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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Utilization of O_4 slant column density to derive aerosol layer height from a spaceborne UV-visible hyperspectral sensor: sensitivity and case study" *by* S. S. Park et al.

Anonymous Referee #3

Received and published: 15 September 2015

Anonymous Referee #2

General comments

This paper explores the possibility to retrieve the aerosol altitude from the O2-O2 spectral band. This is a very important topic, in particular for trace gases retrievals from the UV and Visible spectral bands where there is a need to correct for aerosol effects. I agree with the comments written by Referee #1. The study presented here appears incomplete and gives rise to various questions about all the error sources which impact the quality of the retrievals. As highlighted by Referee #1, the presented study case does not allow to validate the proposed algorithm. Some sections include some confusing elements which need to be clarified (see below for details). Moreover, it is very hard to have a critical judgement and understanding of some results as some technical details are missing on the employed approaches for the analysis and the AEH algorithm. Finally, as this manuscript focuses on the feasibility to implement an algorithm, I wonder if a submission to Atmos. Meas. Tech. would not be more appropriate than ACP. Therefore, I suggest major revisions and clarifications for this paper before being submitted again. The most important revisions (addressed in detail in the following section) include: A complete and detailed description of the proposed algorithm and the employed approaches of analysis, in particular for the error analysis (Section 3.2) and for the DOAS analysis (Section 2.2); Clarification of the results and issues risen below: in particular about the error analysis, clarify please all the reference scenarios considered, how this can change depending on the variability of the geophysical conditions, and explain in detail the reason of the somewhat surprising small impact of surface albedo; Inclusion of more than 1 study case, or at least a more convincing case.

Specific comments

Table 6 shows a summary of error sources and the total error budget for the AEH retrieval. The methodology of deriving this table should be described in more detail in section 3.2, using equations for example and giving a clear methodology. Moreover, the reference surface albedo should be given. We can expect that these numbers will change with respect to the geophysical conditions. Are these numbers based on a standard error propagation (i.e. assuming that each parameter will impact the result as random error)? If yes, the presented results may be somewhat underestimated. Indeed, uncertainties on the AOD for example will likely result in a systematic error (i.e. bias) on the aerosol altitude.

The evaluated uncertainty on the AEH retrieval induced by an error on the surface albedo of 0.02 appears surprising and should be explained (around 50 m for WASO

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case, less than 100 m for the other cases). It is much lower than the uncertainty due to the AOD (less than 200m) and SSA (between 229 and 2155 m). As explained in this paper, the AEH is strongly constrained by the O2-O2 SCD. However, this variable is also strongly driven by the O2-O2 continuum reflectance [Acarreta et al., 2004; Chimot et al., 2015] which, by definition, results from a combination of AOD (and associated additional scattering caused by aerosols) and surface albedo. Therefore, the surface albedo should be a key component (at least for a given range of AOT), and it is not understood why here this has so little impact. [Veihelmann et al., 2007] has also shown the importance of the knowledge of surface albedo for aerosol retrievals from the OMI spectral measurements. Finally, what is also missing is a theoretical discussion about the impact of clouds (e.g. in case of low cloud fractions). In the case of O2-O2 cloud retrievals, [Acarreta et al., 2004; Chimot et al., 2015] have shown that the effective cloud pressure value is very sensitive to the range of effective cloud fraction. For low cloud fraction, and thus low continuum reflectance and so low AOD, the relative variability of O2-O2 SCD is quite small and so it is more challenging to retrieve the aerosol altitude with a low uncertainty. The sensitivity of the AEH accuracy to AOD, and in general everything which impacts directly the O2-O2 continuum reflectance magnitude, should be discussed. It is expected that the AEH retrieval algorithm will be more accurate for large AOTs, while for low AOTs the AEH uncertainties should be higher.

Table 8 presents the input parameters of the LUT used for the AEH retrieval. Following my comment above, it is not clear why the surface albedo is not one of the parameters. Does it mean this LUT is generated for one single surface albedo case (in line with the value given from OMLER over your study case)? Section 3 says that "the climatological value from OMI Level 3 (OMLER) is used in this study". How is it used exactly since no input parameter is present in Table 8? Same for surface pressure or surface altitude. What was assumed for these parameters? How does it impact the result of your study case? Section 2.2 (DOAS analysis) mentions that a factor of 1.25 is used as a correction factor on the O4 absorption cross section as suggested by [Irie et al., 2011; Lee et al., 2011]. However, such a factor is commonly employed for ground-based instruments like MAX-DOAS (as done by these 2 papers). There is no explicit evidence this is needed in the general case of satellite measurements. Please explain why you considered it here. On the other hand, it is mentioned that such a factor should cover the temperature dependence of the O4 SCD. I do not think that such a scale factor can cover this effect in satellite measurements. The work by [Maasakkers et al., 2013] demonstrates that this dependence varies in time and space. This can have major impact on the effective cloud retrieval, in case of the O2-O2 cloud algorithm, mostly for cases with low effective cloud fraction (change in cloud pressure between 100 and 200 hPa). Impacts on the aerosol altitude retrieval should be investigated as well, and for different AOD.

