

## ***Interactive comment on “Studying boundary layer methane isotopy and vertical mixing processes at a rewetted peatland site by unmanned aircraft system” by Astrid Lampert et al.***

**Anonymous Referee #2**

Received and published: 22 July 2019

The study by Lampert et al. describes an approach by which air samples can be obtained from different altitudes reaching far into the atmospheric boundary layer (ABL) using an unmanned aerial system. Though the higher level ideas and potential benefits behind the determination of CH<sub>4</sub> isotopic composition within the ABL are distributed throughout the manuscript, a concise summary of the higher level aims of this study in both abstract and introduction is missing. In addition, there is inadequate use of terms with regard to isotopic compositions and isotope ratios, as well as imprecision in describing footprint sizes. After considering the below specified aspects, this publication could be reconsidered for publication in AMT.

C1

1. At this stage, the abstract is not convincing and stops short of revealing the scientific benefit that may arise from profiles of methane isotopic composition reaching far into the atmospheric boundary layer. There is a more or less recent publication by Röckmann et al. in ACP that summarizes nicely the potential benefit of tall tower and, thus, probably also airborne measurements. I suggest using this overarching view to introduce the topic and made a suggestion in this direction in the abstract- section of this referee comment. Some of the ideas can also be found in the conclusions section.
2. In the methods section, I am missing information on from where exactly air is sampled. There is quite some discussion on the adverse effect air parcel transport due to rotor downwash, so that this issue, and how it was tackled (if at all), should be mentioned already in the methods section.
3. In the methods section, water samples are referred to as a proxy for spatial heterogeneity of the emitted methane isotopic composition. However, methane dissolved in water and the methane emitted to the atmosphere will have a different isotopic composition due to the fractionation effect of volatilization. I wonder why the authors have not taken air samples from a closed chamber several times and used the keeling-plot approach to determine the isotopic composition of the emitted methane? This would be a direct measurement of the isotopic composition of emitted methane.
4. Possible influence from surrounding sources, i.e. surrounding land cover/land use, is not discussed at all, but is necessary in view of the highest altitudes at which measurements took place.
5. When on page 4, the design point is mentioned, and the reasoning behind, the introduction makes more sense. Please underline this connection already in the introduction.
6. There is a fundamental misunderstanding of isotope ratios. The isotope ratio (not isotopy ratios) cannot be negative. After transformation of the isotope ratios to the delta scale, negative values arise if the abundance of the heavy atom is lower than that of the reference material. The use of technical terms in a scientific journal has to be right.

C2

7. There seems to be quite some imprecision when the discussion addresses footprints. I suggest consulting the literature, one example is given in the detailed comments. It is unclear why footprints for a measurement taken at 100 m should be similarly small as for a measurement at 10 m, as long as stable atmospheric conditions prevail.

8. Especially the photographs in figure 2 are at least inadequate for a journal like AMT. Both the picture detail and the background makes it practically impossible to discern anything. In addition, the font color is illegible.

9. Figure 3 is not helpful for the manuscript.

10. Figure 9: showing concentration until 10:00 would be enough, source isotopic composition may be best reflected during night. What is the increased concentration at approx. 12:00?

See some more detailed comments below.

Title

ok

Abstract

P1L1: A higher level rationale is missing in the abstract. In addition, the first sentence sounds a bit like quadrocopter air sampling influences laboratory analysis. I get the drift of the authors, but suggest something like "The determination of the methane isotopic composition at a tall tower and in high temporal resolution indicated a high potential to further constrain methane budgets at regional scales. However, tall towers are rare research infrastructures that may be supported by airborne measurement approaches. In this proof of concept study, we demonstrate the feasibility of using a quadrocopter to obtain air samples at heights between 10 and 600 m above ground. The methane isotopic composition of the air samples was subsequently determined in the laboratory. . . ." Introduction

P2L1: I suggest changing to "... 32 times that of CO<sub>2</sub> . . ."

P2L6: Please elaborate on what exactly remains inadequate. The source categories

C3

are quite clear I think, but the relative contributions of the different categories need better constraints.

P2L20: please revise typo in background

P2L21: I suggest changing to "indicates", since isotopic compositions of biological sources and fossil / thermogenic methane may overlap in the region of -55 per mil.

Figure 2: please use a monochrome background for the figure, and change to "battery" on left picture

P3L17: please decide either for methane isotopic composition or for isotope ratio. Isotopic ratio is at least uncommon. In addition, line 16 starts naming the aim, and in line 17, the goals are listed. Please revise the section.

P3L22: I suggest sharing your hypotheses that this is due to the more pronounced influence of the wetland producing depleted CH<sub>4</sub> compared to the atmospheric background in absence of turbulent mixing. See comment above with regard to isotopic ratio ↔ isotope ratio

## Materials and Methods

P4L2: it sounds like the quadrocopter was not based on a commercial chassis. If this applies, please state more clearly.

P4L3: unclear why the payload should alter the dimensions of the UAV. Please provide details. P4L4: I suggest: "At a tare weight of 4 kg, ALICE's maximum take-off weight is 25kg." Does the tare weight include batteries for driving the rotors, or are the LiPo batteries for both operating the scientific instrumentation and driving the rotors?

P4L27-31: I don't understand exactly, if there are both manual and magnetic valves necessary. Please explain in more detail. My first impression would be that only magnetic valves that are normally closed would suffice the purpose?

P4L34: From this sentence I guess that I am right that there are two sets of valves. However, the meaning of this sentence is unclear.

C4

P5L4-6: this section seems redundant to me. The electromagnetic valves were explained some lines above.

P5L16: I suggest starting with where the samples were analysed and that they were brought there directly after the end of the mission, and then go into detail. Otherwise the transport issue pops up out of the blue.

P6L11: I cannot follow that a restored peatland should become a net sink for methane?

P6L25: I suggest including subsection heads "site description", "water sampling" and "flight strategy" P6L35: Please provide rationale for sampling during descent only.

P7L5: Please explain why the first flights were after sunrise though the aim was to investigate the transition from night time stable conditions to daytime turbulence.

#### Results

P7L11/12: please change typo to evidenced, suggest to change to "indicated"

P7L22: Please indicate nocturnal temperature inversion in figure.

#### Discussion

P8L25: please change to stratification

P9L9: -48 to -49 is not an isotope ratio, but the delta value. I suggest using the term isotopic composition throughout the manuscript.

P9L26: This assumption is erroneous. The footprint of a measurement at a given height is larger under stable conditions, because the effect of advective transport is much more distinct compared to a situation dominated by turbulence in which vertical mixing is stronger. Please refer to several papers for example by Kljun et al., e.g., "A three-dimensional backward lagrangian footprint model for a wide range of boundary layer stratifications". In addition, the footprints of measurements at 10m height will be much smaller than those at 100m height.

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