

Interactive comment on “Glyoxal retrieval from the Ozone Monitoring Instrument” by C. C. Miller et al.

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We thank the reviewer for their time reviewing our paper and for their valuable comments. We have revised the manuscript to address the reviewers' points. Please see below for our responses to specific comments.

- **A paper has been recently submitted by Alvarado et al. in AMTD. Please replace the reference to the poster presentation by a reference to that manuscript.**

We have updated the manuscript to reference Alvarado et al. (2014)

- **Section 2.1: Could you explain what is the added value to include in the fit the common mode spectrum (except for decreasing the fit residuals)? As**

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this spectrum results from an average of a set of spectrum residuals, it is by definition orthogonal to the glyoxal cross-section and shouldn't impact the retrieved glyoxal SCD. Also, if this spectrum is generated using also oceanic scenes, it might lead to a degradation of the residuals rather than an improvement (because of liquid water spectral structures not entirely corrected for).

The spectrum fit residuals are used to estimate random error. The common mode is included to reduce the magnitude of systematic residuals that will lead to an overestimate of random error. The assumed source of these errors has been assumed to be from imperfectly correcting for undersampling (Chance et al., 2002), imperfect knowledge of slit functions, or other systematic measurement errors. The use of a common mode made from a combination of ocean and land scenes uniformly reduces RMS in our retrieval.

- **Section 2.2: Please add a reference for the O2-O2 cloud algorithm. Could you explain how cloudy pixels are treated? Is a cloud correction applied or a simple cloud filtering? In this case, what is the cloud fraction threshold used to reject cloudy pixels?**

We treat clouds with the commonly used independent pixel approximation for cloudy scenes without rejecting cloudy pixels. More specific details can be found in Gonzalez Abad et al. (2014). We have updated the manuscript to make the reference clearer.

- **Section 2.2: Can GEOS-Chem provide glyoxal profiles over oceans? It would be useful to present typical profiles for different regions and to discuss their reliability.**

GEOS-Chem does not currently include any significant oceanic glyoxal sources. The majority of glyoxal is produced from the oxidation of short-lived non-methane volatile organic compounds (NMVOCs). Unfortunately the reliability of glyoxal

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profiles has been difficult to assess due to the lack of independent profile measurements. We intend to validate the CTM profiles when this data become available. We have updated the document to include a discussion of the profile uncertainty over oceanic scenes.

- **Section 2.3: This section focuses on the errors associated to the slant column retrieval, but the authors neglect the errors due to the AMF computation. This should be discussed. Also, please provide an estimate of the total error associated to the retrieval.**

The SCD errors were focused on as they were relevant to the following sections on retrieval optimization. A comprehensive error budget has been presented in a previous glyoxal retrieval study for the GOME-2 instrument (Lerot et al. (2010)). Since we expect similar uncertainty in species profiles and cloud retrieval properties we should expect similar errors associated with AMFs. We have updated section 2.2 with reference to this paper, and changed the title of section 2.3 to Slant Column Error Estimation.

- **Section 3.1: Please explain already here that the Ring effect is not included in the simulations. The added value of these experiments for the choice of the fitting window is not obvious at all since the model to generate the synthetic spectra is very similar to the one used for the retrieval. To support the discussion of section 3.4, it would be interesting to generate synthetic spectra using a RT model including inelastic scattering and to perform retrieval with the simpler fit model. If this is feasible, I think the paper would gain a lot.**

We have included a sentence to make clear that we do not simulate inelastic scattering. Our current modeling framework interfaces with the VLIDORT radiative transfer model, which does not simulate rotational Raman scattering. The added experiment would involve interfacing our code with a different radiative

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transfer model.

