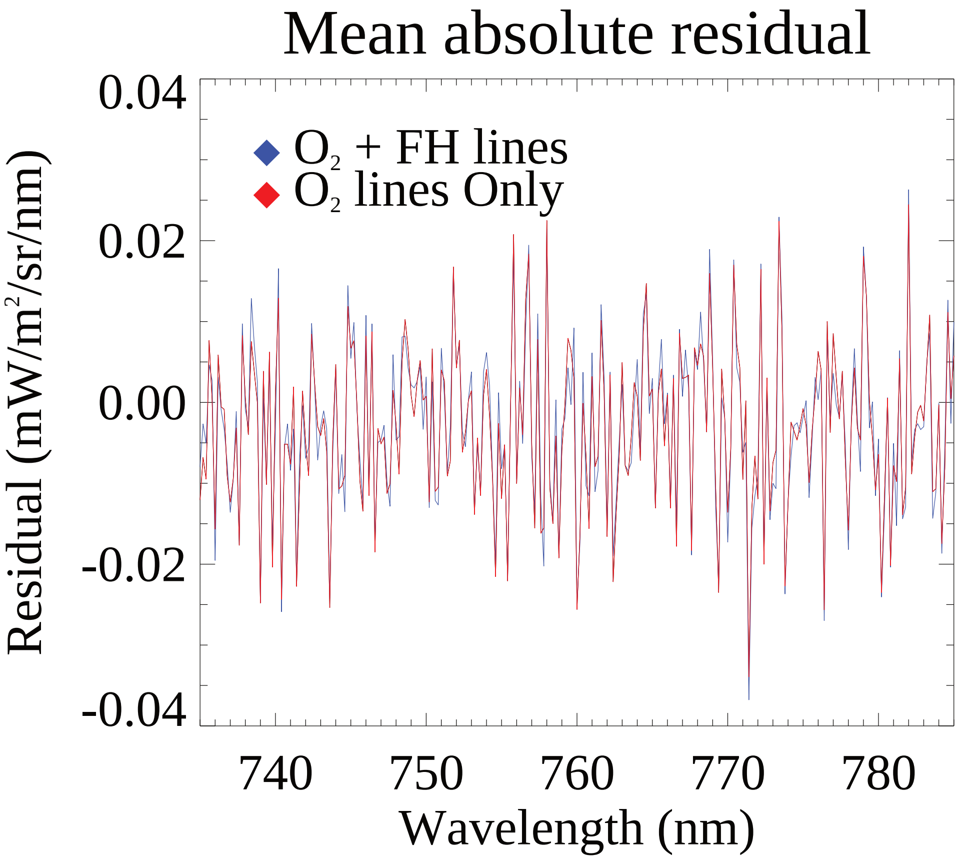

Fig. 4.

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