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Atmospheric Measurement Techniques Discussions

Interactive comment on "Inversion of tropospheric profiles of aerosol extinction and HCHO and NO_2 mixing ratios from MAX-DOAS observations in Milano during the summer of 2003 and comparison with independent data sets" *by* T. Wagner et al.

Anonymous Referee #2

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General comments:

This article describes aerosol and trace gas (NO2 and HCHO) results from MAX-DOAS measurements over Milano, Italy in September 2003. Spatial heterogeneity of the aerosol and gas pollution was studied by simultaneous MAX-DOAS measurements in west, north and south directions. The authors present a parameterized inversion

algorithm to retrieve trace gas total vertical column (NO2 and HCHO)/aerosol optical depth, layer height, and profile shape parameter. Sensitivity studies were conducted to evaluate effect of profile shape parameter on the retried total gas column/AOD and layer height. A cloud classification and screening algorithm is introduced to identify cloudy and clear sky conditions. Effect of clouds on the retrievals was studied. Extensive correlation analysis was conducted to compare MAX-DOAS results with other independent measurements.

This paper addresses a very important question of the profile retrieval from MAX-DOAS measurements. While optimal estimation is widely used in such retrievals, it requires a priori knowledge about the profile distribution and its variability. In most cases this information is not available, and a priori profile is assumed. Optimal estimation often retrieves unrealistic (negative) concentrations. As with any other method the solution is not unique (due to limited information in MAX-DOAS measurements). Attempt to use parameterization of the profile is an alternative solution that does not depend on the a priori information (although initial parameter guess plays an important role) and does not produce negative concentrations. Understanding limitations and possibilities of different parameterization scenarios is very important. I believe this paper fits the goals of AMT and recommend publishing the paper after some revisions. In general, the paper is well written and organized. The main confusion, however, arises in sections 3.4 and 3.5. Specific comments and technical corrections are listed below.

Specific comments and technical corrections:

3900, 15 -18. DSCD retrieved relative to a single (fixed) reference spectrum also will reflect changing photon path due to solar movement (solar zenith angle).

3900, 29. Please specify aerosol loading from AERONET at 340 nm

3901, 17 – 18. Please clarify if the O4 correction factor of 0.75 was derived from the data collected during this study or taken from Clemer et al. 2010

AMTD

4, C1575–C1579, 2011

3901, 26 – 27. Please rephrase the second part of the sentence.

3902, 1. Please clarify: measurement sensitivity to what?

3902, 3 – 6. Please explain how you estimate 5 km distance. Do you expect homogeneity condition to hold along this distance at the measurement site?

3904, 24. Replace: Either convex “or” concave.

3905, 5. Please explain how dSCD measurements at multiple wavelengths can provide additional pieces of information about the profile shape.

3905, 6. “Two layer profiles” term is a little misleading since only one elevated layer is retrieved.

3905, 15. Please clarify value of which parameter is fixed: “For the two-layer profiles we fixed the value of the lowest layer”

3906, 16. What is the assumed shape parameter (S) under “unstable” inversion conditions?

3907, 24 – 25. According to eq. 4, Eq. 8 and 9 should be: Ave AOD (or Ave VCD) = AOD (or VCD) / [L*(2-S)]

3908, 5. Please specify the wavelength at which modeling simulations are performed

3911, 17. In the first step of the “trace gas” profile inversion

3912, 7. Is your statement “that the information content of our MAX-DOAS observation is not sufficient to discriminate these different profile shapes” applicable to all your measurements during the campaign or just to 15 and 19 September, 2003? It is expected that different AOD profiles might produce similar O4 dAMF. Have you made an attempt to identify the “common” conditions under which this happens?

3912, 11. You probably can make a general statement here that behavior on 15 Sep is representative of elevated aerosol layers (lower ext. coefficients at the surface than

AMTD

4, C1575–C1579, 2011

aloft) and 19 Sep is typical for aerosols located mainly close to the surface (based on the sensitivity studies).

3912, 17. How do you choose the "correct" profile from your inversion? While on 19 Sep 2003 the AOD agree (within 20%) for different profiles the actual fit of the measurements to the forward model is not as good as than on 15 Sep 2003. What are the "typical" differences between the AODs retrieved using different shapes for clear, similar atmospheric conditions?

3912, 22. Please replace "observations" with "retrieved parameters"

3913, 23. Could you please explain your choice of SZA 30° and RAA 0° for your hypothesis testing? Modeling results using RAA of 0° and small relative zenith angles (in this case e.g. 12° for 18° elevation angle) might be difficult to test with MAX-DOAS observations. External stray (unwanted) light entrance from Sun into a MAX-DOAS instrument is possible at such a small RAA and RZAs. Since these "stray" photons travel a shorter path than the "properly" scattered photons the resulting O4 dAMF is lower. Such data will result in higher AOD retrievals. In addition, aerosol forward scattering is very sensitive to aerosol phase function.

3914, 1. I believe you need more forward model simulations for other aerosol types and profile parameters, and relative viewing geometries to support your conclusion here. Please also provide your "confidence" in the modeling results for 1deg viewing elevation angle. On Fig. 5 please add shape parameters (S = 1) for red and green curves.

3914, 14. From your discussion here, I conclude, that the shape parameter S = 1.1 provides the most stable AOD retrieval but you believe that S = 1 is physically more realistic, so you perform the S=1.1 retrieval and then make it look like S = 1 by adjusting the L. If this is correct please rephrase.

3914, 17. Not sure why you are referring to Fig. 4 here.

AMTD

4, C1575–C1579, 2011

3915, 8. This sentence is somewhat confusing. It gives an impression that O4 analysis of aerosol profiles using your parameterization technique with the pragmatic approach is not useful for the trace gas analysis. Since the final goal is trace gas profile inversion it is not clear why you discuss the pragmatic approach at all.

3917, 20. If the average VMR is independent of the profile parameter, and assuming all of the NO2 is in PBL, would the information about the PBL height help determining which profile parameter to use to obtain the "correct" VCD?

3919, 11 What is the cloud height and thickness?

3921, 3. Can you be more specific? Which wavelengths would you recommend?

3923, 17. Could you summarize which aerosol and trace gas profiles (shape parameters) were used in retrieving the final results?

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 3891, 2011.