- **Section 3.2: There is also a consolidated OMI sun spectrum available (Dobber et al., Solar Phys., 2008, DOI 10.1007/s11207-008-9187-7). Using this one might help to limit issues related to the daily measured solar spectra (undersampling, noise, . . .). Did you try this consolidated spectrum in your glyoxal retrievals? That being said, it is likely that it would not remove entirely the need for a destriping correction.**

The sun spectrum from Dobber et al. (2008) is not a consolidated OMI sun spectrum for retrievals – it is a high-resolution solar irradiance reference spectrum used to spectrally calibrate the OMI Sun measurements, similar to the one used in our retrievals (Chance et al., 2010). The Dobber et al. (2008) spectrum is within 2% of OMI in the visible, however typical glyoxal optical depths are two orders of magnitude lower than this, which does suggest that the destriping correction will still be necessary. Although we have not tried a HR solar reference in this study, our past experience with other OMI retrievals has shown that the use of instrument derived solar spectra improves fit performance as common errors associated with the solar and earthshine spectra tend to cancel. This suggests that this effect outweighs the errors associated with undersampling and random solar spectrum noise.

- **Section 3.4: The decrease in the retrieved SCD below 435 nm is not very clear in Figure 11. It gives the feeling that the lower window limit could be anywhere between 429 and 435 nm, which questions the discussion on possible interferences with the Ring signature. Could you clarify or adjust the figure to make more visible the decrease you mention? Do you have any idea on the cause of the strong discontinuity at 429 nm?**

We have rescaled the colour scale to more clearly show the decrease in average SCD with lower window limit. The strong discontinuity could be related to a

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significant Ring feature at 430nm (See the differential Ring Spectrum in Figure 2(d) of Chance et al. (1997)). Whilst the mean SCD remains positive between 429-435nm, since the impact of inelastic scattering was untested in the OSSE we feel that it is safest to avoid the spectral region with strong Ring signatures until it is more carefully investigated.

- **Section 4 - line 22: I don't think that the larger GOME-2 and SCIAMACHY glyoxal columns in summer can be explained by interferences with NO₂ since its concentrations in the boundary layer peak in winter in NE China rather than in summer.**

There are two factors that increase the importance of the NO₂ temperature bias in summer.

1. The photon penetration depth is greater in summer due to viewing geometry, therefore the impact of boundary layer NO₂ is greater
2. The surface temperature during winter is lower (Summer-Winter surface temperature difference is 30K in Beijing) reducing the interference from the NO₂ temperature dependence

We will amend the document to include this explanation

- **Section 4: Your statement about the impact of water vapour cross-section, and the pressure and temperature conditions for which it has been derived is interesting. Again, the paper would benefit greatly if this was supported with a sensitivity test. You should at least mention your choice of temperature and pressure to derive your own RCS.**

Changing the temperature of the water vapour RCS used in our retrieval leads to maximum changes in VCDs of $1 \times 14 \text{ molec cm}^{-2}$ per 20K. Given the consistency with surface observations over the ocean, we believe that our current choice in

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H₂O RCS temperature (280K, 0.9atm) is appropriate. We have updated the document to cite RCS temperature and pressure.

- **Conclusions: I'd recommend to specify also here the order of magnitude of the ratio glyoxal to formaldehyde for different types of emissions.**

We have amended the conclusions to specify an approximate order of magnitude

References

Chance, K. V. and Spurr, R. J. D.: Ring effect studies: Rayleigh scattering, including molecular parameters for rotational Raman scattering, and the Fraunhofer spectrum, *Appl. Opt.*, 36, 5224–5230, 1997.

K Chance (ed.): OMI Algorithm Theoretical Basis Document, Volume IV, OMI Trace Gas Algorithms, ATBD-OMI-04, Version 2.0, 2002.

Gonzalez Abad, G., Liu, X., Chance, K., Wang, H., Kurosu, T. P., and Suleiman, R.: Up- dated SAO OMI formaldehyde retrieval, *Atmospheric Measurement Techniques Discussions*, 7, 1–31, doi:<http://dx.doi.org/10.5194/amtd-7-1-2014>, 2014, <http://www.atmos-meas-tech-discuss.net/7/1/2014/>, 2014.

Lerot, C., Stavrou, T., De Smedt, I., Muller, J.-F., and Van Roozendael, M.: Glyoxal vertical columns from GOME-2 backscattered light measurements and comparisons with a global model, *Atmospheric Chemistry and Physics*, 10, 12 059–12 072, 2010.

Interactive comment on *Atmos. Meas. Tech. Discuss.*, 7, 6065, 2014.

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