

## ***Interactive comment on “Potential and limitations of the MAX-DOAS method to retrieve the vertical distribution of tropospheric nitrogen dioxide” by T. Vlemmix et al.***

### **Anonymous Referee #1**

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This is an interesting paper that examines the potential of the MAX-DOAS technique to derive the vertical distribution of nitrogen dioxide (NO<sub>2</sub>) in the troposphere. Such profile information is particularly important for the validation of satellite data in which MAX-DOAS observations play a significant role. The retrieval algorithm used is based on pre-calculated look-up tables of NO<sub>2</sub> and O<sub>4</sub> differential slant column densities for different NO<sub>2</sub> vertical distributions and aerosol conditions. The retrieval algorithm is tested in several sensitivity studies and it is applied to observations performed during the CINDI campaign. Retrieval results are also compared to independent data sets. Being well written and clearly structured, this paper is a valuable contribution to the

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MAX-DOAS research field. Therefore I recommend it for publication in AMT after addressing the following comments:

General comment:

It is not clear for me what are the advantages/benefits of the approach used by the authors compared to the well established method of optimal estimation. I think the authors should discuss this point more extensively in the Introduction (end of Page 4017/beginning of page 4018) and/or in the Conclusions. It will be also interesting to show a comparison between both methods using CINDI campaign observations.

Specific comments:

Page 4016, line 18: Please also refer to Hendrick et al. (2004) for stratospheric NO<sub>2</sub> retrieval from zenith-sky measurements.

Page 4017, line 11: You refer to Figure 1 for sensitivity functions. Please mention in the legend of this figure that these are actually altitude-dependent air-mass factors. Otherwise the reader has to wait till page 4022 to find a description of these sensitivity functions.

Page 4017, lines 14-17: 5 degrees of freedom for signal (DOFS) from MAX-DOAS observations is very optimistic and is only obtained in theoretical studies (e.g., Friess et al., 2006). Using real observational data, the DOFS is generally not larger than 2-2.5.

Page 4024, line 8-10: What is the geometry used for the radiative transfer calculations ? Spherical ? Pseudo-spherical ? Please mention it.

Page 4025, line 21 and page 4039, lines 16-19: Fixed values based on AERONET observations in Cabauw are used for single scattering albedo and asymmetry parameter. What is the natural variability of these parameters at the Cabauw site ? What is the impact of using fixed values for these parameters on the agreement with independent data (see Fig 11) ?

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Page 4029, line 17: 200 inversion runs are used to create an ensemble of retrieval outcome. Why do you choose 200 and not 50, 500 or 1000 ?

Page 4038, line 14: five should be six. Which criteria do you use for selection of days from the CINDI campaign ? Cloud-free days ? What is the computing time for one day of MAX-DOAS retrievals ?

Page 4038, lines 19-21: For the application to the CINDI campaign data, models with one and two NO<sub>2</sub> layers are used. Do you assume NO<sub>2</sub> uniformly mixed in the layers ? If yes, what is the impact on the comparison results of varying the NO<sub>2</sub> profile shape ?

Page 4040, lines 1-9: The uncertainties on the retrieved parameters are larger in the afternoon, maybe due to the occurrence of clouds. Why do you apply your algorithm in cloudy or partly cloudy conditions since it is valid only for clear-sky conditions ?

Page 4041, lines 1-4: what is the error bars on the NO<sub>2</sub> sonde data points ?

Page 4044, lines 15-21 and Fig 15 page 4072: Could you estimate the error bars on the data points in Fig 15 in order to better discuss the significance of the differences between MAX-DOAS and in-situ measurements ?

Technical corrections:

Page 4020, line 9: Hermans should be between brackets.

Page 4040, line 15: 'at the 24th' should be replaced by 'at June 24th'.

Page 4068, Fig 11: Plots of Fig 11 are too small, making the discussion related to this figure very difficult to follow.

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