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Interactive comment on “Retrieval of desert dust aerosol vertical profiles from IASI measurements in the TIR atmospheric window” by S. Vandenbussche et al.

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The authors would like to acknowledge the Referee for his work in reviewing this manuscript, helping the authors to provide an improved version of their work. Here under are our response to the Referee questions and comments.

1) "Some indication of the expected uncertainties or contribution functions would be useful to evaluate the information content in these results."

Retrieval uncertainties due to uncertainties in the auxiliary datasets (forward parameters) are under investigations, and part of it is already included in the current

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manuscript. A full error analysis is planned in the future, but at the moment we are only able to provide estimates of the smoothing error (through the averaging kernels) and the retrieval noise (through contribution functions). The contribution functions for the first vertical profile in Figure 9 (10 in revised manuscript) are shown in Fig. 1 here below. Those functions are of the order of $10^4 - 10^5 \text{ sr}/(\text{W cm}^2)$, allowing to compute the retrieval noise (G^*e where e is the radiometric noise). The radiometric noise being of order $10^{-7} \text{ W (cm sr)}^{-1}$, the retrieval noise is evaluated to be around 0.01 cm^{-3} (or maximum 0.1 % in the selected example). Therefore this value may be considered small with respect to the smoothing error (in the selected example: maximum 30 % from 0 to 3 km altitude, 150 % at 4 km altitude and 60 % at 5 km altitude), mainly because IASI radiometric noise is extremely small.

2) "The paper often talks about vertical profiles of dust being retrieved, but with only 1.5 pieces of independent information it is more of an effective height than a true "profile"."

We agree that with less than 2 pieces of information it is quite ambitious to call it a profile and one could certainly argue that it could be better to define one or two partial columns depending on the real degrees of freedom for each retrieval. However, as mentioned in the manuscript, those degrees of freedom reside at different altitudes for each retrieval. Therefore, the altitude boundaries of partial columns can not be defined before undertaking the retrieval. However, after the retrieval, results may be integrated to partial columns using the averaging kernel trace to isolate independent vertical columns, which is why we mentioned that the averaging kernel is important to report together with the profile (lines 738-740 in the first manuscript).

We insist also on the fact that reporting the mean layer height and the OD obtained from the full profile retrieval is not enough to properly represent the radiative effect of the aerosols. Indeed, the same OD (or total column) of aerosols "dispatched" between different levels or placed in a single well-mixed layer (even though the mean altitude is the same in both cases) would clearly not have the same radiative effects. Even the same OD placed in a 1 km-thick or 2 km-thick well-mixed layer with same mean altitude

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do not have the same radiative effect.

3) "Is all the "white space" in Figure 6 and 7 inside the two circles failed retrievals or spectra where no retrieval was attempted? Perhaps some indication could be given for where retrievals were not attempted because of the data filtering process."

Most of this white space is indeed where the retrieval was not attempted, because of the BT filter for dust presence. Over land there are also a non-negligible amount of cases for which the retrieval was unsuccessful. We have added grey crosses in Figures 6 and 7 (7 and 8 in revised manuscript), showing where a retrieval was attempted and not successful. This is also described in the revised manuscript:

- Added in legend of Fig. 6 (Fig. 7 in revised manuscript): "The grey crosses show unsuccessful retrievals. White space represents places where no retrieval was attempted because of the pre-filters."

- First paragraph in section 5.1 now reads (figure numbering is according to the revised manuscript): "Before comparing the results with other sensors, we look at the quality of the retrievals, and their information content. First, there are IASI spectra which pass the BT pre-tests described in Sect. 4.2 and for which the retrieval does not converge (represented on Figs 7 and 8 by grey crosses). This is the case for a negligible number of ocean spectra ($< 1\%$) but for about 15% of the land spectra, mostly in the Northern part of the area studied, where the OD is probably at the limit of detection (see Fig. 9 for other sensors results). Furthermore, land retrievals are probably more inclined to fail because of additional uncertainties due to the use of surface emissivity itself obtained from IASI retrievals, lower surface emissivity (especially above deserts), higher surface temperatures with respect to atmospheric temperatures and lower atmospheric water vapour content. [...]"

