Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-227-AC2, 2019

Atmospheric Measurement Techniques
Discussions

Interactive comment on "Spectral Sizing of a Coarse Spectral Resolution Satellite Sensor for XCO_2" *by* Jonas Simon Wilzewski et al.

Jonas Simon Wilzewski et al.

jonas.wilzewski@dlr.de

Received and published: 1 November 2019

Reply to interactive comment by anonymous reviewer #2

We thank the reviewer for the helpful comments to our manuscript. Below we repeat the reviewer's questions in **bold** font and subsequently provide our responses.

General Comments

The authors traded-off the spectral resolution but performance with and without O2A is not clear. Did they consider an O2A spectrometer with moderate spectral resolution?

We realize that knowledge of particle scattering in the atmosphere would be improved by observing the oxygen A-Band. Any information, even at coarse spectral resolution, on O_2 absorption in the NIR would be useful to characterize aerosol properties. However, we have not considered an additional spectrometer as this would significantly increase cost and mass of the proposed instrument that we envision to be employed in fleets of relatively inexpensive and small satellites. In terms of possibly losing performance due to uncertainties in the airmass, because of our one band set-up, we would like to emphasize that RemoTeC does not rely on the O_2 A-band to calculate airmass. Instead, information from prior topography and meteorology (such as surface pressure values from the ERA Interim product by ECMWF) is used to determine the air mass below the satellite.

A short discussion of how RemoTeC calculates airmass was added on page 7, line 23 – 27: "For both, native GOSAT and degraded SWIR configurations, airmass information is derived from ECMWF surface pressure reanalyses (ERA-Interim) and topographic data from the Shuttle Radar Tomography Mission (SRTM). For each sounding, we use ECMWF and SRTM data to calculate the ground-pixel average surface pressure and the corresponding dry airmass.. This is the standard operation procedure for RemoTeC trace gas retrievals from the GOSAT, OCO-2 and TROPOMI satellite instruments."

GOSAT has measured several data over cities such as Tokyo and LA using its target observation function. The authors can pick up and discuss aerosol effect over cities.

We investigated the possibility to focus on localized signals by looking at target observations of the Los Angeles basin. However, the data were still too sparse to evaluate the effect of aerosols in a significant matter.

They also concluded that dust is the largest error source by specifying lat-

itudinal ranges. GOSAT has observed desert area such as Sahara and Arabian Desert with its medium gain. The authors can analyze directly by picking up medium gain data

Our analysis shows that errors correlate with the desert latitudes. This is apparent from our analysis, which is based on a mix of high and medium gain spectra (medium gain measurements account for ca. 12 % of the dataset). We do not see what additional information an analysis of medium gain data alone would provide.

Specific Comments

(1) Page 1, Abstract The spectral resolution coarser than native GOSAT and the single-band of CO2 without O2A band are both key parts of this study. However, the latter is not clearly mentioned in the abstract.

We have emphasized that we carry out single-band retrievals in the abstract (page 1, line 11): "...and we evaluate single-band retrievals...".

(2) page 6, Line 18, "non-scattering retrieval", Page 8, Line 9, "the non-scattering SWIR-1 retrieval" Brief description is needed.

Non-scattering retrievals refer to retrievals where scattering by particles is neglected.

We added an explanation (page 6, line 8 – 9): "This approach, which is essentially a transmittance calculation along the geometric lightpath, is hereafter referred to as non-scattering retrieval."

(3) Page 6, Line 20, "More than 75 % of all retrievals converge at any given FWHM that we consider in this study." It is difficult to understand

This statement refers to the fact that the retrieval algorithm converges towards a

solution after a reasonable number of iterations for the majority of retrievals we perform. As the degree of freedom for signal for the aerosol parameter retrieval varies with resolving power, the retrieval becomes more or less tightly regularized so that it may not find the global minimum of the cost function. We added to a sentence in the paper to make this clearer (page 7, line 9 – 10): "Although variations in DFS may lead to changes in the ability of the retrieval algorithm to converge towards the minimum of the cost function, ...".

(4) Page 7, Line 19, "1.856%" It is not clear. Is it 1.8% of XCO2? 7.4 ppm?

To make the spectroscopic cross sections of CO_2 near 2 μm consistent, we apply a scaling factor to the strong CO_2 band. This factor was determined from calculating XCO_2 from the two bands separately. The referee is right that it was not clear which way our scaling of the XCO_2 cross sections at 2.01 μm goes. We added the information in the text (page 8, line 1): "i.e. the cross sections of the 2.01 μm band need to be scaled by 0.981".

(5) Page 10, Figure 4 Use of three individual figures will become clearer.

We have updated the figure accordingly.

(6) Page 16, Line 30 "an additional aerosol sensor may help" The largest error source seems to be vertical profile of particles. Conventional aerosol imager provides horizontal distribution only. Which kind of sensor do authors consider?

Ideally, we want an aerosol instrument that provides multi-angle, radiance and polarization information over a wide spectral range (from the UV to the NIR) while the instrument is sufficiently compact to fit on a small satellite. Hasekamp et al. (2019) describe such an instrument to be deployed on the NASA PACE mission (we included a reference to this work in the manuscript on page 17, line 17).

Technical Corrections (1) Page 6, Line 11 XH2O Definition of 'XH2O' should be described

A short description was added in the text (page 5, line 27 – 28): "throughout this work X*molecule* refers to the column-averaged dry air mole fraction of a molecule"

(2) Page 12, Figure 12 At present, it is monochromatic. It should be a color figure such as figures 6 and 11. Grey line is difficult to see.

This Figure was updated with the same color map as Figures 6 and 11.

References

Hasekamp, O. P., Fu, G., Rusli, S. P., Wu, L., Di Noia, A., aan de Brugh, J., Landgraf J., Smit, J. M., Rietjens, J., van Amerongen, A.: Aerosol measurements by SPEXone on the NASA PACE mission: expected retrieval capabilities, Journal of Quantitative Spectroscopy and Radiative Transfer, 227, 170 – 184, https://doi.org/10.1016/j.jqsrt.2019.02.006