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Interactive comment on "Intercomparison of MAX-DOAS Vertical Profile Retrieval Algorithms: Studies using Synthetic Data" *by* Udo Frieß et al.

Anonymous Referee #3

Received and published: 16 February 2019

This manuscript describes intercomparison of MAX-DOAS vertical profile retrieval algorithms for O4 (aerosols), NO2, and HCHO, based on synthetic SCD data. The algorithms include OEM, parameterization, and analytical approaches. Ensemble means of SCD were synthesized using forward RTM calculations with prescribed aerosol/gas profiles, instead of using measurements, and then they were inverted by the algorithms to yield vertical profiles, which were finally compared with the given original profiles. From large number of experiments where various aerosol and gas concentration profiles were assumed, deviations were systematically analyzed. Causes of deviations were sometimes identified. The methodology is new, forming a closure, and sounds robust. The results include important implication and the new knowledge obtained will be reflected into key revision of algorithms in the future. However, at certain times I

found points needing clarification. For example, I wonder how the NASA algorithm using only RTM calculations with Rayleigh scattering, works to yield aerosol profiles; O4 optical depth could be assigned for each layer, but I believe only RTM calculations with aerosols can connect the O4 information and aerosols. Secondly degrees of agreement with surface values (section 6.6) should be compared to those with vertical total columns. The last sentence of Abstract and the second sentence of Conclusions focused on difference quantification of "concentrations", but implication for column values would be similarly or even more important, considering MAX-DOAS is heavily used for satellite validation. Clarification on several other points listed below should also be made. Overall, I recommend publication after minor revision.

Specific points:

1. Page 1, line 12. The authors state that the values are root mean squares, but they are not described much in detail in text (section 6.6).

2. Page 2, line 34. A posteriori modelled "d"SCDs? Same for the rightmost green box in Figure 1?

3. Page 3, equation (4): What is S_e? How were they assumed in the OEM calculations? The dSCD errors listed in Table 6 correspond to this?

4. Page 10-11. Description of NASA algorithm should be elaborated as mentioned earlier. In Page 11, line 2, Are there cases where less than four measurements are available, for this synthetic-data-based study? Page 11, line 6. O4 dSCDs at low angles are used instead of the aerosol retrieval results – how this approach works without RTMs is difficult to understand.

5. AER8, 9, and 10 in Table 3 and 5. Parameters for fog/clouds (particularly for single scattering albedo) are same as those for aerosols?

6. Bottom panels of Figure 3 for gases: Results for all scenarios with different aerosol profiles are included?

7. Page 20, lines 1-3. The authors should mention that O4 profile shape is heavily weighted to low layers.

8. Page 20, line 13. Better specifically mention as "synthetic" measurement vector (y)? Same for x axis label of Figure 9. Y-axis label in Figure 9 should be better mentioned as a posteriori modeled dSCDs?

9. Page 20, line 3. Any reasons for the underestimation of O4 at 477 nm?

10. Figure 10 and 15. Y-Axis range for Slope is better zoomed to narrower range?

11. Figure 13 caption. Legend for coloured symbols corresponding to aerosol scenario is not found.

12. Figure 14. My guess is that MAX-DOAS gas determination would be difficult in the AER2+TG7 scenario. Can the scenario be identified in the plot for some discussion?

13. Page 28, lines 1-5. How the failure in retrievals in aerosol/cloud affected the gas retrievals? If correct aerosols profiles are given, better agreement is obtained?

14. AER0 and TG0 cases for bePRO, HEIPRO, MMF, and PROAMF in Figures 16 and 17. As mentioned in page 30 lines 7-8, a positive bias is present. This might be fatal for satellite validation in clean region. Can they be easily screened out during post error analysis, for example, comparison with largest dSCD values?

15. Y-axis of Figure 16. AOT is used throughout text?

16. Page 33. Degrees of agreement with surface values (section 6.6) should be compared to those with vertical total columns.

17. Section 6.7. Any time loss during data I/O for some algorithms?

18. Page 36, line 7. bePRO

19. Page 36, line 10. have shown

20. Page 37, line1. Do the authors mean "direct-sun" observation here?

21. Recommendation learnt from this study should be listed in Conclusions?

Interactive comment

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