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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.

D. Donohoue et al.

wrsimpson@alaska.edu

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We thank Anonymous Referee #1 for the constructive comments on this manuscript. In the text below, we will indicate points that that the reviewer raises with an asterix (*) followed by our reply. Also see the reply to Reviewer 2 and the comments for general discussions of the manuscript.

The reviewer indicates that the manuscript contains useful information regarding basic MAX-DOAS methods and compiles it in one place. That was our intent in writing this manuscript. The reviewer also indicates that we need to carefully revise the manuscript. Therefore, we will reply to comments below and use these comments to substantively improve the manuscript. We thank the reviewer for these comments.

* The reviewer notes that SA-VCD can be confused with SA minus VCD

We agree that there is a problem with the symbols and will repair this problem. The reviewer is completely correct that our surface-associated VCD is highly weighted towards the surface. For that reason, we feel it is important to not simply use the term VCD because VCD nearly always used for the total VCD and not a partial VCD as we detect in ground-based MAX-DOAS.

* The reviewer asks about the RTM assumptions versus parameters of the RTM

The reviewer has a good point. Of course at any individual time we do know the SZA and relative azimuth between the observation and sun. However, for this rapid method we pre-calculate airmass factors for the set of profiles using fixed SZA and Az, as described in the methods. We have done calculations varying the SZA and Az, and the effect on the AMF is relatively small. Additionally, the Hoenninger et al. initial paper on MAX-DOAS graphically shows the independence of the surface-associated layer retrieval on the solar parameters. Therefore, we do not actually use the knowledge of the solar parameters in our calculation of airmass factors.

* The reviewer asks if we developed these methods and asks for references to other manuscripts.

A number of groups have described similar methods, some of which we were aware of and referenced and described in our literature review. A few similar method papers were unknown to us and will be added to our description.

* The reviewer asks about the way that we estimate the surface associated VCD, and asks if the VCD EST is actually a VCD.

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Interactive Comment

This is an important point, which we did not sufficiently clarify. While the reviewer is quite correct that if you knew the right profile (e.g. had the correct dAMF) and there was no noise or systematic error in the measurement of the dSCD, each individual calculation of the VCD = dSCD(a) / dAMF(a) would give the same VCD. However the method described here is approximate and there is significant noise on the observations, and the AMFs are from a lookup table. Therefore, it was chosen to derive one VCD estimate by averaging the dSCDs and dividing by the averaged dAMF. If the profile is correct, then the result would be the VCD (see below), but if the profile is incorrect, the result is not physically meaningful, as the reviewer insightfully realizes. The advantage of the method, however, is that measurements having small dSCDs (and small dAMFs) are inherently de-weighted in the analysis. If one were to do the averaging as suggested by the reviewer, then the low elevation measurement (which is many times more sensitive to surface-associated gases) would be averaged with high elevation measurements, which have low dAMFs. Although the ordering of averaging is not physically meaningful, we use this method to inherently weight the observations with larger values of dSCD more heavily.

To consider when, as the reviewer states (A+B) / (C+D) is or is not equal to A/C + B/D, let us call the set of dSCDs: S1, S2, S3, and the dAMFs: A1, A2, and A3. If these are the correct dAMFs, then the VCD (call it V) is given by: V = S1/A1 = S2/A2 = S3/A3. Thus, we can tell the three following equations: S1 = V*A1, S2 = V*A2, S3 = V*A3. Now consider the VCD Estimate given by equation 3: V_EST = (S1 + S2 + S3) / (A1 + A2 + A3)

Note that each S is simply the same V times the respective A, so

V_EST = (V*A1 + V*A2 + V*A3) / (A1 + A2 + A3) = V * (A1 + A2 + A3) / (A1 + A2 + A3) = V

Thus, the estimated V is correct and physically meaningful in the case that the dAMFs are correct.

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Interactive Comment

* The reviewer is asking for revisions to the error analysis and pointing out that we need to propagate errors in division of terms with error.

The error discussion was not sufficiently clear and is being revised significantly.

* The reviewer asks for improved symbols.

We agree that the use of SA-VCD and some other symbols did not come out well in the typesetting and will improve this aspect of the work.

* The reviewer asks about the pathlength estimate using O4 data and other wording.

We agree that this pathlength should be used with caution and will improve the language.

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