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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Comparison of ozone profiles and influences from the tertiary ozone maximum in the night-to-day ratio above Switzerland" *by* Lorena Moreira et al.

Anonymous Referee #1

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General Referee Comments:

This manuscript (by Moreira, Hocke, and Kampfer) describes comparisons of ozone profiles above Bern, Switzerland, between a ground-based millimeter-wave ozone spectrometer (GROMOS) and space-based data from the Aura Microwave Limb Sounder (MLS). The somewhat minor atmospheric discussions (that might justify submitting this work to ACP rather than AMT, for example) deal with the tertiary peak in ozone in (and above) the mesosphere as well as mesospheric diurnal and seasonal changes.

My main criticism has to do with the fact that there is not too much new regarding the upper atmosphere (e.g., Sonneman et al., 2007, and refs. therein mention the mid-

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dle mesospheric maximum in ozone and its extension to mid-latitudes), and that the comparisons are not performed with too much attention to potential explanations of differences versus the satellite data near 0.05 hPa, which is near the upper range for both instruments, and in a region where the measurement response starts to weaken. If one wants to understand the absolute differences as well as differences in the seasonal variations, more care should be taken to clearly demonstrate the sensitivity to the profiles both above and below 0.05 hPa, as this region is close to a minimum in ozone, and can be quite sensitive to the profile and its a priori, in particular for pressures in the 0.02 to 0.005 hPa region. This is of concern when there are week-long periods during which the MLS and GROMOS tendencies vary in opposite ways (see Fig. 6), even if the annual cycles agree in a broad, semi-quantitative sense. It would be much better to at least give potential reasons, backed up with some quantitative analyses, especially since this is one of the main reasons for this manuscript (otherwise, one can refer to the work by Moreira et al., 2015, which was focused more on trends and limited to the more "valid" vertical range below 55-60 km). There should be a more complete discussion of how things are different in the new plots of averaging Kernels and acceptable vertical range, or one is left wondering whether the vertical range limit of 0.05 hPa is actually too optimistic (the recommended range in Moreira et al., 2005 stops at about 0.3 hPa, after all). What is new, and how does the newer retrieval really compare to the older one? This is discussed only briefly, but with essentially no comparison or detailed discussion.

Furthermore, Fig. 2 implies that MLS ozone values tend to be larger than GROMOS retrievals for pressures less than about 0.2 hPa (and larger by more than 50% near 0.05 hPa), wheras Fig. 5 shows GROMOS values usually larger than MLS values at 0.05 hPa (both day and night). This really would need to be clarified, besides the sensitivity tests that I am suggesting, given how sensitive to the region 10 km above and below the target altitude the GROMOS retrievals will be. Also, the MLS retrievals are not recommended for pressures less than 0.02 hPa; therefore, there is some sensitivity to MLS a priori values (for pressures less than 0.02 hPa) for the convolution

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of MLS profiles that attempt to simulate the GROMOS vertical smoothing. If the authors feel that these more detailed analyses are somehow "beyond the scope" of this paper, then this remains too qualitative a study, in my view, and probably not worth publishing (essentially as is) in ACP; I would suggest shifting this to AMT in this case, which does not mean that somewhat better explanations for the differences should not be attempted. Finally, other datasets, such as MIPAS or ACE-FTS could be useful in helping to determine whether or not the absolute values and variations implied by GROMOS are sufficiently robust - or whether there are some significant issues with some of the satellite datasets. Such a study would be much more useful (wherever it gets published). I find that this work, at the very least, requires substantial clarifications (in addition to more relevant references regarding MLS data).

More specifics:

The ozone profile has a minimum in the region where the manuscript attempts to focus the reader's attention (near 0.05 hPa). Above and below this, there are strong gradients (with somewhat smaller values above, and then much larger values for pressures less than 0.01 hPa, especially during the night, and increasing values as well for lower altitudes into the upper stratosphere and lower mesosphere). The low resolution GROMOS profiles will depend on quite a range of values (within about 10-15 km of 0.05 hPa, above and below). The convolved results for MLS profiles (for comparison to GROMOS) also are taken over a limited time (very short compared to the observation period for GROMOS, which is at least an hour or two). Given that the lifetime of ozone is short in the middle mesosphere, there is also no discussion of the impact of the temporal sampling (or averaging) on these measurement comparisons. Obtaining larger values near 0.05 hPa for MLS (Fig. 2), if that has the right sign, could come from a priori values for pressures near or less than 0.01 hPa that are too large. Another potential explanation could be that GROMOS really does not have enough sensitivity at the uppermost altitudes and may therefore not sense the larger values well enough. Sensitivity tests or retrieval simulations could help determine what seems more plau-

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sible as an explanation (or it may be an unknown systematic effect). One should note that MLS profiles have been validated in the past for this region (see Boyd et al., 2007), and even though this comparison was versus microwave ground-based data as well, the agreement seemed to be significantly better than implied by the manuscript under review here.

