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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ground-based MAX-DOAS observations of tropospheric aerosols, NO_2, SO_2 and HCHO in Wuxi, China, from 2011 to 2014" *by* Y. Wang et al.

Anonymous Referee #2

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This paper presents the temporal variation and vertical distribution characters of the tropospheric aerosol extinction (AE) and trace gases (TGs, including NO2, SO2 and HCHO in this study) derived from relatively long-term (2011-2014) ground-based MAX-DOAS observations in the Wuxi city, located in eastern China. The authors developed a new profile inversion logarithm (PriAM) and applied it to deal with their MAX-DOAS measurement data in this study.

For the retrieval method, the authors find that large, systematic biases of the retrieved AE profiles and thus AOD can be induced if the seasonal variations of temperature and pressure are not considered. They also show that the traditional geometry approximation could lead to larger biases than the profile integration in the retrieval of

tropospheric vertical column densities (VCDs) by analyzing the separated processes in the retrieval from their MAX-DOAS measurement data. The authors further analyze the data retrieved from MAX-DOAS measurements and characterize the seasonal, diurnal and weekly variations of NO2, SO2, HCHO and aerosols. One of their results is the finding of a significant annual decreasing of SO2 for both VCD and surface mixing ratio.

The study and its results are interesting, providing important information not only for the development in MAX-DOAS technique, but also for further investigations of urban and reginal air pollution issues in eastern China. The manuscript can still be improved before publication if some methods could be described more clearly and some results be presented more concisely. Below are my comments and suggestions in detail.

Specific comments

In Sect. 2.3, the authors compare the VCD derived by integrating the retrieved vertical profile (VCD_pro) with the VCD calculated by the so-called geometry approximation (VCD_geo). The relative difference is denoted as Diff_total (see Eq. (3)). To identify the dominating difference (which they called "error") source, they split the total difference (Diff_total) between VCD_geo and VCD_pro into two parts: one is the difference between VCD_geo and VCD_geo_m, denoted as Diff_inversion (see Eq. (4)), and another is the difference between VCD_geo_m and VCD_pro, denoted as Diff_geometry (see Eq. (5)), where VCD_geo_m is calculated by applying the geometric approximation to the modelled dSCD. I would say it is a good idea to make such a trial. But one should be noted that the VCD_pro has been taken as a standard value in the comparison and the retrieved profile is assumed to be true in their evaluation. Are the results shown in Fig. 20 for all the measurements including cloudy and haze-foggy conditions? Since both the VCD_pro and VCD_geo_m are calculated from the retrieved profile, a large bias in the retrieved profile may lead to biases in both Diff_inversion and Diff_geometry as well as their relative contributions.

Sect. 3.5.2 can be omitted as some discussions are very speculative and the meaningfulness of results seems to be local. The measurements site of this study were made at a suburban site, located in the industrial area. From Fig 1 and Fig. 23, one can see that the dominating winds come from the NE, which is neither in the direction of Wuxin urban center nor in the direction of the large industrial sources. There is no doubt that pollution plumes from the urban center and the larger industrial sources could affect the measurement site, as shown in Fig. 22. Since the characters of the emission sources from the urban area, including the fractions of pollutants and emission heights, can be rather different from those from the industrial area, the concentrations of trace gases, aerosols and its components as well as their vertical distribution might be different for different plumes. These episode effects can be investigated in-depth explicitly in the future studies considering the focus and length of the paper .

Technical issues

P1, L15-16: Change “spatial distribution” to “vertical distribution” and remove “using vertical profiles”. The measurements were made only at one station and might not be used to characterize the (3-D or 2-D) spatial distribution.

P1, L28: Change “from the aerosol results” to “for the aerosol results”.

P1, L30 – P2, L2: The sentences here need to be rewritten. The phrase “are found” or “is found” occurs so many times here. Better to use them only for the most important findings. The result on wind direction dependency can be skipped as it is only locally meaningful with little information for general chemistry and transport.

P2, L8-9: Add “respectively” after “nitrate and sulfate”. Remove “and methane” as methane also belongs to VOCs.

P2, L18: Actually, photochemistry of precursor gases was not discussed in the paper of Huang et al. (2014).

P2, L23: Change “Since about 15 years” to “Since about 15 years ago”.

P3, L10: The “stability” and “flexibility” issues can be explained a little bit, taking the OE and look-up table methods as example.

P4, L9-12: Use “Section” or “Sect.”, and the same for other places in the manuscript.

P4, L13: Change “discussed” to “summarized”.