4) "In Figure 6, while the mean altitude of dust over the ocean shows a well-defined systematic trend and seems quite believable, over the land there are pixels with altitude greater than 4 km and less than 1 km juxtaposed next to each other. This looks like

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noise or poorly-converged retrievals. Do the authors believe these small-scale variations in dust aerosol height?"

The IASI retrieval results were displayed on a lat/long 1° resolution map, which lead to binning results from different retrievals sometimes at about 100 km distance. It was indeed not a problem above ocean surfaces but lead to the high average altitude differences noticed by the referee above land surface where aerosols altitude variations occur at a smaller horizontal scale, due partly to topographic variations. The IASI retrieval results are now displayed on a 0.5° lat/long resolution map, better showing the small scale horizontal variations. The few specific places where high variations in mean plume altitude occur on a very short horizontal scale correspond to places where topographic changes also occur more "sharply" (up to 300 m surface altitude difference along 1°). Therefore, even though we can not be absolutely sure that these are the "true" vertical profiles, we are quite confident that it is not simply noise or retrieval artefacts. In the revised version of the manuscript, we explain how the results maps were obtained and we added interpretation for the "more variable" mean altitude of the dust plume above land

- Added to legend of Figs 6 and 8 (7 and 9 in the revised manuscript) and at first version line 606: "Data was binned to a $0.5^\circ \times 0.5^\circ$ latitude/longitude grid."

- First line of paragraph 4 in section 5.1 now begins by: "Above the ocean, the mean altitude of the dust plume varies smoothly between 1.5 and 3 km"

- Added after the first line of paragraph 5 in section 5.1: "Places where sharp variations of mean plume altitude are observed coincide with topographic altitude gradients (up to 300 m surface altitude difference along 1°). Therefore, even though we can not fully rule out that these dust plume altitude variations could be an artefact, we believe that they are linked to the presence of different air masses."

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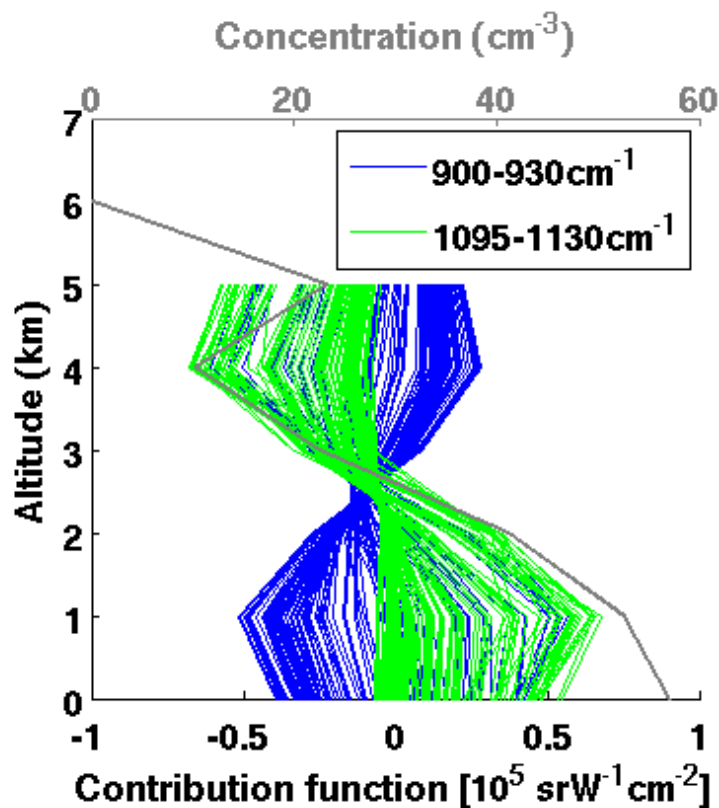
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Fig. 1. Example of contribution functions for one specific case corresponding to the first aerosol vertical profile shown in Fig.9 (10 in revised manuscript). The retrieved dust profile is plotted in grey.

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