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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simultaneous Retrievals of Polar Mesospheric Clouds (PMCs) with Ozone from OMI UV measurements" *by* J. Bak et al.

J. Bak et al.

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The authors thank the referee for providing the constructive comments on our paper.

Comment #1: My main comment is that the relative importance of this PMC light scattering effect for OMI is not made clear. It is not clear from the paper how often this PMC effect occurs, and if there is any trend. Only two months from the entire OMI 11-year time series are considered. It is not clear how representative these two months are. Please provide more information and more statistics on the PMC effect for OMI, and preferably provide also a trend.

Response #1: The main purpose of this paper is to demonstrate the impacts of PMC on our OMI nadir ozone profile retrieval and develop an approach to reduce the impacts

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through simultaneously fitting PMCs. We think that using two months of OMI data is adequate for this purpose and these two months (one for NH PMC season and one for SH season) are representative. The occurrence of PMCs is well defined: hemispheric summer season ($\sim$ 30 days before to $\sim$ 65 days after summer solstice) at high latitudes and occasionally at mid-latitudes. So OMI retrievals will be affected during the season of PMCs. Studying the frequency, the spatiotemporal distribution, and trend of the PMC effect is beyond the scope of this study and can be a very good subject of another paper.

Comment #2: Missing are references to the PMC work done with the SCIAMACHY nadir and limb modes by Von Savigny, Burrows, et al.

Response #2: To our knowledge, there are no published papers about analysis of SCIMARCH nadir measurements for PMC, except for a presentation at a conference this summer “Langowski, M. P., and von Savigny, C.: Detection of noctilucent clouds in SCIAMACHY/Envisat nadir UV-measurements, presented at the 12th International Workshop on Layered Phenomena in the Mesopause Region, Boulder, CO, 10-13 August 2015”. According to Reviewer 1 and 2, we have added some sentences to describe previous PMC works from other limb sensors including SCIAMARCHY in the introduction part of this revised manuscript.

Comment #3: Please also provide altitude in km when giving pressure levels. E.g. in the abstract, line 7: "... above 6 hPa ...": this is an unclear formulation: do you mean pressures higher than 6 hPa, or do you mean altitudes above the altitude level where the pressure is 6 hPa? Please give also a height range. In Figs. 1, 2, 6 and 9, please give also any-axis with altitude in km.

Response #3: It means the pressures less than 6 hPa. We have revised the indicated sentence for more clarification to “at pressure less than 6 hPa ($\sim$35 km)” and included km-axis in Figures 1, 2, 6, and 9.

Comment #4: Please change the formulation "BUV radiances" into "OMI radiances" or

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just UV radiances, since BUV was also a satellite instrument. This acronym with the word "backscattered" does not add any information. For example, change the title of sect.3.2.

Response #4: We have corrected the “BUV radiances” to “UV radiances”.

Comment #5: Conclusions: please say more about the importance of the PMC effect for OMI, and possibly other instruments, like GOME-2 or OMPS.

Response #5: We have revised Section4. Summary and Discussion to include some important points including the importance of the PMC effect for other nadir-viewing instruments.

-Revised text (page 14, line 343-346): Despite the large relative biases in the upper atmosphere, the impact of PMCs on our retrieved total ozone ($\sim$305 DU for the NH summer polar region) is negligible with the absolute biases of $\sim$ 0.05 DU at 0.5 hPa.

