Reply to comments on "Toward a versatile spaceborne architecture for immediate monitoring of the global methane pledge" by Yuchen Wang et al.

Reply to CC #1:

The article shows a very interesting approach to investigate the different methane emissions using available satellites (TROPOMI and PRIMA) and suggesting that a multitiered constellation could be implemented. Some comments on the article of possible improvements.

Response: We truly appreciate your positive responses and valuable comments. We have addressed all of them in our revised manuscript.

The followings are our point-to-point responses to the reviewer's comments. The responses are shown in brown font, while the added/rewritten parts are presented in blue font. All revised figures and tables are also included in the manuscripts.

Line 60 you introduce the term "super-emitters" for first time, the term should be defined better (how big/small, released methane, how spread, etc.) in contrast with hot spots and area sources. This should be tailored for the satellite swath and resolution.

Response: Thanks for this valuable comment. We have supplemented the descriptions to clarify the definition of "super-emitters". In this study, super-emitters can generally be defined to be emission sources that comprise highly concentrated methane plumes and dominate localized methane budgets (~ 5 × 5 km^2). In contrast to region-scale hotspots (or area sources), they can be attributed to individual facilities (e.g., factories, chimneys, and pipelines), typically with side lengths varying from several meters to tens of meters depending on monitoring instruments.

Added/rewritten part in Sect. 1: Super-emitters can generally be defined to be emission sources that comprise highly concentrated methane plumes and dominate localized methane budgets (~ 5 × 5 km^2). In contrast to region-scale hotspots (or area sources), they can be attributed to individual facilities (e.g., factories, chimneys, and pipelines), typically with side lengths varying from several meters to tens of meters depending on monitoring instruments.

Between lines 80 to 92 a review of existing and capable of detecting methane satellites is shown. However, the swath, passes, resolution, etc. is not given for all satellites. I would suggest to add a table with such information. This would help to better understand/propose a future multi-tiered constellation which could act globally.

Response: Thanks. This is a very valuable suggestion. We have supplemented a table (Table 1) to collect the potential satellites and their necessary information (e.g., swath and resolution).

A conclusions section with a better explanation of what number of satellites (which ones in the pipeline / resolution), and aircrafts needed to have a proper coverage would be needed. Also, would it be night monitoring important, which method or missions could be used? Atmospheric Lidars? Would the retrieval of structured atmospheric column help the analysis?

Response: Very illuminating suggestions. We have supplemented brief discussions to clarify these three issues. Overall, this multi-tiered framework based on multifarious satellites, aircrafts, and UAVs keeps pursuing wider coverages and faster revisits. We would thus derive the next objective in this manner, i.e., how to achieve effective, efficient, and economic monitoring of global methane pledges, in which how to make better coverage-resolution balance between instruments is crucial. This will be the topic of a next separate study.

Second, yes, nighttime methane monitoring is important because abnormal leakages or pulses might also occur during nighttime (Plant et al., 2022; Poindexter et al., 2016). In these events, the LIDAR-equipped ones (involving satellites, e.g., MERLIN) can allow to retrieve methane fluxes at all-latitudes, all-seasons, and all-weather (involving nighttime) as they are not relying on sunlight. Fourth, better characterizing methane vertical profile would in principle help to optimize our analysis, like minimizing the uncertainties in tropospheric air mass factors and subsequent methane enhancements.

Added/rewritten part in Sect. 3.4: Note that such a multi-tiered framework based on multifarious satellites, aircrafts, and UAVs keeps pursuing wider coverages and faster revisits. We would thus derive the next objective in this manner, i.e., how to achieve effective, efficient, and economic monitoring of global methane pledges, in which how to make better coverage-resolution balance between instruments is crucial. This will be the topic of the next separate study.

Third, nighttime methane monitoring is important because abnormal leakages or pulses might also occur during nighttime (Plant et al., 2022; Poindexter et al., 2016). In these events, the LIDAR-equipped ones (involving satellites, e.g., MERLIN) can allow to retrieve methane fluxes at all-latitudes, all-seasons, and all-weather (involving nighttime) as they are not relying on sunlight. Fourth, better characterizing methane vertical profile would help to optimize our analysis, like minimizing the uncertainties in tropospheric air mass factors and subsequent methane enhancements.

Cosmetics:

Spacing between text and references. In Line 57, 59, 136, 223, 225, 244, 312, 343, 360.

Response: Thanks. We have supplemented these necessary blank spaces.

Reference in line 117, is this correct format for the current article? In contract to the one in line 145. Is it need to have same info twice?

Response: Thanks. We have checked the format of the reference. Besides, in Line 117 and Line 145, we have deleted the repetitive references.

Reference

Plant, G., Kort, E. A., Brandt, A. R., Chen, Y., Fordice, G., Gorchov Negron, A. M., Schwietzke, S., Smith, M. and Zavala-Araiza, D.: Inefficient and unlit natural gas flares both emit large quantities of methane, Science (80-.)., 377(6614), 1566–1571, doi:10.1126/science.abq0385, 2022.

Poindexter, C. M., Baldocchi, D. D., Matthes, J. H., Knox, S. H. and Variano, E. A.: The contribution of an overlooked transport process to a wetland's methane emissions, Geophys. Res. Lett., 43(12), 6276–6284, doi:https://doi.org/10.1002/2016GL068782, 2016.