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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Comparative analysis of low-Earth orbit (TROPOMI) and geostationary (GeoCARB, GEO-CAPE) satellite instruments for constraining methane emissions on fine regional scales: application to the Southeast US" *by* Jian-Xiong Sheng et al.

Anonymous Referee #1

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The paper by Sheng et al. examines the information content on methane (CH_4) emissions contained in column-average concentration measurements by three satellite configurations. These configurations reflect the TROPOMI mission in low-Earth-orbit and the GeoCarb and GeoCAPE missions in geostationary orbit. The information content is estimated by a Bayesian inversion for simulated measurements above the Southeast US for a week in summer.

The paper is well written and interesting for the readers of Atmospheric Measurement Techniques in particular since the study can serve as reference for how to size future satellite techniques in terms of spatiotemporal resolution. Therefore, I recommend publishing the paper after considering my comments below:

- The paper is a case study for 1 week of CH_4 emissions in the Southeast USA. How representative is this case study for the overall challenge of inversely estimating methane emissions on regional scales globally for all seasons? The study would gain scientific mass by extending to other regions and other seasons.

- The Bayesian inversion essentially is controlled by the weighting between the measurement uncertainty and the a priori uncertainty. While the assumed measurement uncertainties are described in quite some detail, the text is sparse for the a priori uncertainties. I recommend elaborating in more detail how large the assumed a priori uncertainties are, e.g. a map would help. Is the uncertainty relative to the a priori fluxes i.e. vanishing a priori fluxes remain zero? Likewise, it would be helpful to illustrate the effect of Gaussian Mixture Model used for spatial binning. This information should be included even if it is redundant with previous publications.

- The performance analysis focusses on the DOF which is a very condensed measure. I would recommend extending the analysis to the a posteriori flux errors (or the error reductions wrt. the a priori). Could it be enlightening to plot the averaging kernel matrix for cloudy and less cloudy conditions to illustrate the effects of clouds on the information content?

- The assumed gorund-pixel sizes (table 1) are valid for the sub-satellite point (to the best of my knowledge). For wide-swath LEO missions such as TROPOMI, ground-pixels grow substantially toward the outer parts of the swath. Likewise for GEO, ground-pixel sizes grow with latitude and longitude away from the sub-satellite point. In that sense, the study is too optimistic with respect to the real satellite performance (cloud contamination, measurement density).

- Figure 2, right panel: The inset is somewhat misleading since intuitively one would expect the inset to show kind of the same quantity as the main figure. But, in fact, it is TCCON-model departures in the main figure and cloud cover in the inset. It took me a while to get it. Consider making it separate figures.

- The most recent publication for TROPOMI CH_4 (real data) is Hu et al., https://doi.org/10.1002/2018GL077259, 2018

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