Reviewer 2 comments

Interesting study, focusing on the emission quantification of LNG facilities. Especially the use of the already emitted CO2 as a tracer is valuable. This study is therefore a good addition within this field of research. It also gives a good overview of the advantages and disadvantages of the mass balance and tracer approach. Furthermore, the statistical substantiation is well provided. The paper is written clear and a relevant topic, that contributes to a better understanding of methane emissions in the environment. It is also helpful to the OGMP 2.0 implementation as a potential method.

We thank the reviewer for their comments and address the specific issues below in turn. Our responses are in blue and additions to the manuscript text in red italics. Page and line numbers refer to the tracked changes version of the manuscript.

Specific comments:

In the abstract, the authors present 2 approaches, downwind mass balance method (1) and the tracer correlation approach (2). In line 38 the authors mention the tracer correlation approach can be used, but here the mass balance approach is not mentioned. Maybe good to also mention the results of this approach in comparison to approach 2.

We have added the mass balance approach to this statement on the similarity of the results. The sentence now reads:
P2. L38: Our results indicate that the mass balance and the CO_2-based tracer correlation approaches provide estimates of CH_4 emissions from LNG facilities that are consistent with each other.

I miss information on the site description and size of the LNG facilities. I understand that they are anonymised, but later on some measurements are above water instead of land. This can have major influences on the dispersion and mixing of the plumes.

As noted, the sites are deliberately anonymized, partly to allow the focus to be purely on the methods. However, we acknowledge that certain aspects may be a little too implicit and require prior knowledge of typical LNG features. Therefore, we have added some further information on the location and size of the four sites alongside the infrastructure that this study covers to the methods section 2.2.

P7. L186: Each of the four LNG facilities is located within close proximity to the coastline, allowing easy access for LNG ships to transport the LNG to customers. The facilities range in size from a single processing train to multiple trains which impacts the amount of LNG produced and the expected emissions. Each processing train is around 200-300 m in length and each facility covers an area of at least 1 km^2, not including the transfer jetty. In addition to processing trains, sites include power generation units, multiple flares, storage tanks, domestic gas processing, condensate processing and other infrastructure. Given the size and potential for multiple sources

of both CH_4 and CO_2, measurements used for quantifications were performed at a downwind distance of between 2-17 km from the centre of each site.

Each LNG facility is situated in a sparsely populated area of Australia. Potential neighbouring CH_4 and CO_2 sources included one of the other LNG facilities, a neighbouring industrial chemical facility, neighbouring O&G infrastructure and termite mounds. To ensure the influence of these were excluded the following strategy was deployed. For each site a reconnaissance leg was flown to identify detectable sources, including any upwind of the LNG facilities. Where another non-LNG plume was detected, only those curtains that had clearly defined separable plumes were used in the analysis. An example is shown in SI Fig S1. Whilst low-level dispersed emissions may have been generated by sources such as termite mounds, these were not detectable as plumes and any widespread upwind contribution of these would be incorporated into the background component which is removed to calculate the enhancement attributable to LNG emissions.

Line 488: For completeness, maybe add that also because of closer distances, plumes from differenced sources of the facilities will not be well mixed already. At closer distances, the individual sources can be detected, which may result in difference CH4:CO2 ratios. This is also shown in Figure 6, with the different sources having different CH4:CO2 ratios at closer distances (Figure 6 a, b and c) and are well mixed at further distances (8 km; Figure 6 d).

Agreed, we have added this point to the text.
P22. L542: Furthermore, at closer distances the plumes from individual sources are unlikely to have mixed and transect ratios may be representative of individual sources, rather than the site-level average. It is notable in Fig.6 that the most consistent site-level correlation is achieved from the measurements taken furthest away, shown in Fig 6(d).

Line 538: Here the authors mentioned that measurements were often taken over water. This can also explain part of the poor mixing below 250 m (line 536). The mixing/dispersion of plumes behave different above water compared to above land (this is for example included in the EPA OCD (Offshore and Coastal Dispersion) model.

Thank you for pointing this out. We have added this point to the discussion.
P27. L595: Since the measurements were often taken over water, other considerations could be the presence of LNG tankers or other ships that might have caused these larger variations as well as poorer mixing due to reduced surface heating over water than over land.