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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Validation of Ozone Monitoring Instrument (OMI) ozone profiles and stratospheric ozone columns with Microwave Limb Sounder (MLS) measurements" *by* X. Liu et al.

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Response to referee 2's comments

We would like to thank the referee for constructive comments on our paper. We have addressed them as follows and made changes in the revised manuscript.

General:

My major comments refer to a lack of systematic error estimation for the OMI ozone data and a possible estimation of horizontal smoothing errors of the MLS profiles.

Response: These comments are answered following these specific comments.

Specific:

S.1 p. 24915, l. 6 and p. 24929, l. 15: 'and it demonstrates implicitly that tropospheric ozone column can be retrieved accurately from OMI or similar nadir-viewing ultraviolet measurements alone.' To support this conclusion, at least a reference to the validation of the total ozone column amounts has to be given.

Response: We modify ", and also serves as an implicit validation of our TOC retrievals, since TOZ can be derived accurately from OMI" on p24917 lines 10-11 to ". It also serves as an implicit validation of our TOC retrievals since total ozone column can be derived accurately from nadir-viewing backscattered ultraviolet radiance spectra using our retrieval algorithm (Liu et al., 2005; Liu et al., 2009)." Two references are added. The first reference showed that GOME total ozone from our algorithm compares very well with TOMS, Dobson and Brewer measurements. Both references show that our estimated retrieval errors due to random-noise and smoothing errors in total ozone are in the few DU range for both GOME and OMI.

Our profile algorithm is also an advanced total ozone algorithm in that it utilizes almost all the spectral information available in the UV radiance spectra (providing stronger sensitivity to lower tropospheric ozone) and the retrieval of vertical profile reduces the dependence of total ozone retrieval on profile shape (which can be an important source of error at larger solar zenith angle). We plan to write a paper to highlight the quality of our retrieved OMI total ozone column through validation against OMI operational products.

S.2 p. 24919, l. 1: The authors should also provide an estimation of systematic retrieval errors or at least a list of leading systematic errors for OMI.

Response: As mentioned in our algorithm paper (Liu et al., 2009), errors due to forward model and forward model parameter assumptions are generally much smaller compared to the smoothing errors. The main sources of these errors are systematic errors in temperature and cloud-top pressure. A systematic 3 K temperature error leads to about 10% errors for individual tropospheric layers, and a 100-hPa error in cloud-top pressure causes 6-7% errors in the troposphere for average cloudy conditions. Systematic measurement errors (especially those varying with wavelengths) are the most difficult to estimate largely due to lack of full understanding of the OMI instrument calibration. We will determine systematic measurement errors remaining after soft calibration through intercomparison with other measurements.

In the revision, we added "Errors due to forward model and forward model parameter assumptions are generally much smaller compared to the smoothing errors. The main sources of these errors include systematic errors in temperature and cloud-top pressure. Systematic measurement errors (especially those varying with wavelengths) are the most difficult to estimate largely due to lack of full understanding of the OMI instrument calibration. We will determine systematic measurement errors remaining after soft calibration through intercomparison with other measurements" before "For more details."

S.3 p. 24920, l. 23: Here, the horizontal smoothing errors in MLS data using OMI data as the truth should be discussed. MLS as a limb sounder has a much worse horizontal resolution than OMI and in principle the OMI horizontal profiles should be convolved with the horizontal averaging kernel of MLS. Could the authors give any quantitative information how this horizontal smoothing errors could affect the comparison?

Response: Although we did not mention MLS horizontal smoothing errors specifically,

the source "geophysical variability due to different footprints" includes part of it. To be more specific, we change it to "geophysical variability and OMI/MLS horizontal smoothing errors due to different footprints (OMI pixel size is smaller by a factor of ˜15 along the track but larger by a factor of ˜8 across the track)." It should be noted that analysis of MLS horizontal smoothing errors is not straightforward not only because OMI has coarser vertical resolution but also because MLS horizontal averaging kernels are two-dimensional (along-track x vertical, i.e., different tangent heights along the track). We plan to simultaneously investigate both MLS along-track smoothing and OMI vertical smoothing in a separate study.

S.4 p. 24924, l. 6: ‘In addition, OMI still shows some crosstrack position dependent biases. Could you give a reference for this together with typical crosstrack error values?

Response: Cross-track position dependent biases (especially for those extreme off nadir angles) are common to all the OMI products likely due to cross-track dependent radiometric calibrations. In our retrievals, cross-track dependent errors in the upper and middle stratosphere (derived by assuming ozone fields averaged over 7 days do not vary with cross-track position) are generally within 3% for most cross-track positions (UV1 position 4-27), but could be up to 8% for the first and last 3 position. In the lower stratosphere, these errors are generally within 5% for most cross-track positions, but could be up to 15% for these extreme off-nadir positions. In the OMI/MLS comparison, the coincident position varies from 20 in the tropics to 15 at higher latitudes. Therefore, these errors are up to 5% in the UT/LS region and within a few percent at higher altitudes.

We changed the sentence "Since the cross-track position collocated with MLS varies with latitude, cross-track position-dependent biases in OMI retrievals can also contribute to these overall OMI/MLS biases" to "For OMI/MLS coincidences, the OMI cross-track position varies from UV-1 position 20 in the tropics to UV-1 position 15, cross-track position-dependent biases in our OMI retrievals can be up to 5% in the upper troposphere and lower stratosphere and within a few percents at higher altitudes. These errors will also contribute to these overall OMI/MLS biases."

Technical:

p. 24923, l. 11: ca -> can

p. 24923, l. 22: Latitude and SZA -> altitude and SZA

Figures 4,5: Units should be indicated.

Figure 9: Please state the size of the area [xDU ? yDU] on which the density is defined.

Figure 10: diamonds -> squares

Response: We made these changes. We added in Figure 9 caption "The color scale shows the percentage of observations falling in 5 DU x 5 DU areas."

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 24913, 2009.