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Atmospheric Measurement Techniques
Discussions
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Interactive comment on "Three-dimensional radiative transfer effects on airborne, satellite and ground-based trace gas remote sensing" *by* Marc Schwaerzel et al.

Anonymous Referee #2

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1 Overview

Schwaerzel et al. use a 3D radiative transfer model to investigate errors induced by the 1D assumptions typically made by atmospheric retrievals for two specific cases - a ground based MAX-DOAS observation and hypothetical plume observation from an airborne pushbroom spectrometer. They first validate the 3D RTM against by simulating horizontally homogeneous conditions. They then investigate the potential 1D induced errors associated with sub-grid variability in the retrieval gas target for the two case studies.

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Discussion paper

The paper is clearly written and is definitely suitable subject matter for AMT. I highly recommend publication after the following comments are addressed.

2 General Comments

Pg3, Ln43: The first review pointed out that it would be difficult to obtain the relevant profile information required to use the 3D scattering weight information. Turning this problem on its head, I think it would be worthwhile commenting on the potential to constrain the horizontal gas distribution if you could scan the instrument azimuthally i.e. is there enough information present to invert concentrations radially in the same manner that different viewing zeniths can be used to partially infer the vertical profile. I think this was alluded to in the conclusions but could be expanded on.

P3, Ln 190: *"This hypothesis could be tested by including more streams"*
I agree with the reasoning, but wouldn't it be easy to rerun the SCIATRAN simulation with a higher stream number just to confirm that it converges towards the monte carlo method so you can make a more definite statement?

Pg 13, L239: The discussion on the line-of-sight sensitivity in this paragraph is useful for gaining some physical intuition for the observations. It would be useful to more systematically explore this as a function of AOD/view geometry, to provide guidelines for situations that permit the interpretation of when the majority of photons are coming to the instrument by single scatter into the path of the detector. It is possibly more relevant to only consider the line-of-sight within the assumed boundary layer, where the largest horizontal variation of NO_2 is expected to be.

Pg 13, L245 It would be nice to see a concrete example of assuming the horizontal homogeneity from the computed box-AMFs by using high resolution CTM output (if the authors have access to any). Although the resolution still may be slightly too coarse, NO2 data from the NASA GEOS-5 nature run is publicly available and may be possibly worth trying (https://portal.nccs.nasa.gov/datashare/G5NR-Chem/Heracles/12.5km/DATA/0.125_deg)
I realize it may not be computationally feasible to run multiple scenarios with the correct solar geometries for particular scenes, but even applying the computed box-AMFs in Figure 8 to ground locations across a set of CTM fields may shed some light on what diurnal/synoptic-time scales

3 Minor Comments/Corrections

I think somewhere it would be helpful to mention how long the monte carlo calculations take perhaps in a until of time/photons to get an idea of how long the scene calculations take

Pg 3, Ln 69: The following equation for SCD more accurately captures the way you have described it

$$SCD = \frac{1}{n} \sum_{i=1}^{n} \int_{path_i} c(l) dl \quad (1)$$

Pg 5, Ln 98: I think MCARaTs is another Monte Carlo RTM with the capability of computing AMFs (https://sites.google.com/site/mcarats/home)

Pg 15, Ln 293 *"The SCCs are larger than the VCDs (panel a) because the AMFs (panel c) are generally larger than 1"* SCC -> SCD. Also, is this a tautology?

Pg 17, Fig. 8 x=19 km and y=13 km -> x=1.9 km and y=1.3 km

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