

Interactive comment on “Validation of MAX-DOAS retrievals of aerosol extinction, SO₂ and NO₂ through comparison with lidar, sun photometer, Active-DOAS and aircraft measurements in the Athabasca Oil Sands Region” by Zoë Y. W. Davis et al.

Anonymous Referee #2

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This paper presents vertical profiles of aerosols, NO₂, and SO₂ retrieved from MAX-DOAS measurements at the Fort McKay South field site (Alberta, Canada). This site is located close to two mining plants which are major sources of industrial pollution in this region. The MAX-DOAS retrieval results are compared to co-located ancillary observations from lidar, AERONET, active DOAS, Pandora, and airborne in-situ analysers instruments. These comparisons based on data sets from various techniques provide a unique opportunity to investigate the performance of MAX-DOAS retrievals under

varying atmospheric conditions in an industrial area.

The manuscript is well written and clearly structured, and presents very interesting results which fit well with the scope of ACP. I recommend the final publication of the manuscript after addressing the following specific comments and technical corrections:

Specific comments:

1/Page 6, lines 1-12: It is not clear in which direction the active-DOAS measurements are performed. Is it the same direction as the MAX-DOAS instrument ? Maybe this information could be added in Figure 1.

2/End of page 7-beginning of page 8: You should add Wagner et al., Atmos. Meas. Tech. (2019) in the list of references on the O₄ scaling factor. No O₄ scaling is used in the present study. Did you perform sensitivity tests on your aerosol retrievals and you came to the conclusion that a scaling factor was not needed ? Or you simply decided not to use any scaling factor ? I think this should be further discussed in the paper and sensitivity test results could be also added to make the study more robust (e.g. what is the impact of a scaling factor on the agreement with AERONET data ?).

3/Page 9, line 3: According to Rodgers (2000), weighting function K should be equal to $\delta y/\delta x$ and not $\delta F/\delta x$.

4/Page 9: I think you should justify your choice of aerosol extinction and trace gas concentration a priori profiles. Did you perform sensitivity tests for the selection of these a priori profiles, especially in terms of scaling height ?

5/Page 9, lines 30-31: To my knowledge the SCIATRAN RTM is not based on a Monte Carlo approach. This point should be clarified.

6/Page 10, line 10: The relative error of the a priori was set to 100% for the construction of the Sa matrix. Did you set the extra-diagonal terms to zero and, again did you perform sensitivity tests for the selection of this relative error value. Also related: nothing is said in the paper about the quality control of your MAX-DOAS retrievals. For instance,

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what are the typical degrees of freedom for signal (DOFS) values of your aerosol and trace gas MAX-DOAS retrievals and what is the level of agreement between measured DSCDs and those modelled using the retrieved profiles as input ?

7/ Comparisons between MAX-DOAS and AERONET AODs (Figs 4a-9a): MAX-DOAS significantly underestimates (by sometimes more than a factor of 2) AERONET AODs. What happens if you used a different a priori profile with a scaling height larger 0.6 km (e.g. 1.2 km) ? Does it improve the agreement with AERONET without degrading the quality of your retrieval (see point 6/) ? Also, is the application of a O4 scaling factor can improve the agreement with AERONET ?

8/Page 22, lines 1-3: You said that a major advantage of the MAX-DOAS technique is the simultaneous retrievals of total columns and vertical profiles of trace gases and aerosol extinctions without requiring a priori information. I am a bit puzzled by this sentence since a priori information is needed in the Optimal Estimation retrieval approach you used. A clarification is needed here.

Technical corrections:

'->' denotes 'should be replaced by'

1/'Honninger et al.' -> 'Hönninger et al.'

2/'Clemer et al.' -> 'Clémer et al.'

3/The first sentences of both Sections 2.1 and 2.2 are a bit redundant. I would start Section 2.1 by 'The MAX-DOAS instrument was operated at an elevation of ~ 10 m. ...' and Section 2.2 by 'The MAX-DOAS instrument is a mini-DOAS spectrometer from Hoffmann Messtechnik GmbH measuring scattered sunlight.' or something similar.

4/Page 5, line 25: 5°C (C not in superscript)

5/Page 22, line 1: 'total column' -> 'total columns'

6/List of References: 'Atmospheric Meas. Tech.' -> 'Atmos. Meas. Tech.'; Same for

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'Atmospheric Chem. Phys.'

7/Legends of Figures 4-9: You should add a short description of the error bars presented in the plots.

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