Responses to Anonymous Referee # 3

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

General Comments:

This paper describes the results of modeling and simulation studies to characterize biases in the OMI ozone profile retrievals due to contamination by PMC scattering in the polar summertime regions. Clear correlations are seen between negative ozone biases at higher altitudes (as determined by coincident OMI/MLS comparisons) and the presence of PMC's. It is then shown how these biases can be largely eliminated by simultaneously retrieving a PMC optical depth parameter along with the ozone profile.

This study is useful in that it characterizes, and provides a solution for, a clear source of error currently affecting the operational ozone product from OMI. Furthermore, this has larger implications, as the authors point out, because several other similar UV nadir pointing ozone experiments are likely similarly affected by PMC contamination.

The paper is well written and thorough, and is suitable for publication in AMT. I recommend it be accepted for publication after the authors address the issues raised below. These are not serious criticisms and I do not need to see a corrected version of the manuscript before publication.

Specific Comments:

Comment #1: In Section 1, the discussion starting on line 46 of limb-viewing instruments, the SOFIE instrument on AIM should be mentioned as it provides an extensive record of these parameters.

Response#1: the SOFIE has been inserted in the sentence listing the limb-viewing instruments for PMC detection, with the reference ""Hervig, and Stevens, (2014): Interpreting the 35 year SBUV PMC record with SOFIE observations".

Comment #2: Line 52 – "water vapor content" should be "ice water content". There is no water vapor in PMC's. In Section 1, the discussion starting on line 57 of nadir-viewing instruments, the CIPS instrument on AIM should be mentioned.

Response #2: We have changed "water vapor" to "ice water". We have revised the manuscript to mention the CIPS PMC observation "CIPS onboard the Aeronomy of Ice in the Mesosphere (AIM) images the polar atmosphere at a variety of scattering angles and thus provides a direct measurement of the cloud scattering phase function from which the size distribution, index of refraction, and shape of the ice particles could be derived (Bailey et al., 2009)."

Comment #3: Figure 1 – How did you define both PMC and non-PMC averages for the OMI data alone (the black curve in top panels)? Does this involve averaging neighboring PMC/non-PMC pixels? Over what areas is the averaging done? Also, what is the origin of the kink in the OMI O3 profiles near 1 hPa shown in the bottom panels? This does not look physical at all and it's interesting that it looks almost identical in both hemispheres. It also corresponds exactly to the point at which the PMC effect on ozone starts. Surely this is an artifact of some kind?

Response #3: As we noted in Section 2.2, PMC and non-PMC pixels are classified from the OMI PMC detection product by Deland et al. (2010). We performed OMI retrievals at MLS-collocated pixels. OMI (MLS) ozone profile retrievals are averaged over PMC pixels and non-PMC pixels, respectively. We plotted the difference of mean ozone profiles between PMC and non-PMC cases. For clarification we have revised the caption, "Difference in OMI (black)/MLS(red)/MLS convolved with OMI averaging kernels (green) mean ozone profiles between PMC and non-PMC pixels, as functions

of MLS layers, for (a) NH 2007 (July 2007, 75˚N-85˚N) and (b) SH 2008 (January 2008, 75˚S-85˚S) summer seasons, respectively." As we noted in responses to Review 2's comment #2, the kink of the OMI O3 profiles is caused by interpolating OMI partial columns into the MLS grids for comparison.

Comment #4: Line 240 – Here you are just comparing the PMC-induced error you just derived for OMI, based on comparison to MLS, to the REPORTED ozone error bars for SBUV and SBUV/2. Those errors could in principle be larger than reported if in fact SBUV was also biased by PMC's. Has that analysis been done (i.e., is this effect included in published SBUV error bars)?
Response #4: Sorry for the confusion. The errors for SBUV are not overall ozone error bars from various sources but also PMC-induced errors. To clarify this, we have changed the original sentence "~10% PMC-induced error in individual SBUV ozone retrievals based on the SBUV version 5 algorithm (Thomas et al., 1991) and mean PMC-induced errors of up to 2-3 % in SBUV/2 ozone retrievals based on the SBUV version 8.6 algorithm.

Comment #5: Line 243 – I am not sure I understand the comment about how the different wavelength ranges used by OMI and SBUV explain the larger PMC effect on OMI. SBUV uses even shorter wavelengths than OMI, PMC scattering increase at shorter wavelengths, correct? Please clarify. (The horizontal resolution argument makes much more sense to me).
Response #5: You are correct that it is not clear about which instrument has larger impact based on the wavelengths. So we have removed that sentence and changed it to "This is mainly because the spatial resolution of OMI…"

Comment #6: Line 269 and discussion in section 3.2 – Please define physically what VZA and AZA are. It is hard to understand the dependencies shown in this section without a physical picture of what these angles are. They are only given names in Section 2.2 but not described geometrically. The key point is how does either of these angles affect the scattering angle. What is the range of PMC scattering angles measured by OMI? Here's a related question – is the POD defined as the vertical optical depth? In other words, is it normalized by the slant view angle of the line-of-sight (path length effect)? If so that should normalize out effects of varying view geometries, other than the scattering angle dependence.
Response#6: The terminologies of "SZA, VZA, and AZA" are commonly used for the satellite remote sensing and radiative transfer model. The VZA (SZA) is the angle between satellite (Sun) and a line perpendicular to the Earth's surface at the view point, AZA is the angle between sun and satellite vectors projected on a plane tangent to the Earth's surface. We think that it might not be necessary to insert this definition. However, according to the reviewer's comment, we have added in the last sentence of section 2.2, "The scattering angles vary between 60° and 160° ". The POD is defined as the vertical optical depth. We directly include the POD as the state vector, and the normalization to the path length is implicitly taken into account through the PMC jacobian.

Comment #7: Figure 7 – I am confused about a couple of things in these results. Do the symbols in these figures represent all the pixels for this orbit? How is the classification of PMC/non- PMC made – is this based on the separate OMI PMC cloud detection algorithm? If this is correct then I assume what you're doing is running your combined POD+Ozone retrieval on all pixels regardless of PMC classification. The non-PMC/non-zero POD values (greysymbols) then represent "false detections" of your algorithm in some sense. These values seem highly structured in SZA – do you know the origin of this structure?
Response #7: It is indicated that these results are derived from OMI orbit number 15881 and cross-

track position 13 (on 10 July 2007) in the caption. Yes, the PMC/non-PMC classification is based on separate OMI PMC detection algorithm and separate OMI PMC product developed by Deland et al. (2010). We performed POD + Ozone retrieval on all pixels regardless of PMC classification, we have inserted "We should note that POD retrievals are performed over all pixels regardless of PMC classification" before the discussion on Fig 7. Yes, non-PMC/non-zero POD values represent a combination of false detection of the PMC detection algorithm and the POD retrieval uncertainty. As the SZA increases northward along the orbit, so we plot the data as a function of SZA. The PMC structures vs. SZA reflect the spatial distribution of PMC.

Minor/editorial corrections:

Line 47 – "… brightness, AND altitude…"
Line 49 – "Explore" should be "Explorer"
Line 55 – "through" should be "though"
Line 190 – this sentence needs to be edited.

We have accepted the comments for Lines 47, 49, and 55. The sentence in Line 190 has been revised to "We assumed PMCs to be spherical ice particles with a log-normal size distribution ($r_o = 55$ nm, $\sigma_g = 1.4$) because the particle shape plays a minor role in the UV scattering".