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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.

Anonymous Referee #1

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This study investigates the performance of a prospective compact carbon dioxide (CO2) satellite sensor with a single-band SWIR spectrometer and with high spatial but moderate spectral resolution. Existing greenhouse gas satellites (GOSAT, OCO-2) rely on a multi-band strategy with high spectral resolution in order to discriminate between signals of the target gas and other interfering signals and to derive critical information on atmospheric scattering e.g. due to aerosols and cirrus clouds.

Downgrading the spectral resolution and using only a single band (e.g. SWIR-2) may thus have significant implications for the accuracy of the measurements. On the other hand, such an instrument could offer substantially increased spatial resolution allowing to image the concentrated CO2 plumes of strong hot-spot emissions.

The idea of trading off spatial resolution for spectral resolution has recently been put

forward in a number of other studies and instrument concepts. The present study is timely and relevant given the growing interest in hot-spot emission detection from space. Its focus on CO2 and a single-band configuration is, to my knowledge, not yet covered in previous studies. The study provides valuable information for the design of such a future instrument especially with respect to the range of spectral resolution/resolving power that is acceptable. The manuscript is very well written and concise. The results are backed up with high quality figures and tables. Overall, I thus recommend publication and only have a few minor points as detailed below:

Minor points: 1. It is unclear to me how column mean dry air mole fractions of CO2 are obtained in a retrieval without NIR band, i.e. in a retrieval where no O2 column is estimated. Where is the information on O2 taken from? From surface pressures from a weather prediction model? How does that add to the overall uncertainty? Isn't the retrieval very sensitive to topographic variations and thus to the pointing accuracy of the instrument in this case?

2. A problem not really addressed in the study is the fact that coarser spectral resolution instruments tend to have larger uncertainties in the spectral calibration. The retrieval can account for spectral shifts, but this is more difficult in case of coarsely resolved spectra. What were the assumptions regarding spectral calibration uncertainties and how would that affect the conclusions?

3. Only quality-screened cloud-free GOSAT spectra were used in the analysis. How much does that screening depend on the information in the NIR and SWIR channels? Or in other words, how much more difficult would quality/cloud screening be for an instrument with a single SWIR channel? This seems important to me, since only a small proportion of pixels usually survive the strict quality flagging required for satellite CO2 retrievals.

Since the main application of the sensor will be point-source detection and quantification, a future study should focus on local rather than global scales as done here. The

recent study of Cusworth et al. (2019; https://doi.org/10.5194/amt-2019-202), for example, shows that local plume detection can be significantly affected by retrieval errors which are correlated with surface reflectance. The spectral resolution of the instrument proposed here may be high enough to mitigate such problems, but this aspect should receive more attention in a future study.

Congratulations, I didn't discover any typos or grammatical errors!

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