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Atmospheric Measurement Techniques Discussions

Interactive comment on "Towards space-borne monitoring of localized CO_2 emissions: an instrument concept and first performance assessment" *by* Johan Strandgren et al.

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The manuscript by Strandgren et al. describes a new instrument/mission concept for the space-based monitoring of atmospheric XCO2 at a higher spatial sampling (50 m) than currently achieved by other missions. The authors carry out a sensitivity analysis to evaluate the performance of the proposed system for XCO2 mapping in terms of driving error sources such as measurement noise, atmospheric scattering and surface albedo heterogeneity. Their results show that the proposed instrument can resolve emission plumes up to ∼0.3 Mt CO2/yr, which is claimed to be sufficient for the mission to become a useful complement to other existing and planned XCO2 missions

measuring at a coarser spatial sampling.

This is a nice study and manuscript in my opinion. The methodology is sound, the results are clearly presented, the manuscript is well written and the topic fits perfectly into AMT's scope, so I recommend publication. I would suggest the authors to address the following general points in their revision:

1) Plume mapping vs emission quantification - I understand that the quantification of CO2 emissions is the core goal of the proposed system (e.g. "the goal is to reliably estimate the CO2 emissions from localized sources" p1 L7). However, the entire analysis in this manuscript is focused on XCO2 retrieval, without any discussion of the subsequent CO2 flux calculation. Here, I wonder whether the latter drives any observational requirement affecting the instrument/mission configuration. For example, does the CO2 flux estimation interpose any requirement on either revisit or overpass time? On the other hand, the analysis of results in Figs.9-10 is highly based on whether or not XCO2 plumes can be visually detected from the retrieval results. But can those "detected plumes" be used to infer CO2 fluxes within the expected accuracy? I reckon that propagating measurement errors all the way to CO2 fluxes is probably beyond the scope of this study, but some overall discussion of the potential and limitations of the proposed mission/instrument for CO2 emission quantification is certainly missing.

2) Cloud screening - I understand that the retrieval can account for aerosol and cirrus, but I miss a discussion on how optically-thicker clouds would be detected and screened out from the processing. Just avoiding cloudy sites in the mission acquisition plan doesn't seem to be enough. As far as I know, either the O2 A-band or the combination of information from two SWIR channels is used for cloud detection in other CO2 monitoring missions (e.g. OCO-2). What would be the approach here?

3) Spectral albedo variations - the authors discuss the effect of surface albedo on their retrieval using simulations based on Sentinel-2 surface reflectance data, but if I understand correctly a constant reflectance value is assumed for the entire fitting

window. However, I think the impact of different spectral signatures within the fitting window should also be tested. This could be especially relevant for retrievals over urban environments, which are not only characterized by highly heterogeneous surfaces, but also by the presence of artificial materials with strong absorption features in the SWIR. See for example Ayasse et al. (https://doi.org/10.1016/j.rse.2018.06.018) or Cusworth et al. (https://doi.org/10.5194/amt-2019-414) for analysis of the impact of surface reflectance on methane retrievals for 10-nm sampling instruments. It might be the case that the decoupling between CH4 and surface reflectance is less challenging for the much higher spectral sampling of the proposed instrument, but I think a test of this effect would be important nonetheless. The authors could perhaps link their Sentinel-2 background image with the ECOSTRESS spectral library, SPECCHIO (https://specchio.ch/) and/or any other spectral library containing impervious/urban materials (e.g. http://www.met.reading.ac.uk/micromet/LUMA/SLUM.html).

Other minor points:

- p6, L1 SNR already defined (p4, L5)

- Table 1 - specs for swath (1000 across-track pixels?), MTF/PSF and uniformity (smile/keystone) would also be useful

- p9, L1, FMC: does this mean that there is a variation of the view zenith angle from +20° to -20° in the along track direction of the image? how is this handled by the retrieval? Please, comment.

- p10, 3rd paragraph, forward simulation set-up:

* Since CH4 and H2O are included in the retrieval state vector for SWIR-1, shouldn't they be varied in the forward simulations as well?

* Should the surface BRDF be considered in the forward simulations in order to evaluate errors from the Lambertian assumption in the retrieval? Not trivial to implement, but probably relevant esp. In the case of urban environments

- p16, L21 Sen2Core -> Sen2Cor

- p20, L1: "can nevertheless be clearly separated from the background" - OK, but is this still enough for a useful estimation of the emitted flux?

- p21 L1 & L18: references to potential synergies with companion instruments - a discussion of the planned strategy for cloud screening would be useful here

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