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Comment on amt-2020-492

Anonymous Referee #3

Referee comment on "Evaluation of UV–visible MAX-DOAS aerosol profiling products by comparison with ceilometer, sun photometer, and in situ observations in Vienna, Austria" by Stefan F. Schreier et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2020-492-RC3, 2021

In this paper, aerosol extinction (AE) profiles, aerosol optical depth (AOD), and near-surface AE are retrieved from MAX-DOAS measurements acquired on cloud-free days during the September 201-August 2019 period at two stations in the vicinity of the Vienna (Austria) city centre. These retrievals are performed using the Bremen Optimal estimation REtrieval for Aerosols and trace gaseS (BOREAS) algorithm and are evaluated against co-located ceilometer, sun photometer, and in situ instrument observations covering all four seasons. The retrieved AE profiles are found to agree well with those from the co-located ceilometer in fall, winter, and spring, with correlation coefficients ranging between 0.85 and 0.99. During those seasons, a good agreement is also obtained with the ceilometer for the near-surface AE and between the MAX-DOAS and sun photometer AODs. The MAX-DOAS retrieval results appear to be less reliable in summer and the possible origins of the lower performance of BOREAS in those conditions are discussed. Finally, the spatial variability of AOD and near-surface AE over Vienna is assessed by analyzing the retrieved BOREAS aerosol profiling products in the different azimuthal pointing directions of the two MAX-DOAS instruments and for the different seasons.

This paper is well written and clearly structured and presents interesting results which fit well with the scope of AMT. I recommend the final publication of the manuscript after addressing the following major and specific comments:

Major comment: To my opinion, the present study suffers from two weaknesses: no uncertainty budget is presented for any of the MAX-DOAS retrieved quantities (AE profile, near-surface AE, and AOD) and there is no estimation and characterisation of the vertical sensitivity of the MAX-DOAS AE profile retrievals through the calculation and examination of the averaging kernels and corresponding DOFS. The uncertainties on the Ceilometer AE profiles and other ancillary data deserve also to be discussed. Both aspects (uncertainty and vertical sensitivity) of this major comment should be addressed in the revised manuscript.

Specific comments:

Page 3, lines 11-13: I think here it is worth explicitly mentioning that a large part of the sun photometer measurements effort is endorsed by the AERONET network. The AERONET http link could be also added. Then, no need to add the http link again on page 7, lines 7-8.

Page 10, line 20: the choice of the a priori scaling height (1.25km) should be justified here. Is it based on a sensitivity study using different a priori scaling height values?

Page 12, lines 7-9: The level of agreement between measured and simulated O4 DSCDs is used to select valid MAX-DOAS AE profile retrievals. I guess that the criteria used (absolute and relative difference smaller than 1000 molec2 cm-5 and less than 10%, respectively) is applied individually to all the elevation angles. I think this should be explicitly mentioned in the text.

Page 12, lines 13-14: It is said that temporal changes in pressure and temperature can affect the BOREAS retrieval. This general statement requires some explanation: how large can be this effect on a daily basis since daily atmospheric temperature and pressure profiles are used as input for the AE profile retrievals?

Page 13, lines 13-16: the higher correlation coefficient values between MAX-DOAS UV and ceilometer AE profiles is explained by the fact that in the UV, the MAX-DOAS instrument probes air masses closer to the ceilometer which is located at 2.25km from the MAX-DOAS. Is it a valid argument since the effective horizontal distance representative of the MAX-DOAS measurements of O4 in the UV can be as large as 10-15km or even more under clear-sky conditions? Was there any attempt to estimate the effective horizontal distances for both the UV and VIS channels?

Page 13, lines 25-29: According to the authors, BOREAS has difficulty in retrieving AE profiles and near-surface AE during summer. One possible reason is that during that season, AE profiles have a box-like shape and are therefore not well retrieved with the exponential a priori used. Did the authors make a sensitivity test using a priori profiles with box-like shape in order to see whether it improves the AE profile retrievals in summer? If it significantly improves their retrievals but also the agreement with the ceilometer and the sun photometer, I think the authors should consider to include such a sensitivity test in their manuscript.

Page 14, lines 9-17: According to the authors, lower BOREAS AODs are expected because of the limited sensitivity of MAX-DOAS profiling for higher altitudes, while AERONET AODs

better represent elevated aerosol in the free troposphere (and stratosphere). The authors then argue that in Spring, Saharan dust events over Austria could potentially explained higher AERONET AOD, mentioning the detection of such events in the Austrian Central Alps. I think this explanation is very speculative and requires further investigation: for instance, have such events been detected during the period where the MAX-DOAS measurements presented in this study were performed? If yes, is it statistically significant, i.e. during how many days Saharan dusts stayed above the Vienna area?

Technical corrections:

Page 12, line 27: 'intervalls' -> 'intervals'

Page 14, line 12: 'tropsphere' -> 'troposphere'