We thank for the valuable commenting of Referee #1 and the opportunity to revise our manuscript. We fully addressed the reviewer's comments as described below. The column 'Line' is referring to the line number in the revised manuscript.

| Comments Referee #1 | Authors response | Line |
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| 1. The evidence of poor GasFinder performance (compared to the manufacturer's specifications) is convincing. Two of the analyses in this study are most important. First is the accuracy and precision estimates derived from the QCL comparisons. This gives a good estimate of the performance of an "off-the-shelf" GasFinder. I do suggest a refinement to this analysis. Can the authors cross-calibrate the lasers and the QCL (i.e., force agreement in the long-term average concentration), and then recalculate the precision? This situation would be the best-case scenario for a laser application. The second interesting analysis shows the variability of the laser cross-calibrations with time. This is perhaps the most important practical finding, as in the past users accepted poor agreement between lasers, believing that a cross-calibration can eliminate or reduce that problem. The findings from this study show that is not the case. | We addressed the issue (long-term forced agreement between sensors) by separating the total uncertainty into the average systematic bias and the precision (=variability of short-term bias/difference) in our analysis. The presented precision is marginally affected by the instruments long-term calibration. An additional adjustment of the long-term span (which is, in our case, underestimated by the factory calibration) would even slightly worsen the precision estimates (+2% to +7% increase in the estimated values).<br>Thus, using the original factory calibration results in a more optimistic (i.e. smaller) value of the GF precision. | |
| 2. Can the authors make a case that in some circumstances a GasFinder based IDM measurement (upwind & downwind lasers) can provide a reasonably accurate determination of emissions (e.g., < 20% error)? For example, large cattle feedlots can have a CH4 concentration rise (above ambient) in the feedlot interior of approximately 1-2 ppm. Based on the errors given in Table 5, are there upwind-downwind laser combinations that might give an emission rate calculation within 20% of the true rate? Such an exercise would be insightful for GasFinder users, and provide for some added perspective. | It is very difficult to a give general estimation or recommendation concerning the GF3 induced error for IDM measurements. This is because the concentration difference of IDM applications can vary (over an order of magnitude or more) depending on the source strength, the geometry of the experimental setup, and the turbulence conditions.<br>The estimated precision of 2.1 to 10.6 ppm-m corresponds to an uncertainty in the concentration difference of 0.06 to 0.30 ppm for a path length of 50 m and 0.01 to 0.06 ppm for a path length of 250 m, given that the systematic bias has been eliminated by inter-calibration and given that the instruments' span has not been altered and, further, given that the GF3 don't exhibit drift and offset features as discussed in Section 3.1.<br>Taking the mentioned example of a large cattle feedlot with 1 ppm concentration rise and a path length of 100 m, this would result in an integrated (one-way) concentration of 100 ppm-m and, therefore, to an uncertainty of roughly 2% to 10% in the concentration measurement, which would suggest a reasonably accurate application of the GF3 measurements in IDM. In contrast, for a typical farm in Switzerland with | |

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| | only 50 dairy cows, the measured concentration difference can be much smaller.<br>Moreover, it must be considered, that the estimated instrument precision is valid for half-hourly concentration averages and estimating the average emission from a long-term measurement series can significantly reduce the uncertainty in the final emission estimate (Bühler et al, submitted).<br>Therefore, we prefer not to give specific calculation examples for IDM application errors in the manuscript, because they easily can be misinterpreted. | |
| 3. Line 11: The Boreal Laser company should be identified with the first reference to the GasFinder. | The sentence was changed to:<br><br>"Open-path measurements of methane ($CH_4$) with the use of GasFinder systems (Boreal Laser Inc, Edmonton Canada) has been frequently used for emission estimation with the inverse dispersion method (IDM), particularly from agricultural sources." | Lines 11 to 13 |
| 4. Line 12 & 13: Do the authors need to tie this work to agricultural emissions? GasFinders are used more broadly than this (I am aware of their use in CH4 measurements at mines, at heavy industries, waste-water treatment plants, etc.). In terms of the entire manuscript, one could delete almost every instance of "agricultural" from the paper. | The authors were mainly aware of papers discussing IDM uses for estimating agricultural emissions. However, Referee #1 notes correctly that there is no need to tie this work to agricultural emissions.<br><br>The sentence was changed to:<br><br>"Open-path measurements of methane ($CH_4$) with the use of GasFinder systems (Boreal Laser Inc, Edmonton Canada) has been frequently used for emission estimation with the inverse dispersion method (IDM), particularly from agricultural sources. It is common to many IDM applications that the concentration enhancement related to $CH_4$ sources is small, typically between 0.05 and 0.5 ppm, and accurate measurements of $CH_4$ concentrations are needed at concentrations close to ambient levels." | Lines 11 to 15 |
| 5. Line 16: "We investigated the uncertainty of six GF3 devices from side by side intercomparison measurements and comparisons to a closed-path quantum cascade laser device". It is important to add that the comparison was made at near-ambient levels of CH4 (and indicating the concentration range, e.g., 1.8 – 2.4 ppm). | We added the following sentences:<br><br>"The comparisons were made at near-ambient levels of $CH_4$ (85 % of measurements below 2.5 ppm) with occasional phases of elevated concentrations (max. 8.3 ppm)." | Lines 17 to 19 |
| 6. Line 29: "It is in common to many IDM applications that the concentration enhancement related to agricultural CH4 sources is small, typically between 0.05 and 0.5 ppm." This "problem" is not unique to agricultural | The term "agricultural" was removed from the sentence:<br><br>"It is in common to many IDM applications that the concentration enhancement related to $CH_4$ sources is small, typically between 0.05 and 0.5 ppm." | Lines 30 to 32 |

