

## Reply to reviewer #1

First of all we want to thank this reviewer for the positive assessment of our manuscript and the useful suggestions!

We followed these suggestions as explained in detail below.

Calculation of the correction factor  $f_{\text{corr}}$  appears to be an important step in the retrieval of trace gases VMR in this study. However, for this reviewer and perhaps other readers who are not so expert in the RTM and vertical profile inverse, the method for calculating  $f_{\text{corr}}$  seems not to be clearly presented in the manuscript. While it is clear to see that the primitive equation

$$f_{\text{corr}} = \frac{c_{\text{retrieved}}}{c_{\text{real}}} = \frac{d\text{SCD}_{\text{tracegas}}}{L \cdot c_{\text{real}}}. \quad (10)$$

is adapted from Sinreich et al. (2013) ( i.e.,

$$f_c = \frac{c_{\text{retrieved}}}{c_{\text{real}}} = \frac{\frac{d\text{SCD}_{\text{NO}_2}}{L_{\text{eq}, \text{O}_4}}}{\frac{\text{VCD}_{\text{NO}_2}}{\text{PBLh}}}, \quad (4)$$

is the derived  $f_{\text{corr}}$  as function of  $\text{O}_4$  DAMF also the same as that of Sinreich et al. (2013) ( i.e.

$$f_c = \frac{d\text{AMF}_{\text{NO}_2} \cdot \text{PBLh} \cdot \text{CO}_{4,\text{instr}}}{d\text{AMF}_{\text{O}_4} \cdot \text{VCD}_{\text{O}_4}}, \quad (5)$$

or are there any modifications for this study? Anyhow, a complete equation needs to be presented in the paper so that the readers could follow the discussions more easily.

It is stated in Page 8139 and Line 1 that “ $c_{\text{real}}$  is the real surface-near trace gases concentration which was used as input in the RTM”. It might not be appropriate to use “real” here since “ $c_{\text{real}}$ ” is merely a prescribed model parameter instead of the measured trace gas concentration in the real atmosphere. For the first glance of Eq. (10),  $f_{\text{corr}}$  seemed to be a correction factor derived from the measurement data ( $c_{\text{real}}$ ) along with the corresponding model results ( $c_{\text{retrieved}}$ ). After reading the text and also corresponding part of Sinreich et al. (2013) more carefully, I realized that “ $c_{\text{real}}$ ” in both studies actually refers to  $C_{\text{model\_real}}$  (more exactly  $C_{\text{model\_input}}$ ).

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Author reply:

To avoid any confusion, in the last part of Equation 10 (now equation 9) we replaced  $d\text{SCD}_{\text{tracegas}}$  by  $d\text{SCD}_{\text{model}}$  and  $c_{\text{real}}$  by  $c_{\text{model}}$ . We also applied these changes to the text.

The differences of our equation and the equations in Sinreich et al. are caused by the fact that we don't use the term PBLh for the trace gas layer height. In our opinion, the trace gas layer height might not necessarily be similar the PBLh, depending e.g. on the atmospheric lifetime and the location of the emission source of the trace gas.

We therefore replace the term  $\frac{VCD}{PBLh}$  by  $c_{\text{model}}$  assuming that in the radiative transfer simulations the trace gas concentration is constant within the trace gas layer. Besides the use of these different terms, the equations in our paper and the study of Sinreich et al. are identical.

We added this information to the manuscript after equation 9.

Trace gases are assumed to be homogeneous distributed in the box layers with altitudes of 0.1, 1 and 2 km in this study, which are the same as PBL heights? Do  $C_{\text{retrieved}}$  and  $C_{\text{model\_real}}$  stand for the concentrations averaged over the PBL, or box layer,

or the sensitive altitude range (h) at an elevation angle ( $1^\circ$  for this study)? But it seems that the measured  $\text{O}_4$  DAMF that was used to calculate  $f_{\text{corr}}$  should correspond to a sensitive altitude of h instead of PBL in the study.

Author reply:

As pointed out above, we avoid the term PBLh in our study.

The trace gas concentrations used in this paper are average concentrations over the probed altitude range h ( $c_{\text{retrieved}}$ ) or the assumed trace gas layers ( $c_{\text{model}}$ ). We added this information to the text after equation 9.

Will the uncertainties of  $f_{\text{corr}}$  become smaller at the  $1^\circ$  elevation angle than other larger elevation angles?

Author reply:

Yes, as already shown out by Sinreich et al. the uncertainties of  $f_{\text{corr}}$  increase with increasing elevation angle. We added this information to the text after equation 9.

## Technical issues

P8130, L14: Using only one elevation angle?

Author reply:

We changed the text to “We apply the method only to measurements at 1 ° elevation angles (besides zenith view)” and “Using only one elevation angle for off-axis observation”

P8132, L15 and P8133, L14: Full name for dSCD should be given when it appears first in the text.

Author reply:

We added the full name of dSCD as “differential slant column density” in the paper.

P8133, L22: Full name for GM-DOAS is not given before, except in the abstract.

Author reply:

We added the full name of GM-DOAS as “ground-based multifunctional DOAS”

P8136, L22: Is it a typo for “0.817”, since it may not be a representative value for single scattering albedo in the free troposphere.

Author reply:

We agree that the chosen value might not be a very good choice (we took it from the software package OPAC. Fortunately, the exact choice of the single scattering albedo for the free troposphere has only little influence on the calculated correction factors.

P8144, L18-19: As shown in Figure 15, there should be higher AOD and shorter  $L_{\text{eff}}$  on 18 and 21 May.

Author reply:

Based on the suggestion from the other reviewer, the comparison with MODIS data is removed from the revised version.

P8145, L5 and L7: Should be Fig.17, Fig.17a and Fig.17b?

Author reply:

We corrected the number of figure. (Most Figure numbers are different from the original version).

P8145, L19: In contrast?

Author reply:

We replaced 'in contrast' with 'by comparison'

P8153, L1: Supplement should be referred to instead of Table 2. Supplement: It would be helpful to add some words like "Correction factors as function of the O<sub>4</sub> dAMF" in the title of the table.

Author reply:

We replaced 'Table 2' with 'see supplement'

We add 'Correction factors as function of the O<sub>4</sub> dAMF' in the title of the table in the supplement.