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Interactive comment on "Towards verifying CH_4 emissions from hard coal mines using mobile sun-viewing Fourier transform spectrometry" *by* Andreas Luther et al.

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Dear Anonymous Referee #2,

Thank you very much for this review. We answered your questions in all

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conscience. Answers are written in italics.

Referee comments

#1

It is clear from the method that this paper uses, the cross-sectional flux method, that the potential sources of error include the plume enhancement (directly related to the CH_4 measurement), the effective wind speed U_{eff}, and the cross-plume segment Δy. Of these error sources, the dominate error is the use/derivation of the effective wind speed; this dominates the error budget and limits the precision and accuracy of the method. So the first question is: what do the authors consider to be a useful measurement? The authors state that comparing this with independent data, that is, the European Pollutant Release and Transfer Register, is only a "rough comparison". How will we know if this method is successful; there must be a measure of what success looks like in terms of what would be useful to the community (mines, local govt regulations etc).

We showed, that it is possible to estimate coal mine CH_4 emissions with a mobile FTS in combination with detailed wind information. We also report an error range for the estimates (15% to 30%) which includes uncertainties arising from the method used. We compare our estimates with annual mean values reported by the EPRT-R database for whole mines. We observed single shafts of these mines (the mines in this study operated between 2 and 4 shafts) for a short period of time. We call the comparison "rough" as only continuous measurements with multiple repeats during all seasons would help to better

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estimate an annual average. The problem is, that there is no verified and temporal high resolved emission data. A comprehensive validation can only be realized if we compare our method to others, e.g. inside-shaft measurements of CH_4 flux or tracer release experiments. On an operational basis a mobile FTS can be used to estimate emissions fast and flexible e.g. during a leakage event.

#2

The paper by Varon et al stipulates that this method should not be used in calm conditions, that is, with $U_{eff} < 2\,ms^{-1}$. In Varons study it is suggested using meteorological databases to estimate U_{eff} at 10 meters; has there been any attempt to compare the lidar wind data with independent meteorological data? The authors did undertake a sensitivity study, and this might imply that such a comparison with independent wind data is not possible.

Correct wind information is one of the key measures of the method used in this study. We had the chance to deploy three wind lidars covering different parts of the area of interest. In our opinion, wind lidar data averaged to one, PBL-representing value is a better assumption than using the 10 m wind speed as a model basis. The standard deviation of the intra PBL wind speed average does not represent the uncertainty of the instrument/measurement itself, but represents atmospheric variability. If the variability inside the PBL is high, the estimated error rises. Referee #1 asked for a sensitivity study, in which we used just the lower half of the PBL's wind information to generate U_{eff}. This resulted in an average difference of 8% between "full-" and "half-PBL" emission estimates, which is within the error budget. We did not compare the wind lidar measurements with conventional wind data. The lowest level of the wind lidar

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data output we used is about 100 m above ground level.

#3

In terms of the error introduced from U_{eff}, there is the question of how accurate the estimation of the wind speed is from the lidar, and secondly, how turbulence in the wind flow leads to inherent variability in the wind speed. There is also the variability in the CH_4 sources themselves. The authors build these error sources into the error budget. The text states that these sources, up to 20% or more, are estimated. How is this estimate actually done? In most cases it appears to be based on the standard deviation of data from the lidar for example, or is there also factors based on the operation of the lidar? Perhaps the question is what control did the authors have over the operation of the lidars in terms of direct analyses? Did the authors do this wind speed determination directly?

The wind lidars were deployed, operated, and the data analysis directly performed by the institute of atmospheric physics (DLR in Oberpfaffenhofen). The retrieval of wind speed and direction from radial wind speed measurements of the VAD scans was performed with filtered sine-wave fitting according to the literature cited in section 2.2. The uncertainty of radial wind speed estimates is at the order of 0.2 ms^{-1} and is incorporated into the error budget. This level of uncertainty is particularly critical for the error budget in low wind speed conditions. During the Perdigão 2017 experiment, this error value is evaluated by comparing wind lidar data with wind mast measurements (http://www.pa.op.dlr.de/PERDIGAO2017/references/Kigle_Master_thesis.pdf and https://doi.org/10.1088%2F1742-6596%2F1037%2F5%2F052006).

The combined standard deviations for our emissions estimates range between 15% (24 May, noon) and 30% (1 June). Part of these are the wind-specific errors which include the 0.2 ms^{-1} uncertainty, the standard deviation of the vertical average over the PBL, the standard deviation of the temporal average over the whole transect, and the horizontal average based on the fact, that the distance of the FTS to the closest wind lidar never exceeded 33 km and the error related to this distance generally stays below 10% for wind speed and below 3% for wind direction.