Response to reviewer #2.

We thank the reviewer for the positive assessment of our manuscript and for the constructive comments and suggestions, especially regarding the γ parameter of the REBS algorithm. We have added additional sensitivity tests using different approaches for estimating γ and clarified the methodology used to determine this parameter in the revised manuscript. We have addressed all comments raised by the reviewer, and our detailed responses to each comment are provided below, with the reviewer comments shown in black and the author responses shown in blue.

Review Großmann et al. “Atmospheric CO2 and CH4 measurements at Schauinsland station, Germany: A comparative study of diurnal and seasonal variations at 12 and 35 m intake height”

This paper describes and carefully analyses the comparison between measurements made at different heights over a period of several years. This is a really good study with relevance for interpretation of such data, especially with regard to their representation in atmospheric models in the context of inverse model applications. The paper is well-written, and fits well within the scope of AMT. However, a few issues listed below should be addressed before the paper can be recommended for publication.

General comments:

Calculation of mean values: It is unclear if the statistical calculations were made using the requirement that both instruments have data available. Non-overlapping data will cause the means to not be compatible. Further, for the daily mean calculation (L147) is there a requirement that the number of daytime and nighttime hours are similar? Otherwise the diurnal cycle might cause a larger error in the daily mean, if for example all available 12 hours are in the night.

Authors response: All statistical calculations in this study were performed only using time steps for which measurements from both instruments were available. Therefore, the calculated differences and mean values are based on overlapping data only and are directly comparable between the two inlet systems.
No specific requirement was applied for the number of daytime and night-time hours included in the daily means. This is because the available hourly data were not systematically biased towards either daytime or night-time periods, and the distribution of observations over the diurnal cycle was sufficiently balanced.

Section 2.6, description of REBS method: In 2.6 gamma is described as „the standard deviation of data below the baseline curve“. This differs somewhat from the description in section 2.1 of Ruckstuhl et al. (2012). Is gamma estimated daily, annually, or for the full time series? Or is REBS applied to various sections of the time series (in Line 370 it seems so) such that various estimates for gamma exist? It also should be discussed how it is avoided that the diurnal and seasonal cycle in CH4 affects the estimation. My guess is that gamma is derived from negative residuals (obs. – background) rather than from the observations themselves, which would certainly reduce, if not remove the influence from diurnal/seasonal variations. It would also be interesting to know what the actual value of gamma was, especially in the context of the discussions in 3.5 and 3.6.

For better traceability of the application of the REBS method it would be good if the (probly simple) code could be shared.

Authors response: Thank you for this very helpful and detailed comment. We agree that the description of the γ parameter and its estimation in the context of the REBS algorithm required further clarification.
In this study, γ was estimated from the negative residuals (mole fractions at 12 m – baseline estimate) including the complete period to which the REBS algorithm was applied (May–November 2022–2024), which resulted in a constant value of 1.65. Estimating γ over shorter time windows, as for example the previous 24 h as in Cristofanelli et al. (2023), can lead to enhanced γ values in the case of Schauinsland due to periods with very frequent CH_4 spikes, reducing the sensitivity of the algorithm. We have added a sensitivity analysis (Fig. S9) comparing different approaches for estimating γ, including rolling windows from a few hours to two weeks and estimates based on the example period and the full dataset.
We also identified that in the previous version γ was unintentionally recalculated for each example period shown in Figs. 10, 11, S4, S5, and S6 instead of using the constant value derived from the complete dataset. This affected the number of detected spikes but did not change the conclusions. The corresponding analyses and figures have been corrected.

The description of the REBS application has been revised by adding: "… and γ set to a constant value of 1.65, estimated from all data that the algorithm is applied to (Fig. S8)." Fig. S9 shows the algorithm applied to an example time series with various approaches to estimate γ. We added to the Supplements:

"The γ value is estimated as the standard deviation of all data below the fitted baseline curve. While in Cristofanelli et al (2023) this was done using a rolling window of the previous 24 h for each data point, in this study γ was estimated from the complete period to which the algorithm is applied to (May to November of the years 2022 to 2024). Figure S8 shows the application of the algorithm to an example time series using different approaches for estimating γ, including rolling windows ranging from 1 h to two weeks as well as γ estimates derived from the 10 day example period and the complete May to November Time series. At the Schauinsland station the spikes occur very frequently during short periods, whereas other periods are largely unaffected. Therefore, estimating γ for shorter sections of the time series can lead to strongly enhanced γ values (grey line), reducing the performance of the spike detection algorithm. Hence, it was chosen use a constant γ value of 1.65, calculated from the months May to November of the three years of data."

Specific comments

L55: add a semicolon before "or CH4 spikes", as this has nothing to do with manual spike removal. May be consider having a separate sentence for the Westerland example.

Done

L56: "At Ispra station" -> "At the Ispra station"

Done

L233-235: "peak around noontime" this is not obvious to me, please mention specifically where in Fig. 6 this can be seen

Authors response: This indeed needs clarification, we replaced "peak around noontime" with "peak from 09:00 – 11:00 UTC (11:00 – 13:00 LT)" in the manuscript.

L274: That the solar radiation drives the photochemical sink is clear, but the solar impact on anthropogenic sources is not. May be reformulate.

Authors response: To improve clearness, we changed the respective paragraph to: “The seasonality with increased mole fractions in winter and decreased mole fractions in summer reflects the seasonally changing solar irradiation driving the atmospheric CH_4 sink. Superimposed on this seasonality are patterns related to regional transport: From April to November, CH_4 enriched air masses are transported to the station more frequently leading to elevated mole fractions, especially in August and September.”

