

Interactive comment on “On the improvement of NO₂ satellite retrievals – aerosol impact on the airmass factors” by J. Leitão et al.

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This is a good and useful study that provides a detailed view on the impact that aerosol particles have on radiative transfer in the atmosphere, and with that, on clear-sky air mass factors (AMFs) for NO₂. Since the air mass factors are the largest source of error in retrievals of tropospheric NO₂ columns, and not many studies have investigated the aerosol effect on AMFs, this paper addresses a relevant and important topic.

I see two limitations in this study: 1) the results hold for one class of retrievals, i.e. clear-sky situations without clouds. Since 90% (Krijger et al. [2007], and even more for instruments like GOME(-2) and SCIAMACHY) of satellite viewing scenes is partly or completely cloud-covered, this is a major limitation on the applicability of the results

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(and this limitation is not yet acknowledged in the manuscript), 2) even in situations of clear-sky retrievals, it is still very difficult to generalize the results because the observed aerosol information used by the authors is only holds for a few particular places, and falls short of the aerosol fields needed for all local situations. Nonetheless, this type of studies contributes to a better understanding of the impact of aerosols, and I recommend publication and suggest the authors to take into account the following comments and suggestions:

General points

The only general issue I see, is that the text repeatedly suggests that NO₂ retrievals are overestimated or underestimated ‘if the presence of aerosols is not taken into account’. This is true for clear-sky retrievals in the particular retrieval setting chosen by the authors, that is, without a cloud-correction scheme. To give the text of the manuscript a wider appeal, also addressing retrievals that explicitly correct for enhanced light paths and top-of-atmosphere radiance, I suggest the authors rephrase the text in such a way to reflect that it is not the presence of aerosols per se, but rather the effect of aerosols on light paths and TOA radiance, that needs to be taken into account to avoid retrieval biases. The paper would also benefit if the authors provide some discussion of a possible strategy to start generalizing their results; using satellite aerosol observations, or model information to overcome the limited spatial representativity of this study? also recommend investigating partly-cloudy scenes to extend beyond the clear-sky only scenes?

The manuscript could be shortened; the first 15 lines of section 2.3 could be skipped. It should be sufficient to refer to the use of AERONET data here, without mentioning all the other networks. On page 3234, lines 13-28 could be shortened too, a reader gets the point that elevated aerosol layers are a fact-of-life, and there is no need to provide a complete literature overview here. P3235-3237, section 3 could be shortened too. In my opinion the reader could do without an outline of the results first, before actually getting to them.

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Table 1 is useful, but I found it inconvenient to have to page back and forth when interpreting the Figures showing the results. My suggestion is to include in the Figure captions the specific scenario used and what this means in terms of vertical profile, AOT, single scattering albedo, etc.

Detailed points

P3226, l18: because scattering is first and foremost a physical process, I suggest to rephrase that ‘for an ensemble of photons, scattering is regarded as a statistical process’.

P3226, l22: typo, there should not be a comma after ‘both’.

P3226, l22-23: this sentence is difficult to interpret. I guess the authors mean that ‘relative to a pure Rayleigh atmosphere, aerosols change both the individual light path lengths and total radiance observed at the satellite’.

P3227, l18-20: the authors later show that viewing geometry can not be discarded, and I suggest to include viewing geometry in this listing.

P3229, l15: It is unclear what the authors exactly mean by ‘the extension of aerosol’. Is it the vertical extension, or does it also include aerosol optical thickness?

P3229, l26-29: In my view, it is not the purpose of a NO₂ retrieval algorithm to identify the type and distribution of aerosols. NO₂ retrievals are necessarily concerned with the ultimate effect of aerosols on TOA radiances and on light paths, in order to minimize the mismatch between the observed and (forward modelled) simulated TOA radiances/lightpaths (i.e. AMFs).

P3230, section 2.1: Could you please provide some more details on SCIATRAN? Was polarization included? What pressure, temperature grid (vertical spacing) has been used? What is the source of the p,T information?

P3231, section 2.2: I suggest the authors point out that CHIMERE’s model top does

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not extend above 6.5 km. Could the authors say some more about whether CHIMERE NO₂ profiles have been evaluated against profile observations? After all, the authors consider CHIMERE profiles to be ‘more realistic’.

P3237, I22-23: My suggestion is here that the authors specify their statement such that ‘if the effect of scattering by aerosols are not accounted for in the retrieval, the NO₂ VC will be overestimated’.

P3238, I12: ‘when effects of aerosols are neglected in the retrieval’.

P3239, I23-25: that the aerosol effect appears small here, appears to be at least partly due to the low single scattering albedo (0.87) in scenario J. This should be mentioned as well.

In section 3.3, it is argued that the albedo and shielding effect cancel for situations with aerosol mixed with NO₂. It seems that the AOD does not really affect this cancelling, but what about the single scattering albedo? Based on later results, would you expect shielding to become dominant over the albedo effect for lower single scattering albedos?

P3242, I17, there seems to be a redundant comma after ‘both’.

P3242, I19-20: this sentence appears a little cryptic. In fact you say everything you want to say in the two following sentences.

P3243, I7: suggest to reformulate ‘If the scattering effects of an elevated aerosol layer are not accounted for, ...’

P3243, I22: what is exactly meant here by ‘largely extended’?

P3244, I8-18: Since a good number of retrievals corrects for the effects of clouds, I think it would be appropriate make the call here for a more thorough investigation of the impact of aerosols on cloud retrievals in clear-sky and partly cloudy conditions.