More literature review, where the impacts of aerosols on the effective cloud retrievals should be added e.g. [Castellanos et al., 2015; Chimot et al., 2015; Lin et al., 2013; Lin et al., 2015], as they analysed the impacts on the O2-O2 spectral measurements.

As Referee #1 pointed out, appropriateness of the selected study case is questionable. It is mentioned that the AEH derived from OMI is performed for a scene at 1.5 deg (i.e. around 150 km) away from the LIDAR site. This is a very long distance. The comparison with CALIOP seems to present some large differences (1.-1.5 km for CALIOP vs. 2.6 +- 1.7 km for AEH). More or different study cases should be presented for a more robust comparison.

Furthermore, Section 2 mentions that OMI data are selected with cloud fraction fraction less than 0.02. [Chimot et al., 2015] and [Boersma et al., 2011] have shown that the OMI effective cloud fraction is very sensitive to aerosols and AOD, and can reach values between 0.1 and 0.15 for AOT = 1. However values of 0.02 may indicate very little aerosols present in the OMI data (AOT likely less than 0.2).

Technical corrections

P. 7934, 2-4: “using simulated radiances by a radiative transfer model, ... (LIDORT), and ... (DOAS) technique”. Please separate LIDORT and DOAS techniques in this

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statement. Here, DOAS could be understood as a model name, not as a retrieval technique. P. 7934, 13-14: “knowledge on the aerosol vertical distribution type”: please reformulate. Do you mean aerosol vertical distribution and aerosol type? P. 7934, 25: “in regional and global scale”: replace “in” by “at” P. 7935: The necessity to know aerosol layer height for trace gases retrievals should be mentioned too. P. 7935, 12: Change “Vertical structures” to “Vertical profiles” P. 7935, 25: “CALIOP haS been successful (not “have”) P. 7937, 12-14: Please specify that this refers to the impact of aerosols on the O4 signal. Reformulate “path length of light” as “length of the average light path”. P. 7940, Section 2.2.: Please give more details about the approach implemented for the DOAS retrievals, based on the WinDOAS software. In particular, specify what you mean by “using a non-linear least squares method”. Some equations with the retrieval state vectors and considered / assumed elements would help the reader. P7940, 22-23: “comparison of the 477 nm O4 SCD between the inversion from a LUT”: which LUT are you refereeing here? No LUT is explained before in the manuscript. And there is no use of a LUT usually to derive the O4 SCD.

Recommended additional literature

Acarreta, J. R., De Haan, J. F., and Stammes, P.: Cloud pressure retrieval using the O2-O2 absorption band at 477 nm, J. Geophys. Res., 109, D05204, doi:10.1029/2003JD003915, 2004. 8388, 8399, 8400, 8402

Castellanos, P., Boersma, K. F., Torres, O., and de Haan, J. F.: OMI tropospheric NO2 air mass factors over South America: e_ects of biomass burning aerosols, Atmos. Meas. Tech. Dis25 cuss., 8, 2683–2733, doi:10.5194/amtd-8-2683-2015, 2015. 8389, 8408.

Chimot,ÂăJ., Vlemmix,ÂăT., Veefkind,ÂăJ.ÂăP., deÂăHaan,ÂăJ.ÂăF., and Levelt,ÂăP.ÂăF.: Impact of aerosols on the OMI tropospheric NO2 retrievals over industrialized regions: how accurate is the aerosol correction of cloud-free scenes via a simple cloud model?, Atmos. Meas. Tech. Discuss., 8, 8385-8437, doi:10.5194/amtd-

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Lin, J.-T., Martin, R. V., Boersma, K. F., Sneep, M., Stammes, P., Spurr, R., Wang, P., Van Roozendael, M., Clémer, K., and Irie, H.: Retrieving tropospheric nitrogen dioxide from the Ozone Monitoring Instrument: e_ects of aerosols, surface reflectance anisotropy, and vertical profile of nitrogen dioxide, Atmos. Chem. Phys., 14, 1441–1461, doi:10.5194/acp-25 14-1441-2014, 2014. 8388, 8389, 8408.

Lin, J.-T., Liu, M.-Y., Xin, J.-Y., Boersma, K. F., Spurr, R., Martin, R., and Zhang, Q.: Influence of aerosols and surface reflectance on satellite NO2 retrieval: seasonal and spatial characteristics and implications for NOx emission constraints, Atmos. Chem. Phys. Discuss., 15, 12653–12714, doi:10.5194/acpd-15-12653-2015, 2015. 8409.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C6873/2015/acpd-15-C6873-2015-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 7933, 2015.