Nevertheless, even if one can accept some systematic difference as large as 50%, why are the temporal tendencies sometimes different in Fig. 5? A more extended "reach" into the uppermost region from GROMOS (where MLS may follow a priori more) could explain the larger variability and larger values seen in Fig. 5 for GROMOS (especially at night). It seems more difficult to explain how one curve goes up for certain weeks while the other curve is coming down (or is flat), although I suspect that differences in sensitivity and resolution can account for much of this (What else could it be? This is not just an absolute value issue). For example, Fig. 3 in Sonneman et al. (2007) shows that different altitudes in a model simulation of ozone exhibit different temporal changes, so this could explain the results in the manuscript here, in theory, with different sensitivities to different altitudes (in turn, the variations can be caused by rapid wintertime changes in dynamics, temperature, and H2O, as mentioned in the above reference). In the manuscript, Fig. 4 does not include scatter plots or correlation coefficients for pressures less than 0.6 hPa, but the results are undoubtedly not as satisfying as at lower altitudes.

There are also a significant number of details to clean up (see below).

Smaller or more detailed comments:

Page 1, Line 10 (P1L1): the mean relative difference [singular] and its standard deviation increase with altitude up to 50% at 70 km. (I assume you mean that both the bias and the standard deviation are > 50%).

P1L15: not sure what is meant by "anomaly" here (better to use words like "wintertime enhancement").

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P1L19/20: "...are its independence from solar irradiation and..."

P1L22/23: I suggest more concise wording, e.g. "Stratospheric ozone, in spite of its small abundance, plays a beneficial role by absorbing..."

P2L1, I would delete "Thus" at the beginning of the sentence.

P2L23: Suggested wording, "source of odd-hydrogen, coupled with no decrease [or no change] in the production of odd-oxygen..."

P2L29: a short discussion, and the conclusions are summarised in Section 5.

P3L26: Is the estimate of the a priori contribution not (more precisely) equal to 1 - the area, rather than the area itself? Then also, "We consider that the retrieval range is reliable where the true state dominates over the a priori information, ... I would note that this new retrieval characteristic is indeed quite different from past GROMOS papers, where it was not as well characterized near 0.05 hPa, but showing how the new and old retrieval compare, both in biases and in temporal behavior, would be very useful in order for the reader to decide how these are different (and how different versus MLS also). It is not immediately clear what helps to provide the extra information at high altitudes that was not present in earlier retrievals (clarify please). Usually this can come if one adds spectral channels, for example, or if one changes the smoothing characteristics in the retrievals (obtaining noisier retrievals but with more vertical information). In this respect, you quote the vertical resolution of the new retrieval, so comparing that to the old version would be useful as well.

P4L4: For the heading, why not capitalize "Microwave Limb Sounder" also?

Proper documentation/reference for the MLS data should be included. For example, the MLS website points to Data Quality Documentation (Livesey et al.) for version 4 data (including how to properly screen the data), and there are past references for validation as well (including Boyd et al., JGR, 2007, mentioned here already).

P5L2: Change "relies" to "lies".

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P5L13: Change altitudes to altitude. Also, the last sentence in section 3 does not convey anything new and could be easily deleted.

P6L2: typo in "Germany".

P6L14: Change "shown" to "show"; delete "the" before "Figure 6".

P6L17: I suggest "although the latter data exhibit larger amplitudes".

P6L18: whereas at Lindau, winter-to-summer values vary by a factor of 2-3...

P6L19: definition of the MMM being restricted to high latitudes, we can report its observation with a smaller amplitude at mid-latitudes.

P6L23: Change "spaced-based" to "space-based".

P6L26: "we report good agreement between the new retrieval..."

P6L27: Change "Further" to "Furthermore".

Fig 2. I would say "The middle panel shows the mean relative difference..." Also, The mean absolute difference and its uncertainty (blu area) are displayed in the right panel. [with a period after the last word in the Fig. captions]. By the way, more needs to be clarifued here: is this for daytime or nighttime (presumably not) or for an average of day and night? The red line could be made thinner to allow one to see the blue line below it, or make the red line dashed maybe.

Fig. 3: Is this for nighttime data only or both averaged (it may not matter too much at these lower altitudes but still worth clarifying)?

Fig. 4: Same question as for Fig. 3 (same answer presumably).

Fig. 5: Change "ans the second panel" to "and the second panel".

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