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Atmospheric Measurement Techniques Discussions



# *Interactive comment on* "Quantification of methane emission rates from coal mine ventilation shafts using airborne remote sensing data" *by* T. Krings et al.

**T. Krings et al.**

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We thank the referee for the review. The referee had a few minor comments and suggestions that will help us to improve our manuscript. All questions and comments will be addressed in the following.

Referee: P7388L11: *"The author refers to in-situ measurements at the surface. Is this in reference to the aircraft CH4 in-situ analyser or are there additional instruements located on the ground, present for this campaign? Clarification on this would be useful as well as perhaps a comment on how crucial this additional data is to the analysis (i.e.*

*does MAMAP require the additional intrumentation to be present?)."*

Authors' response: There were no additional sensors associated to this campaign located on the ground. The in-situ measurements in the boundary layer were performed with the aircraft $CH_4$ analyser. We will clarify the sentence by slightly rephrasing:

"For $CH_4$, the profile has been updated to 1757 ppb $XCH_4$ (with a surface concentration of 1840 ppb) based on the median value of the airborne in-situ measurements which was about 1840 ppb in the boundary layer for this region."

If no in-situ data is available, the regional background can be determined by using satellite and model data as well as information from surface networks for the region of interest. An error in the assumed background column translates to an error in the inversion result as explained in Section 6.5. We will add following sentence about alternatives to in-situ analyser data for obtaining background column information:

"Generally, in cases where no airborne in-situ data on the background column are available, the regional background can be determined using satellite or model data as well as information from surface networks."

Referee: P7389L25: "*The author utilises the CO2 proxy method but doesn't introduce it in enough detail. I would recommend a few additional sentences explaining the reasons for it's use as well as the inclusion of at least one appropriate reference describing it's use in satellite remote sensing (e.g. Frankenberg/SCIAMACHY, Parker/GOSAT, Schepers/ GOSAT, etc).*"

Authors' response: We will add some more information about the proxy method and refer to Krings et al. (2011) where the method and advantages are described in great detail. We will also add references for satellite application of the proxy method:

"The proxy method offers the advantage of accounting for light path variations that may occur, for example, in the presence of aerosols or sub-visual cirrus. These variations are similar for observations which are spectrally close to one another and cancel to



AMTD

5, C3351–C3354, 2012



a large extent for their ratios. This method has been used also for satellite remote sensing applications (compare, for example, Frankenberg et al. (2005), Schneising et al. (2009)). A quantitative assessment of the proxy method using MAMAP data can be found in Krings et al. (2011)."

Referee: "*Additionally, it's unclear what is taken as the model XCO2 used to re-normalise the XCH4/XCO2 ratio. If this is a constant value, some discussion on how appropriate this value is should be included.*"

Authors' response: The background column averaged dry air mole fraction of $X\mathrm{CO}_2$ was assumed to be constant at 390 ppm (Section 3). A potential, constant bias is accounted for by a re-normalisation of the mean $X\mathrm{CH}_4(\mathrm{CO}_2)$ to background $X\mathrm{CH}_4$. Variations of $X\mathrm{CO}_2$ inside the measurement area on the other hand can potentially introduce an additional error for $X\mathrm{CH}_4(\mathrm{CO}_2)$ and the emission rate estimates. However, beside the power plant emissions, no significant disturbances in $\mathrm{CO}_2$ are to be expected in the region under consideration (Section 2). In the revised version, we will point this out by slightly rephrasing P7388L9:

"For $\mathrm{CO}_2$, a constant background profile of 390 ppm $X\mathrm{CO}_2$ was assumed."

and by later adding:

"The $X\mathrm{CH}_4(\mathrm{CO}_2)$ data was re-normalized to account for a potential, constant bias in the assumed $X\mathrm{CO}_2$ background column."

and further below:

"[This is caused by the increased $\mathrm{CO}_2$ in the power plant's flue gas that appears in the $X\mathrm{CH}_4(\mathrm{CO}_2)$ as a methane depletion as the $\mathrm{CH}_4$ to $\mathrm{CO}_2$ column ratio is lower than background.] Other significant variations of $X\mathrm{CO}_2$ are not to be expected for the generally well mixed $\mathrm{CO}_2$ in the small area of interest. This assumption is further supported by the fact that $X\mathrm{CH}_4(\mathrm{CO}_2)$ exhibits small variability outside the plume areas."

Referee: "*Some justification has been given in ruling out features in the observed*



AMTD
5, C3351–C3354, 2012

*proxy XCH4 being due to the XCH4 or XCO2 (e.g. P7390L16) but the author only briefly touches on whether surface reflectance may be an issue here. Some further analysis/discussion may be appropriate here.*"

Authors' response: This is indeed an interesting topic for further research. To reach meaningful conclusions on the origin of these features, however, additional (laboratory) measurements of the excavated material may be required. As these surface features occur outside the $CH_4$ plumes under investigation, they do not influence the inversion result. This issue will be followed up on in future work, beyond this publication.

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 7383, 2012.