L289-290: I suggest replacing “like” with “as”

done

L314: “renders” > “render”; “introduces“ > “introduce“

done

L332: In the figure title and caption June is mentioned, here the text refers to July -> please correct

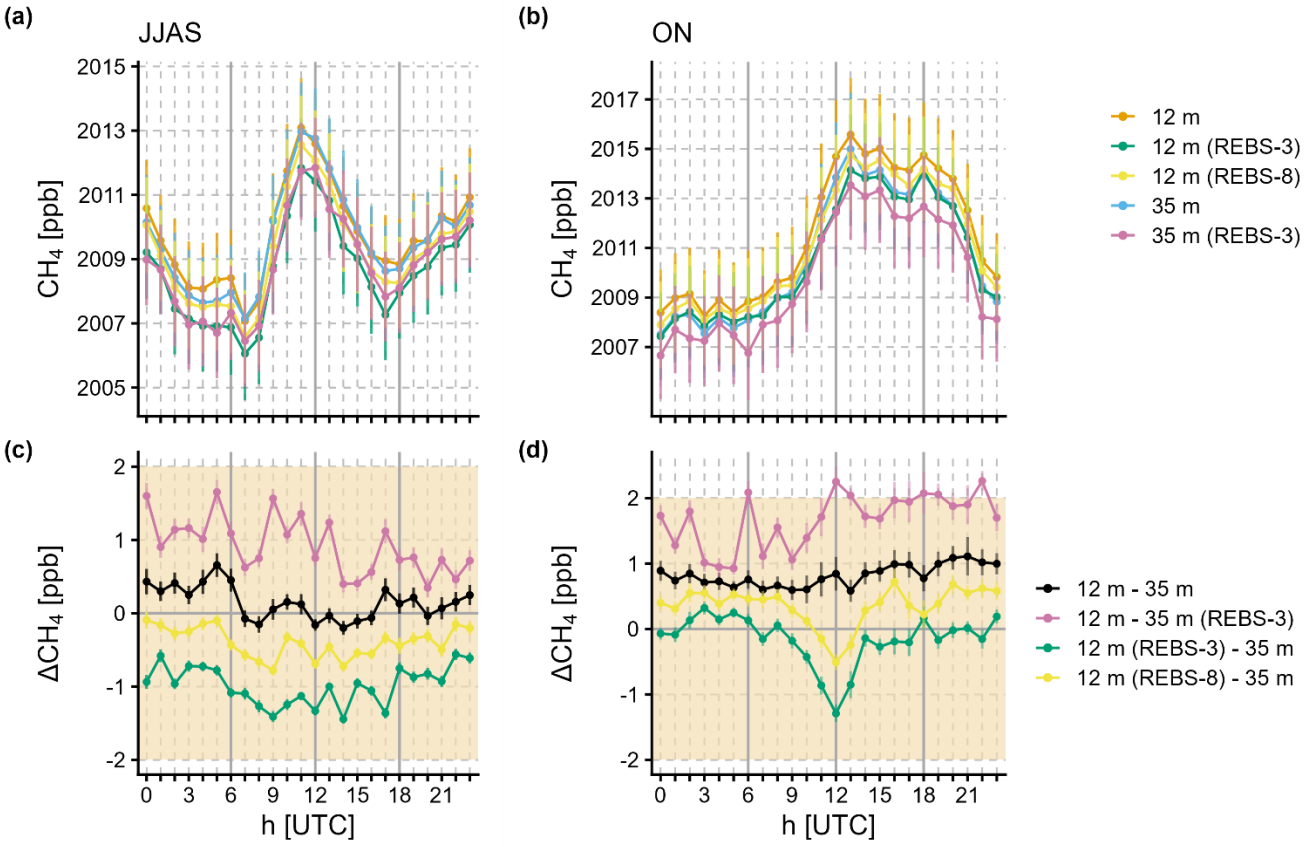
Authors response: Thank you for this comment. June is correct, we adapted the manuscript accordingly.

L371: Was REBS not only applied once with a specific setting? This is unclear, as the outcome of the method for a specific data point does seem to depend on the temporal context, and thus on whether it was applied to the full time series once, or for segments.

Authors response: This was indeed not entirely clear from the current version of the manuscript, we specified the determination of the gamma parameter. However, the baseline estimation, which is calculated as moving average over a 60 minutes time frame, depends on the measured mole fraction during. Consequently, during spike intense periods, the background can be overestimated by the baseline fit and hence increase the threshold for a data point to be identified as spike altering the performance of the algorithm.

L389 – 395: It would be interesting to see if the application of REBS also to 35 m affects the biases seen in Fig. 13. So if the same filter algorithm is used for both levels.

Authors response: Thank you for your comment. Applying the REBS algorithm to the 35 m time series could indeed help assess whether the algorithm introduces systematic biases. In following plot, the diurnal mean mole fraction at 35 m after filtering with the REBS algorithm ($\beta = 3$) has been added to Fig. 13. The resulting differences (purple line) show a positive mean bias in the differences, i.e. reduction of the 35 m mole fraction, with a relatively large variability. Notably, applying the REBS algorithm on the 35 m time series leads to a positive peak in the differences between the lines around 12:00 UTC in October and November, when the application of the algorithm on the 12 m time series shows a negative peak (yellow and green line in plot d). This supports our statement that during periods of large variability, the REBS algorithm filters too many data points that exceed the baseline, introducing a systematic bias into the time series.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