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Atmospheric Measurement Techniques Discussions

Interactive comment on "Rapid methods for inversion of MAXDOAS elevation profiles to surface-associated box concentrations, visibility, and heights: application to analysis of Arctic BrO events" *by* D. Donohoue et al.

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We thank X. Li from Juelich for the helpful comments and questions regarding the manuscript. In the text below, we will indicate points that that the commenter raises with an asterix (*) followed by our reply. Also see the replies to Reviewers 1 and 2 and other comment for general discussions of the manuscript.

* The commenter asks about the details of the radiative transfer model (RTM) simulation and the selection of the wavelength for the modeling.

The RTM was performed using a wavelength of 350 nm, which we will add at Line 17 on page 4653. We selected this wavelength as a compromise between the BrO absorption wavelengths and the O4 absorption wavelengths. Note that only the 360 nm O4 absorption is fitted in our analysis; the 475 nm peak is outside our window. The choice of a single wavelength for RTM simulation is quite common and is in the spirit of the rapid analysis methods described here.

* The commenter asks about the aerosol and BrO profiles in the modeling and also asks about the influence of the BrO absorption on the radiative transfer process.

We have clarified the treatment of the BrO distribution on line 23 page 4654 as below:

The airmass factors were generated by producing all combinations of the following conditions: nine aerosol extinction (AE) values, 0.01, 0.05, 0.1, 0.2, 0.4, 0.6, 0.8, 1, and 2 (km^{-1}) and ten layer heights (Z), 100, 300, 500, 700, 1000, 1200, 1400, 1600, 1800 and 2000 (m). The BrO distribution will be treated as uniform concentration from the surface to Z.

Additionally, BrO is a very weak absorber (peak optical density <5E-3), so it has a minimal effect on the radiative transfer process.

* The commenter asks: From line 14 to line 25 (page 4655), the authors describe the contour plots of O4 SA-VCDEST . These contour plots, however, can be misleading for readers, because the vertical distribution of O4 is proportional to the square of O2, depending on the pressure and the temperature in the atmosphere. If the aerosol extinction changes, as long as the pressure and the temperature profiles are fixed, the O4 VCD will remain the same. From this point of view, there should not be any dependence of O4 SA-VCDEST on aerosol extinction. This independence can also be seen from Eq. 1. When aerosol exists, the effective light path of photons will change the AMF and the observed SCD in the same way.

While it is true that the actual O4 VCD is effectively constant (although it is a function of the pressure and temperature, as stated by the commenter), the estimated O4 VCD is based upon best simultaneous fitting of all of the profile elevation angles and is not constant because it is based upon the data. For modelled profiles that poorly match the actual profile, the O4 SA-VCDEST will be quite different from the true value. That is precisely why we make a criterion for fitting that requires the estimated O4 SA-VCDEST to be close to the true value. Please see the reply to Reviewer 1 for more details regarding the VCD estimation method.

* The commenter asks about the cloud classes, which was also asked by one of the reviewers

We did not include the definition of cloud type as it is not essential to this work. Essentially these classes describe the degree of visibility from excellent to poor. For the commenter's reference, the details are below.

The quality of MAXDOAS analysis is highly dependent on the visibility, we characterized the data into one of four cloud classes, with each cloud class having increasing error, based the dSCD O4 at a view elevation of 2°. Since the sensitivity of the technique is decreased with decreasing visibility, all measurement with dSCD O4 below 1.55×1043 molecules2 cm−5 (around 5 km visibility) were classified as cloud type IV and not converted to BrO SA-VCDs or BrO concentrations. The other cloud classes are characterize as Cloud Type I: Very good visibility (dSCD O4 at 2 degrees elevation > 3.5E43 molec2 cm-5; Cloud Type II: Good visibility (3.5E43 < dSCD O4 > 2.0E43 molec2 cm-5; Cloud Type III: Average visibility (2.0E43 < dSCD O4 > 1.55E43 molec2 cm-5)

* The commenter asks: Moreover, in lines 1 – 3 (page 4658), why only three but not four cloud types are associated with a certain error?

As mentioned on line 10-11 page 4657, we did not include cloud type IV as data in this cloud type was not converted to VCDs or concentration so not error can be estimated.

Therefore, we added an additional comment on line 3 page 4658

Data classified into cloud type IV does not have an associated error as it was not converted to VCDs or concentrations.

* The commenter asks: From line 12 (page 4657) to line 3 (page 4658), the authors describe the errors of the BrO SA-VCD. It would be helpful for the readers to clearly distinguish between the systematic errors (which come from the uncertainty of cross sections used in the DOAS fit, the uncertainty of the TRACY-II input parameters, etc.) and the random errors (e.g. error from the least square fitting).

We believe that we have sufficiently characterized the errors in the lines mentioned while we have not used the terminology mentioned by the review we have detailed the source of each error and believe that the reader can determine whether this error is systematic or random. In response to another reviewer, this section is being reworded.

* The commenter asks: Lines 17 – 20 (page 4657). The DOAS fit algorithm used by DOASIS, WinDOAS and QDOAS are nearly the same, especially WinDOAS and QDOAS are using the same code. So, why can the error originating from the fit program be as high as 7%?

This error was determined by fitting the entire data set using each of the fitting methods and then comparing the resulting SCD. While the difference between the WinDOAS and QDOAS was only 3% the maximum error between all three programs was 7%. These errors include twilight data where the signal to noise is relatively poor. We believe that is error stems from small differences in elements of the fitting procedure, for instance the wavelength calibration procedure used in WinDOAS and QDOAS. It is also possible that small differences in the computational methods used by the software / operating systems differs slightly. This is a very conservative estimate of error that was included to estimate the potential for systematic errors associated with the fitting method.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 4645, 2010.