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Atmospheric Measurement Techniques Discussions

# *Interactive comment on* "Explorative study on GOME-2 total column ozone retrievals and the validation with ground-based and balloon measurements" *by* A. Wassmann et al.

**Anonymous Referee #1**

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The authors present in this study a series of sensitivity tests for total ozone retrievals from the GOME-2 instrument aboard METOP-A. In particular, they demonstrate that the removal of the smoothing error term via the application of satellite averaging kernels on the 'true' ozone sonde profile reduces the systematic satellite-ground-based differences. They also assessed the impact of the instrumental degradation on their product, and showed that it can be mitigated using simple relative correction factors computed specifically for their fitting interval. A series of other sensitivity tests allowed to estimate the impact of different factors, including cloud contamination, radiative transfer model approximations, and polarization.



This paper fits well within AMT. It is well structured and the results are clearly presented. However, I have a few major comments that should properly addressed before this study can be published in AMT.

**Major comments:**

- The authors tend to put in opposition total O3 products generated using given a priori profiles and their effective column approach. To my opinion, such a distinction doesn't make sense. Indeed, using a single (scaled) O3 profile is somehow a very simple climatology. I think that the important message is that a smoothing error is associated to every O3 column estimate and that this error is directly related to the quality of the a priori profile data base. Providing the averaging kernels is important in any case to allow users to apply them in case they have more reliable a priori information. Of course, when using a single profile for all ozone retrievals, having the averaging kernels is even more important as the smoothing error associated to the "effective" column will be generally much larger. Without those kernels and realistic information on the true profile, the effective columns are probably useless in numerous conditions on contrary to a total O3 product generated with a more reliable a priori profile data base. In summary, I think the best option is to use the best a priori profile database for the retrievals and also to provide users with averaging kernels. Since the authors used a better climatology in the validation section, I think that they will agree with that statement but they should provide a clearer message through the whole manuscript.

- It is not exact to say that Lerot et al. (2014) rely on the scaling of a reference profile. They use a total O3 column classified climatology, which provides O3 profiles as a function of the month, latitude and the O3 column itself. The stratospheric profile shape depends therefore on the O3 column. At each iteration of the fit, the appropriate O3 profile is interpolated through the database (see also Van Roozendael et al., JGR, doi:10.1029/2005JD006375). Because of this, the

product quality is expected to be better than using a simple scaling approach. In addition, the O3 products presented in their work also contain the averaging kernels as well as a priori profiles corresponding to the retrieved columns. Please adapt the manuscript wherever it is necessary.

- Page 4920 - lines 28-29: Have you estimated how a real trend in the ozone columns would impact this assumption? I agree that for short time series, it is not really relevant, but that might be the case for longer periods.

- Page 4923 - lines 16-19: Have you verified that the spectral structures of the ratio of the tabulated reflectances do not depend significantly on the viewing zenith angle, azimuth angle, albedo and altitude height?

- Page 4923 - lines 23-29: Could you specify the instrumental spectral response function you use in your algorithm? Could you explain the physical origin of the two spectral calibration parameters? Does $\Delta\lambda_s$ account for the Doppler shift and $\Delta\lambda_{ISRF}$ for possible wavelength registration issues in the measured solar spectrum? Are those two parameters not cross-correlated in the fit?

- Pages 4927-4928 and Fig. 1: Please provide additional information on the parameters used for the simulations (solar and viewing zenith angle, cloudiness, albedo,...). The impact of the a priori information may be significantly dependent on those parameters. In particular, at extreme solar zenith angles (>80$^\circ$), the error due to the a priori profile may increase up to several percent. So stating that the error due to the profile is on the order of 1% is overoptimistic for those conditions. Could clarify this in the text and provide specific estimates at those large SZAs?

- Removing the smoothing error from the satellite-ground-based comparisons with the application of the averaging kernels relies on the linearization of the forward model. I wonder how efficient is the process when the a priori profile used for



the inversion is very different than the real profile (e.g. the US standard profile is used for retrieving columns in ozone hole conditions). Have you tested this? I'd recommend to perform a few sensitivity tests to better assess what are the possible limitations of the approach.

