Author's response to RC1

Dear Referee,

Thank you for your insightful comment. I will present our point-by-point feedback as follows.

Point-by-Point Feedback

- *"The overlapping of plumes is a real scenario that can occur worldwide. However, it is not understood the impact of these cases at a global level. Thus, it could be a very specific topic that is only applicable in some examples."*

Response: Thanks for your advice. Our motivation for separating methane plumes for quantification has arisen from real-world cases, e.g., the recently published research by EMIT (Thorpe et al., 2023). They manually inspected the L2 data and found plume overlapping can be common. The plume overlapping is especially common in O&G concentrated areas, which generally agrees with our analysis on VISTA-CA source inventory, as well as our Monte Carlo simulation for AVIRIS-NG observed sources.

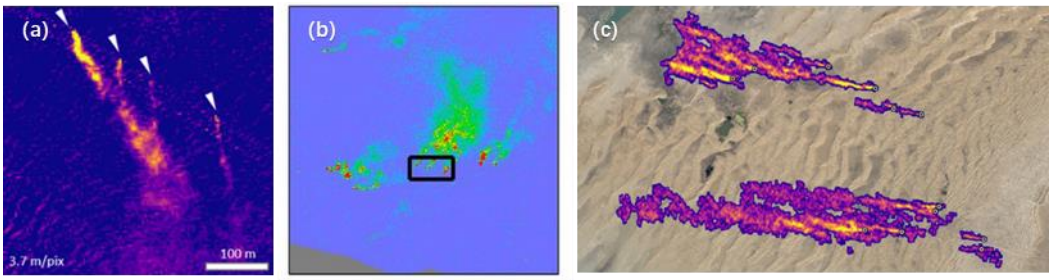

Figure RC1.1 Overlapping plumes observed by (a) Worldview-3 (Sánchez-García et al., 2022); (b) AVIRIS-NG (Duren et al., 2019); (c) EMIT (Green et al., 2023).

While a comprehensive global analysis of plume overlapping appears essential, it can be challenging due to its dependence on both instrumental and environmental factors, in addition to the source distribution. Thus, it seems beyond the scope of this paper. Future work could further investigate this phenomenon with real satellite observations for deeper understanding.

- *"Moreover, the proposed methodology is rather complex. Is it possible to just quantify the non-overlapped area of the plumes (of e.g. FIg 2 and 8) and apply (considering the caveats) the IME method over them?"*

Response: While quantifying the non-overlapped area of the plumes using direct morphological methods seems an interesting possibility, it presents challenges. This method requires predefined shape priors of each plume to eliminate the overlapping area and attribute plumes to sources, which can be challenging. It usually requires massive manual inspection and labeling work, and may also introduce extra systematic errors caused by the subjectivity of the operators.

Even if an algorithm were implemented to automatically eliminate the overlapping pixels and perform source attribution, obstacles may occur in specific cases. (1) When a source is located downwind of an interference source and its plume is fully covered by the interference plume, the method above is not applicable. (2) In cases where the isolated pixels are near the source (in most cases), the quantification can be unstable. As shown in Figure RC1.2, the downwind IME near the source exhibits instability, and this uncertainty will propagate proportionally into the quantification results.

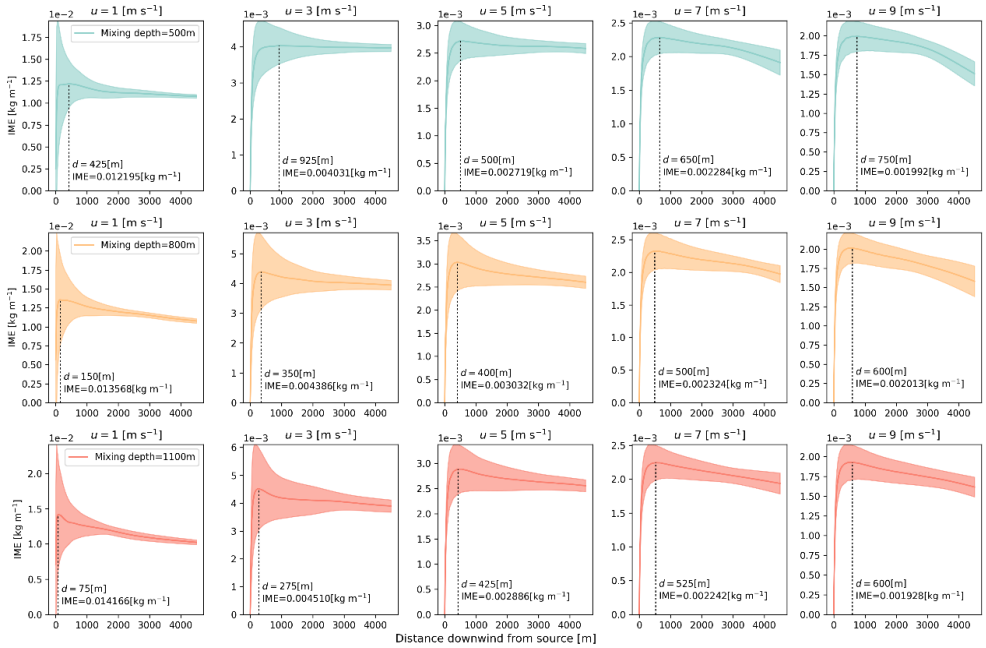

Figure RC1.2 The integrated mass enhancement (IME) distribution downwind in our simulation. The IME is calculated by integration across wind direction (i.e., over the y-axis).

- *"The results indicate a strong underestimation in the quantified flux rate when applying the separation methodology. The authors argue in L421 that this could be the result of some pixels not being attributed to any source. Thus, the results indicate that the methodology needs to be reviewed."*

Response: We found an underestimation trend (see Figure 6), which exhibits a linear relationship with a correlation coefficient of 0.93 (R=0.93). Consequently, this underestimation is corrected using linear regression analysis.

We derived the correction coefficient from the simulation data and applied it to correct the quantification result of the EMIT observation. However, despite this correction, the separated quantification result on EMIT is still lower than the result of directly applying IME quantification, as shown in Table 2.

By superimposing plume pixels detected by the reference method (Varon et al., 2018; UNSEP) with those identified using our method (combination of separation and the reference method; SEP), we can see some plume pixels are excluded by our method (see Figure RC1.3). These excluded pixels can't be attributed to any source. This issue can be raised by irregular plume shapes, mislabeling of source(s), and interference from background noise. These challenges are common in this field. A detailed comprehensive discussion of these issues seems beyond the scope of this article.

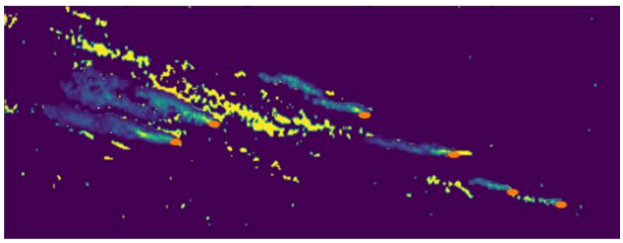

Figure RC1.3 Whole plume pixels (yellow) and separated & attributed plumes (Viridis coloring).

Reference

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