-Revised text(page 15, line 374-402): This study indicates that the impact of PMC scattering is likely not negligible for stratospheric ozone retrievals from OMI, SBUV, SBUV/2, GOME, GOME-2, SCIAMACHY, and OMPS Nadir Profiler as the effects of PMCs have not been taken into account in any of the operational ozone profile algorithms. The presence of PMCs has greater influence on our OMI ozone retrievals compared to the PMC-induced errors on SBUV and SBUV/2 ozone retrievals shown in Thomas et al., (1991) and Bhartia et al. (2013), which could be explained by OMI having more chances to see brighter PMC pixels due to its much smaller pixel size and by our algorithm using continuous wavelengths of 270-330 nm whereas the SBUV algorithms use several discrete wavelength bands between 240 and 340 nm. In addition, the different ozone retrieval algorithms have different sensitivity to PMC contamination. For example, PMC-induced errors in Nimbus-7 SBUV ozone data based on the NASA Version 5 algorithm (McPeters et al, 1980) can be as large as 10 %. Recently, Bhartia et al. (2013) did some analysis of PMC effects on NOAA-18 SBUV/2 ozone data using the NASA Version 8.6 algorithm and found that the average effects are typically in the

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2-3% range. Likewise, the OMI operational ozone profile product, OMO3PR (Kroon et al., 2011) has different response to PMC contamination due to different implementation details although it is also based on optimal estimation with the same fitting window; the comparison between two OMI algorithms has been described in Bak et al., (2015). We compare the OMO3PR ozone product between PMC and non-PMC pixels, similarly to Fig. 1.a (not shown here). The impact of PMCs on the OMO3PR product is comparable to our ozone retrievals below 0.1 hPa, but becomes smaller above them with erroneous ozone reduction of $\sim$ 10% at 0.5 hPa. This smaller impact is likely due to fitting of second-order polynomial radiance offsets to account for stray lights [Personal communication, P. Veefkind], which is not used in our algorithm. The impact of PMCs on total ozone retrievals such as OMTO3 (Bhartia and Wellemeyer, 2002) and OMDOAO3 (Veefkind et al., 2006) are negligible because the total ozone algorithms use longer wavelengths than 310 nm where the PMC signal is very weak and the impacts of PMCs on the ozone columns are too small to affect the total ozone retrievals.

Textual corrections:

Comment#1: often the article "the" is missing.

Response#1: We have paid careful attention to “the”.

Comment#2: p. 25908, l. 10: wavelength

Response#2: We have changed “depends on wavelengths” to “depends on wavelength” in abstract.

Comment#3: p. 25910, l. 12: 550 > 500

Response#3: We have changed “550” to “500”.

Comment#4: Please provide here a reference to Levelt et al., 2006 for the OMI instrument and level-1 calibration.

Response#4: We have inserted this reference in Sect 2.1.

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Comment#5: p. 25913, l. 22: "for with/without": please reformulate

Response#5: We have corrected them to “with and without”

Comment#6: p. 25914, l. 24: that > who

Response#6: We have changed “that” to “who”.

Figures:

Comment#1: Fig. 2: explain N, give the years/months.

Response#1: The “N” indicates the number of samples used for comparisons and the year/months was given in the Figure 1. For clarification, we have revised the caption as follows: “Same as Figure 1, but for the mean differences (solid lines) between OMI and collocated MLS convolved with OMI averaging kernels, (OMI-MLS)/OMI a priori$\times$100 %, and their 1σ standard deviations (dashed lines) for PMC (red) and non-PMC (black) pixels. The number of collocations (N) is shown in the legend.”

Comment#2: Fig. 5: is this figure really needed? You could summarize the information into a few sentences.

Response#2: We think that it is useful to keep this figure. This figure shows visually the dependence of the retrieved POD errors on various angle parameters.

Comment#3: Fig. 9: it is unclear what the relation is between the numbers indicated with # in the legend and the numbers given in the caption.

Response#3: This comparison of differences between OMI and MLS is performed from both PMC and non-PMC pixels. “#” of the legend indicates the number of pairs for each comparison and the caption indicates the number of PMC pixels among “#”. We have revised the caption and figure for more clarification; the numbers of the Non-PMC and PMC pixels are included as legends.

Please also note the supplement to this comment:

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http://www.atmos-chem-phys-discuss.net/15/C11438/2016/acpd-15-C11438-2016-supplement.pdf

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