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| sources, so the “agricultural” qualifier is unneeded. | | |
| 7. Line 32: “They are based e.g. on the determination of the absorption over a small wavelength range e.g. in the infrared spectrum (tunable diode laser technique for CH4; DeBruyn et al., 2020).” Awkward and unclear sentence. Rewrite. | The sentence was deleted, and the preceding sentence was changed to:<br><br>"In recent years, optical open-path instruments became commercially available that determine the path-integrated $CH_4$ concentration over measurement path lengths of up to several 100 meters.” | Lines 33 to 34 |
| 8. Line 37: “On the other hand, it is more difficult to assess and control the quality of measurements by open-path gas analyzers in comparison to closed-path instruments.” Very good point. | We thank the reviewer for the supporting appraisal. | |
| 9. Line 45: “In this paper, we focus on the GasFinder3-OP (GF3) system for CH4 measurements (Boral Laser Inc, Edmonton Canada) with the ’Lo-Range’ calibration option.” Some explanation for the “Lo-Range” option is needed. Is this a specific type of laser? Does it use a different fitting curve in the concentration calculation? But I would say this is an unneeded detail in the broad objectives paragraph. Also, correct the company name to “Boreal”. | The sentence was changed to:<br><br>“In this paper, we focus on the GasFinder3-OP (GF3) system for $CH_4$ measurements (Boreal Laser Inc, Edmonton Canada) with the “Lo-Range” methane option (i.e. factory calibrated for a detection range between 2 and 8500 ppm-m).” | Lines 45 to 46 |
| 10. Line 62: “The output data in units of ppm-m was converted to the path-averaged concentration C in units of ppm (i.e. divided by the single path length) and corrected with temperature and pressure …” Use “one-way” pathlength rather than “single”. | We changed ‘single path length’ to ‘one-way path length’. | Lines 60, 62 and 128 |
| 11. Line 70: “According to the manufacturer, a valid concentration measurement can be expected if the ’received power’ of the reflected incoming laser beam is in the range of 50 to 3000 µW …” Is power a routine output variable from the GasFinder? | The sentence was extended to:<br><br>"Together with the concentration measurement, the supporting parameters 'received power' (of the reflected incoming beam) and 'R2' (the goodness of fit between the sample and the calibration waveform) are provided as standard outputs of the GF3 instruments. According to the manufacturer, a valid concentration measurement can be expected if the following constraints are met: 'received power' is in the range of 50 to 3000 µW and ‘R2’ is above 0.85 (Boreal Laser Inc., 2018b).” | Lines 69 to 72 |
| 12. Line 78:” Two campaigns, P16 and P17, with a focus on the comparison … close to an animal housing facility (approx. 100 m north).” Does the sensor proximity to the animal housing mean the CH4 concentrations were elevated over ambient levels? Other campaigns also took place near gas sources. The authors might want to clarify whether they are looking at true ambient | We changed the previous sentence to:<br><br>“In total, eight intercomparison campaigns were conducted at different sites in Switzerland with varying ranges of near-ambient concentrations of $CH_4$ (Table 2).” | Lines 78 to 79<br><br>Table 2 |

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| concentrations, or concentrations that ranged from ambient to somewhat above ambient, or near-ambient, etc. | Moreover, we added a summary of the measured concentration (average, minimum and maximum) for each campaign to Table 2. | |
| 13. Line 220: "However, it remains unclear to what extent a side-by-side intercalibration can be transferred to the actual measurement setup, since relocation of the devices might cause systematic changes, as indicated by the different regression coefficients for different intercomparison campaigns". Excellent and very important point. | We appreciate this positive feedback. | |

References:

Bühler M., Häni C., Ammann C., Mohn J., Neftel A., Schrade S., Zähner M., Zeyer K., Brönnimann S., and Kupper T.: Assessment of the inverse dispersion method for the determination of methane emissions from a dairy housing, submitted to Agric. For. Meteorol.