P5, L13-17: I would suggest to rewrite this paragraph as “The PriAM algorithm was originally introduced by Wang et al. (2013a and b). Below we summarize the basic concept of the PriAM algorithm and its implementation settings for this study, while details can be found in Sect. 2 of the supplement. Like for other algorithms, a two-step inversion procedure is used in PriAM. In the first step, tropospheric vertical profiles (in the layer from the ground to the altitude of 4 km) of aerosol extinction are retrieved from the O4 dSCDs. Afterwards, the profiles of NO2, SO2 and HCHO volume mixing ratios (VMRs) are retrieved from the respective dSCDs in each MAX-DOAS elevation angle sequence”.

P5, L24: “Fig. 7” appears earlier than “Fig. 3”.

P5, L29: To do (simulate) what with RTM?

P5, L32: For the single scattering albedo, a fixed value of 0.9 is used, or it is allowed to change between 0.85 and 0.95 in the retrievals?

P6, L18: Fig. S10 should be relabeled as Fig. S8 (its position should also be moved to the front in the Supplement).

P7, L24: Change “shown” to “as shown”.

P8, L16: How are clear sky conditions classified, by AERONET data or by MAX-DOAS data?

P9, L24-25: It makes me confusing that the retrieval is based on a “forward model”. Do you mean a “radiation transfer” model or you still have a “backward” model?

P11, L12-13: I would suggest moving Figs. 16-19 to the Supplement.

P12, L10: Change “45 k” to “45 K”.

P14, L5-13: Sect. 3.1 can be skipped.

P15, L1-2: This sentence can be rewritten, e.g., as “The observed seasonal variations of the different species are related to various processes: the seasonal variations of source emissions, chemical formation and destruction, dry and wet deposition, and atmospheric transport”.

P15, L10-12: It is difficult to understand that there is no seasonal variation for NOx while the SO2 emissions vary by about 20%. Note that the boiler for domestic heating could also make a contribution to the NOx emissions.

P17, L33 - P18, L3: Similar to the seasonal variation (P15, L1-2), the diurnal variation can be affected by various factors. The explanations here seems to be very speculative and can be skipped.

P18, L16: The title of Sect. 3.5.1 can be omitted since Sect. 3.5.2 has been suggested to be skipped.

P18, L17-19: I would suggest to skip over the sentences “Huang et al. (2014) . . .. . . The aerosol in Wuxi close to Shanghai is expected to have similar properties”. There are many kinds of properties for aerosols. It is not clear what properties of aerosols are referred to here. The statement that the aerosols in Wuxi have similar properties with those in Shanghai is very speculative.

P19, L18-21: Too speculative.

P20, L2: Change “3 km” to “4 km”.

P21, L18-24: This paragraph can be omitted.

P22-30: Use indented lines for each reference.

P31, Table 1: The format of this table looks not good and needs to be rearranged. Try to avoid using the same items in both column and row. For instance, use species for each column, and for the row use Cross section, Fitting interval, Polynomial degree, Intensity, and so on.

P34, L9: Change “mean maps of” to “maps of mean”.

P37, Fig. 5; P39, Fig. 8; P44, Fig. 15: Better to reduce the absolute maximum/minimum values in Y-Axis appropriately so that the differences can be seen more clearly.

P39-41: Figs. 9-12 can be merged into one figure, with 4 columns for different seasons.

P41-42, Fig. 13: It might be difficult to understand the top panels (colored) of this figure if one had not read the manuscript carefully. It can be more helpful if some words like “primary sky” and “secondary sky” are added, e.g., to the legend, in the figure.

P45-46: It is suggested to move Figs. 16-19 to the Supplement.

P48-49, Figs. 21-22: These two figures can be omitted or be moved to the Supplement. Since the seasonal variability of wind directions is not so high, you may consider making a wind rose diagram averaged for all the experiment period and adding it to Fig. 1.

P58, Fig. 27: The positions of the characters in X-Axis need to be adjusted.

P59-60, Fig. 28: This figure can be omitted or be moved to the Supplement.

Supp.-P1, L31: With what do NO2 and O4 dSCDS show an systematic increase or decrease?

Supp.-P3, L12: The dSCDs shown here read not as large as two times of the mean RMS.

Supp.-P6, L16: Fig. S9 should be renumbered as its position be moved the place after

Fig. S23. Change “the for elevation angles” to “ the elevation angles”.

Supp.-P7, Fig. S1; P8, Fig. S2; Fig. 10, Fig. S5: Both RAA and SAA are used. Please check if they refer to the same variable.

Supp.-P12, Fig. S8: I did not find a place in the main manuscript as well as in the Supplement that this figure is referred to.

Supp.-P15, Fig. S10: This figure should be moved to the front.

Supp.-P19, L3: Change “ds” to “DoF”?

Supp.-P7-37: Please try to let the main body figure and its caption to be in the same page.

Supp.-P39: Use indented lines for each reference.

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