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Atmospheric Measurement Techniques Discussions

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

Anonymous Referee #2

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General Comments

This manuscript presents a detailed intercomparison of the performance of eight algorithms used to retrieve vertical profiles of aerosol, HCHO, and NO2 in the atmospheric boundary layer from MAX-DOAS slant column densities. A set of synthetic measurements is first generated from the medians of seven simulated datasets of slant column densities simulated using five radiative transfer models. Simulations are performed for 11 aerosol profiles, 10 trace gas profiles, and multiple viewing geometries (11 elevation angles, three solar zenith angles, three relative azimuth angles), resulting in 990 O4 SCDs at 360 nm and at 477 nm, and 9900 SCDs each for HCHO and NO2.

The simulated SCDs from the different RTMs agree well under all conditions. The retrievals use three approaches: five algorithms are based on the optimal estimation

method, two on parametrised methods, and one on an analytical method. Differences between the retrieved vertical profiles, surface concentrations, and total columns obtained from the eight algorithms are quantified and generally agree, with the exception of some outliers. The retrievals result in DOFS of 1.5-3.5 in the lowest 2 km of the atmosphere, depending on the target species and the atmospheric conditions. Limitations resulting from the use of synthetic measurements are identified, and so these results may be interpreted as a best-case scenario relative to retrievals using atmospheric measurements with real instruments.

This study is part of the Fiducial Reference Measurements for Ground-Based DOAS Air-Quality Observations (FRM4DOAS) project, and the results provide a benchmark reference for the development of a community algorithm for a harmonised near-real-time processing of MAX-DOAS data.

The manuscript is straightforward and well-written, providing a clear and concise description of the intercomparison strategy, the algorithms, the RTM simulations, and the results of the retrieval intercomparisons. I have only minor comments, and I recommend publication after these are addressed.

Specific Comments

Page 1, line 12 – Here, or in the main text (e.g., pages 35-36), provide some context for these RMS differences. Are these numbers negligible or significant? How do they compare to typical absolute values?

The multi-panel figures include a lot of information, but it is difficult to read some of the text (e.g., the numbers in the panels of Figures 5-7) and to distinguish some of the features discussed in the text. I suggest looking at all of the multi-panel figures and enlarging text or making other revisions where possible to make them clearer and more easily readable.

Technical Corrections

Page 1, line 11 – root mean square (not squares)

Page 1, line 12 – between THE true . . .

Page 1, line 16 – emissions. Monitoring . . .

Page 2, line 19 – here and elsewhere, hyphenate “state-of-the-art”

Page 2, line 23 – straightforward

Page 3, line 7, 24, 24, etc. – Here and for all equations, include punctuation – add periods to equations where relevant.

Page 3, line 15 – define variables s and rho in Eqn 3

Page 4, line 8 – DOFS is more commonly used than DFS for Degrees Of Freedom for Signal

Page 4, line 20 – well-established

Page 4, line 22 – should AVL be AVK?

Page 5, Figure 1 – Should rightmost green box say “Reference dataset for dSCDs” rather than SCDs? Line 12 says that the dSCDs are the reference dataset.

Page 5, line 15 – reorder as: This dataset is referred to below as the . . .

Page 6, Table 1 – All acronyms should be defined here or in the text.

Page 7, line 22 and page 10, line 10 – a-priori is hyphenated here but nowhere else

Page 7, line 29 – grid points, (add comma) . . . layer, which IS considered . . .

Page 8, line 23 – define MMF (it’s not defined anywhere – also check that all acronyms are defined throughout)

Page 9, line 16 – and second, (add comma)

Page 9, line 18,19 – move definition of (RAA) immediately after “relative azimuth an-

gles”

Page 9, line 28,29 – allows the uncertainty of the resulting profiles to be determined.

Page 10, line 3 – quantify what “level of agreement” is used in flagging data

Page 10, line 12 – (2011, 2015a)

Page 10, line 19 – a-posteriori is hyphenated here but nowhere else

Page 10, line 26 – algorithm WAS developed . . .

Page 11, line 14 – atmospheric radiative transfer models

Page 11, line 19 – for the forward MODELLING than . . .

Page 11, line 31 – during THE CINDI-2 . . .

Page 12, Figure 2 – Add a reference in the figure caption to Tables 2 and 3 for definitions of the profiles indicated in the legends.

Page 14, line 1 – Table 5. RTM parameterS for . . .

Page 14, line 7 – serve as A reference

Page 14, line 13 – as THE forward

Page 14, line 14 – in THE case

Page 14, line 19 – “some of” or “a portion of” rather than “parts of” ?

Page 14, line 20 – representationS

Page 15, Figure 3 – Add more tick marks to the horizontal axes.

Page 16, Figure 4 caption – root mean square (no S) ... correlation BETWEEN the . . . compared to the medianS from . . .

Page 17, line 9 – similar magnitude to the

Page 17, line 14 – trace gas profileS

Page 17, line 15 – azimuth angleS

Page 17, line 22 – interpolated onTO the

Page 19,20 Figure 7 and 8 captions – Same as Figure 5 . . .

Page 21, line 5 – RMS has already been defined – delete “root mean squares difference”

Page 21, line 7 – problems retrievING the

Page 23, line 2 – in THE case of

Page 27, line 4,5 – requires, however, excludING

Page 28, line 12 – values FOR altitudes

Page 28, line 30 – as is the case (delete “it”)

Page 28, line 31 – prevents THE retrievAL of negative

Page 28, line 33 – in THE case of

Page 29, Figure 16 – The label on the top of the left column says “AOD” but the caption refers to “AOT”. Choose and use one consistently throughout.

Page 29, Figure 16, last line of caption – all data ARE shown

Page 30, Figure 17 caption – not correct to say this is the same as Figure 16. This uses the TG profiles, while Figure 16 uses the AER profiles. Revise.

Page 30, line 2 – high-altitude cloud

Page 32, Figure 19, last line of caption – all data ARE shown

Page 35, line 6 – algorithm, MAPA. (add comma)

Page 36, line 10 – have showN that bePRO generally performs well with . . .

Page 36, line 20 – which is particularLY the case

Page 37, line 4 – median dSCDs (add s) . . . ARE available

Page 37, line 5 – THEY can serve as

Page 37, line 7 – delete definition of CINDI-2 as it was defined on page 10

Page 37, line 10 – available on REQUEST. (what about the availability of the other algorithms?)

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-423, 2018.