- Page 4929 - lines 26-27: Do you have any idea why the statistics is poorer for pixel 1? Systematic clouds? Does it mean that pixel 1 is systematically discarded in your O3 column product?

- Page 4931 - lines 18-20: It is also important to mention that the systematic error in the Dobson measurements due to their temperature dependence leads to significant seasonal/SZA dependences at mid- and high-latitudes. This is most likely the main cause for the larger SZA dependence in the satellite-Dobson differences in the validation section. You should adapt the text accordingly.

- Page 4935 - line 12: Again for high latitude stations, the error may be much larger, especially in local winter and during the ozone hole season.

- In the paragraph dealing with the effect of cloudiness, could you clarify how you model the effects of clouds within your algorithm (IPA?)? Do you add a ghost column to account for the partial O3 column between the cloud and the ground or is the systematic underestimation in case of strong cloud contamination could come from the shielding effect?

- Page 4939 - line 14 (and abstract): I wouldn't say that polarization can be completely ignored as the current goal in the development of total ozone algorithms is to reach a level of 1% accuracy in most geophysical conditions. To reach that level of accuracy, I think that the forward model should be as accurate as possible, and including polarization contributes to this. Although I agree that the effect is relatively small, some seasonal-dependent errors may be reduced when accounting for polarization.

- About the analysis of the instrumental degradation, is it not possible to extend the analysis to the full time series? We have now more than eight years of GOME-2A data, while only the first four years are presented here. That might give an even more convincing demonstration of the importance of correcting for this degradation to have accurate retrievals.
- Page 4943 - lines 13-15: This has already been reported in Loyola et al. (JGR, 2011, doi:10.1029/2010JD014675). You might refer to this study.
- Fig. 16: The Lerwick Dobson station is not really appropriate for this illustration as the Dobson measurements suffer from a SZA dependence due to the temperature seasonal variation. The SZA is unfortunately directly correlated to the scattering angle. Could consider to use a Brewer station instead?

**Editorial comments:**

- Page 4919 - line 27: The latest version of the operational O3MSAF/EUMETSAT total ozone product is GDP v4.7 and has been presented in Hao et al., AMT, 2014 (doi:10.5194/amt-7-2937-2014). You should use this reference.
- Page 4920 - line 2: "measurments" to be replaced by "measurements"
- Page 4920 - line 3-4: please specify which data products and versions have been used in that study for those different sensors.
- Page 4923 - line 10: I would specify that several O3 cross-sections at different temperatures are used.
- Eq. (9): please define 'i'
- Page 4930 - line 20: one extra comma.



- Page 4932 - line 16: I think $\chi^2$ is not defined.
- Section 4.2: I'd recommend to split this section into several subsections to facilitate the reading.
- Page 4934 - line 27: 'coregistation' to be replaced by 'coregistration'
- Page 4935 - line 8: minute?
- Page 4935 - line 10: 'SOAZ' to be replaced by 'SAOZ'
- Page 4935 - line 27: one extra comma.
- Page 4937 - line 5: "to" instead of "for". The Dobson is more susceptible to solar zenith angle dependencies than what? the Brewer?
- Page 4937 - line 8: "Ushuaha" to be replaced by "Ushuahia".
- Page 4943 - line 10: "which are larger than the retrieval errors. . ." instead of "which are more strongly affected compared to the retrieval errors. . ."
- Page 4943 - line 26: this sentence is confusing. The sensitivity of nadir-viewing UV-Visible instruments is never maximum in the lowermost troposphere. However, it is clearly larger there when there is no cloud contamination. Is it what you mean? Please rephrase.
- Figs. 4 and 5: Please homogenize the legends (effective or with nullspace, and direct or without nullspace).
- Fig 9.: top-right panel: legend not consistent with caption.
- Fig. 10: "percent " instead of "per cent"

- Fig. 14: Please specify the values of the other parameters used for these simulations (e.g. VZA, O3 column,. . .).
- Fig. 15: “include” instead of “including”.
- Fig. 19: “west pixel bins, which include pixels numbers 1-12 and 13-24, respectively“ instead of “west pixel bins, separated between pixel numbers 12 and 13”

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 4917, 2015.