Review of EGUsphere Manuscript (#egusphere-2025-635)

"Airborne Quantification of Angolan Offshore Oil and Gas Methane Emissions" by A. Fiehn et al.

General Comments

This study presents aircraft-based measurements of methane emissions from offshore oil and gas (O&G) operations along the West African coast, using the mass balance approach. The authors demonstrate that bottom-up inventories significantly overestimate emissions, whereas operator-reported values underestimate them. The findings highlight the need for regular airborne and in-situ measurements to improve methane emission quantification and support mitigation efforts. Given Angola's commitment to the Global Methane Pledge, these empirical assessments are critical for guiding policy and regulatory strategies aimed at reducing O&G sector emissions.

Overall, I think this study contributes valuable insights into offshore methane emissions, an underrepresented source in global emission inventories. It underscores the importance of empirical verification and identifies key areas for targeted mitigation strategies. The paper is well-written in general and may be accepted for publication after addressing the following specific comments.

Special Comments

1. **Abstract:** Could the lower observed methane emissions from the aircraft measurements compared to EDGAR and CAMS inventories be due to possible unmeasured methane sources in the region?
2. **Line 36:** Suggest removing "long-lived". The methane lifetime of approximately a decade is relatively short, especially compared to CO2, which persists for centuries. This is also conflicts with the phrase "short lifetime" in Line 39)
3. There is some repeated information, e.g., Line 34 and Line 38 about "the second most significant (important) long-lived anthropogenic greenhouse gas". Please make it concise and combine the first 3 lines into the paragraph starting in Line 36.
4. **Line 43:** The 22% figure is repeated from Line 35. Please consolidate for clarity.
5. **Figure 1:** The methane enhancements in downwind plumes are on the order of 5 ppb. What are the instrumental precision values, and how do they contribute to the overall uncertainty in the mass balance emissions estimate?
6. **Line 139:** How did the authors ensure that methane plumes from facilities are horizontally and vertically well-mixed from the surface?
7. **Line 144:** Is a 5–10 km distance from the source sufficient for plumes to be vertically well-mixed? This is a key concern, as later discussions suggest that plumes are likely not well mixed, which could introduce additional uncertainty.
8. **Lines 149–150:** The statement "These criteria are most likely to be met in the early afternoon, when the PBLH has reached its maximum" may not be entirely valid, particularly regarding the last criterion: "the trace gas plume is well-mixed between the lowest flight track and the ground."
9. **Methane Emission Variability:** while relatively consistent CH4 fluxes were observed for some facilities across different days, flight-to-flight variations — such as the two

high-emission events from two facilities — are not explicitly accounted for the uncertainty analysis. This should be addressed.

10. **L.539-542:** this paragraph seems more appropriate for the Acknowledgement section.
11. **Appendix A:** the authors provided a thorough analysis of mass balance method uncertainties, covering statistical errors, background concentration, and plume height. However, another two key uncertainties should be addressed or at least mentioned: how well the CH_4 plume is mixed within the planetary boundary layer (PBL) and day-to-day variability of emissions. Fig. 1 A shows a factor of 5-6 variation in fluxes at different altitudes, suggesting that the plumes were not very well mixed at typical distances of 5-15 km downwind from the facilities. This is back to my earlier comment that this distance range might not be enough for plumes to be well mixed within the PBL. This is particularly relevant for surveys with fewer transects, as insufficient sampling could lead to larger uncertainty, i.e., less transects will have large uncertainty due to not being well mixed.
12. **L.620-625:** Fig. B1: the caption and text refer to CO2 emissions, but the figure scale label shows CH4 fluxes. Please ensure consistency.
13. **Temporal Variability**: The study was conducted over a three-week period, which may not fully capture seasonal variations in emissions.
14. **Limited Facility Access**: While the study covered a significant number of facilities, more extensive coverage across different offshore production environments could provide a more comprehensive picture.