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Atmospheric Measurement Techniques Discussions

Interactive comment on "The CU 2-dimensional MAX-DOAS instrument – Part 1: Retrieval of NO_2 in 3 dimensions and azimuth dependent OVOC ratios" *by* I. Ortega et al.

Anonymous Referee #3

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The paper of Ortega et al. describes the University of Colorado (CU) two dimensional (2-D) Multi-Axis-Differential Optical Absorption Spectroscopy (CU-2D-MAX-DOAS) instrument which has been developed to probe the 3D distributions of aerosols and atmospheric trace gases that are relevant to air quality and tropospheric chemistry. This spectrometer was deployed as part of the Multi Axis DOAS Comparison campaign for Aerosols and Trace gases (MAD-CAT) in Mainz, Germany from 7 June to 6 July 2013. 2 modes of operation of the telescope (off-axis scans at a fixed azimuth angle and azimuthal scans at fixed elevation (almucantar scans)) as well as the light path variation with wavelength are exploited to retrieve aerosol and NO2 vertical profiles and the

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horizontal distribution of the NO2 near-surface concentration and OVOC slant column ratios (HCHO-to-NO2, CHOCHO-to-NO2 and CHOCHO-to-HCHO). A first attempt of OMI NO2 data validation using these measurements is also presented.

Although investigating too many different topics to my opinion, this study is a valuable contribution on how to better exploit/characterize the horizontal extend of MAX-DOAS observations, which is a timely subject matter. Therefore I recommend the paper for publication in AMT after addressing the following comments:

Major comments:

1/Except for aerosols (comparison of retrieved AODs with AERONET), there is no attempt to validate/verify the retrieval results presented in this study, even if the challenges of validating 3-dimensional measurements are discussed in Sect. 4.6. To my opinion, this weakens the paper. In particular, what is the validity of approximating the PBL height as the altitude over which the NO2 mixing ratio decreases to 1/(2e) of the near-surface value of the retrieved NO2 vertical profiles ? Is this approximation also applicable to aerosol extinction profiles (Fig. 6 seems to indicate that the mixing layer height is quite different using aerosols or NO2 profiles) ? During the MAD-CAT campaign, a ceilometer was also operated by MPIC to derive information on the vertical structure of the aerosol extinction. I recommend to compare the retrieved PBL height with those measured by the ceilometer. This is critical since the PBL height through the correction factor fc is a crucial parameter in this study. Also related to validation, why the retrieved NO2 surface concentrations are not compared to values from the regional Rhineland Palatinate and Hesse air quality networks ? An interesting verification exercise would be also to compare the NO2 surface concentrations from the retrieved vertical profiles to those derived by using the Sinreich et al. (2013) approach. For instance, is the level of agreement between the two approaches depending on the considered ring/layer (L1/L2/L3) ?

2/Investigating the HCHO-to-NO2, CHOCHO-to-NO2, and CHOCHO/HCHO dSCD ra-

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tios is an interesting study on its own but is for me a bit out of scope here, especially given the fact that dSCDs are used to investigate these OVOCs ratios and not near-surface concentrations. The reason invoked is that the use of dSCDs does not require 'complex and laborious RT calculations, resulting in a fast retrieval for near-real time monitoring of air pollution/chemistry'. Does it mean that the surface concentration retrieval methods presented here are not applicable for near real time analysis (let's say within 24h delay) due to a too high computing time ? If yes, how this could be improved ? Is it related to the type of RT model (full spherical Monte Carlo) used in this study ? May be this should be discussed in a revised Sect. 4.6 on the challenges of 3-dimensional MAX-DOAS measurements/retrievals themselves and not only their validation. This point is important for future satellite validation campaigns involving MAX-DOAS measurements.

Minor comments:

Page 11663, lines 4-6: the zenith spectrum measured at the end of each EA sequence is used as reference for removing the stratospheric contribution for all trace gases and for a complete modes 1+2 cycle. By proceeding this way, you don't take into account the possible variation of the stratospheric contribution during a complete cycle. A better approach would be to interpolate the zenith SCD at the time of each single measurement using the zenith SCDs of two consecutive cycles.

Page 11666, lines 8-11 and Eq. (4): It is not clear to me how the Sa matrix is constructed, in particular, what are the variance and correlation length which have been used ? Please mention these information in the revised manuscript.

Page 11671, lines 10-11: it is stated that, according to the averaging kernels, the first two kilometers are well constrained by the measurements. This would be more convincing if you show these averaging kernels.

Sect. 4.2.2, page 11674: It would be useful for the reader to include a table summarizing the error budget on the retrieved NO2 vertical profiles and surface VMRs.

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Sect. 4.4, page 11676: what are the uncertainties on the three OVOC ratios ?

Sect. 4.5, pages 11677-11678 + Figure 11, page 11709: nothing is said about the uncertainty on the OMI NO2 VCDs presented here and there is no error bar on OMI observations in Figure 11. They are probably quite large given the fact that only two pixels are used. So, is the overestimation of OMI by MAX-DOAS still significant if you put error bars on OMI data in Fig. 11 ?

Table 1, page 11693: the spatial resolution of the measurements is estimated to 5-30 km. Maybe you should mention how these values are derived ?

Figure 3, page 11701: Examples of DOAS fits are shown for the different trace gases. Why the date of these example fits (June 6th, 2013) is not corresponding to the date of all the retrieval results presented in this study (June 17th, 2013) ?

Technical corrections

Table 4, page 11696: CHOCHO cross sections (No. 6) is missing in the list of cross sections fitted for CHOCHO/NO2.

Sect. 3.2.2, pages 11665-11666: The title of this section 'NO2 vertical profile and boundary layer height' is a bit misleading since there is no discussion about the boundary layer height in it. I think renaming this section 'NO2 vertical profile retrieval' would be more appropriate.

References

Sinreich, R., Merten, A., Molina, L., and Volkamer, R.: Parameterizing radiative transfer to convert MAX-DOAS dSCDs into near-surface box-averaged mixing ratios, Atmos. Meas. Tech., 6, 1521–1532, doi:10.5194/amt-6-1521-2013, 2013.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 11653, 2014.