Authors' response to Referee#1

First of all, we would like to thank the Referee for his/her positive evaluation of our manuscript and would like to thank him/her for the comments and suggestions, which have helped us to improve the manuscript. Below you will find our detailed, point-by-point responses to the comments and suggestions. Responses are given in blue.

General:

The author of the manuscript presents and discusses long-term CO2 measurements at a Central European station in Hungary. I enjoyed reading it. The manuscript is nicely written and organized and can be considered for publication with only minor changes outlined below.

Thank you for the positive evaluation!

Minor points:

L 10 …gives the technical description and its changes over time…

The addition was accepted and inserted in the sentence.

L 10 …physical environment
What does this mean? what about other conditions like to agricultural, biological situations?

„Physical" was used as an „umbrella" term for all environmental factors potentially affecting the measurements (climate, human activities, vegetation, soil characteristics, relief, etc.). To avoid the misinterpretation the attribute „physical" has been omitted.

L 16-17 You may state by how many days the growing period has lengthened over the entire measurement period.

A sentence has been added that gives the increase in the length of the CO_2-deficit season during the measurement period (1995-2022: 9.0±6.1 days).

L 63 yes, but what do you tell us about this? In the western European part, there are a couple of more southern stations!

The prevailing wind in the non-Arctic part of Europe blows from the west and carries the emitted CO_2 to the east. The southwestern monitoring stations are less helpful than the eastern ones in assessing the emissions in Western Europe, which gives their importance. In Finland, there are monitoring sites geographically east of HUN but they are characterized by the Arctic circulation pattern.

L 68-69 I guess it is enough if you state this in section 2.2.

The sentences have been moved to the end of Section 2.2.

L 74 air intakes...

How many and at which levels? This information can be given already here. At least give the number of air intakes or move the sentence of line 131-132 to here.

This section describes the monitoring site and its characteristics. The characteristics of the monitoring system, including the number and heights of the intakes are given in the next section (2.2 Monitoring system). Although we could also mention the number of intakes and their heights here, this would break the structure of the section and cause the duplication of the information. In the description of the monitoring system, the number and locations of the intakes have to be given for completeness anyway.

L 94-96 These numbers are very low, what about the uncertainty of these values? The values tell us that there is no influence during winter from local emissions.

Thank you very much for the question! Reading the question it was realized that the average excess is not the right term to characterize the local influence on the measurements. It makes little sense because the frequency distribution of the excess CO_2 is very far from normal. Instead, it is said that during 83.2 % of the studied period, the local emissions from the nearby village did not reach the sampling intake at all because either the emission sources were leeward to the monitoring site or an inversion layer prevented the intake height from contamination. The excess CO_2 derived from the local anthropogenic emissions exceeded 0.04 µmol mol^{-1} only during 0.09 % of the studied time. The sentence was rewritten accordingly.

L 108-109 Reference: I could not find this information. You may consider a reference directly to the original publication where these classification are defined.

The referenced WDCGG web page lists the metadata of all monitoring stations, including their climate classification. You should scroll down to HUN (Hegyhátsál) and you will find the climate classification of the station. Unfortunately, the structure of the WDCGG website does not allow a more direct link to the data of the monitoring site. For easier access to the information the revised manuscript refers to the GAWSIS database.

L 153-154 Also the NDIR systems can be run as absolute measurement devices. It is a question of calibration.

Yes, they can. We used the NDIR analyzers in relative mode to achieve higher sensitivity.

Fig. 3 Resolution of the graph should be increased!

We will contact AMT technical staff about this issue. The figure in the copy of the manuscript downloaded from AMT is sharp and clearly legible. However, if there is any problem with the resolution of the figure we will do our best to provide a higher quality.

L 201 What are the intake 1 and intake 2?

We wanted to show that even if the concentration difference between two intakes (hypothetical Intake 1 and Intake 2) is as high as 70 µmol mol^{-1}, the deviation from the true concentration falls below 0.1 µmol mol^{-1} within 35-45 s after switching from the one intake to the other. The sentence has been reworded for clarity.

L 201-203 This is somewhat misleading as in this case, you could use all 2-minute values? Of course, this does not make sense as it is required to flush the Picarro measurement cell.

The sentence has been rephrased for easier understanding

L 218 Calibration: this is rather infrequent with monthly calibration

Since the compilation of the manuscript, we performed a 6-month test period in cooperation with ICOS Atmospheric Thematic Centre. As a result of the rigorous tests, it was agreed that monthly calibration is enough to provide high-quality data for the ICOS monitoring network.

L 220 What about the target tank concentration measurements? Or stability of standard gas raw measurements

No target gas measurement was included in the measurement protocol. In the case of the NDIR analyzers, the frequent "zeroing" could be considered as some kind of target measurement but in fact, those measurements were used for drift compensation. The continuous drift compensation makes it difficult to evaluate the stability of the raw standard gas measurements. Taking into account the very low drift of the Picarro analyzer, originally no target measurements were planned. It was introduced only in late 2023 to comply with the ICOS requirements.

Fig. 4 I guess you have averaged all days of the corresponding month of the complete data series. It would be good to add for each height uncertainty range by light shadowing using the same color.

Unfortunately, this is technically not feasible. Hegyhátsál is a mid-continental monitoring site where the concentration varies considerably. The scatter of the data is high. Even the 1-sigma uncertainty ranges would completely overlap each other during the daytime and partly during the other times of the day.

Fig. 5 The same here, add the range of variation by color shadowing

See the response to your comment regarding Fig. 4.

L 311-312 You might move this sentence after the next sentence and start with: Furthermore, according to...

The two sentences have been swapped as suggested.

L 321-323 How was this calculated?

The mean planetary boundary layer (PBL) concentrations were estimated from the vertical concentration profile along the tower (10-115 m) and what was measured from the aircraft (from ~200 m to the top of PBL). The estimated mean concentrations were compared with those measured at the top of the tower (115 m above ground). Details are given in the referenced paper.

Fig. 6 The shift of the red dashed line….
if the increase is uniform

The sentence has been completed.

Fig. 8 Add see text for reference

The reference has been added.

Fig. 9 Which level have you used here? The lowest I guess. Anyhow write it.

For consistency with the trend calculations, the measurements from the top of the tower (115 m) were used for the evaluation. Now, this is explicitly stated in the caption of Fig. 9.

L 415 NDVI values …add reference

The reference has been added.

Fig. 10 Define summer and winter by specifying the summer (months of...) as well as winter (months of ...)

The caption of Fig. 10 has been completed by defining the summer and winter periods.

L 439 This number could be checked by radiocarbon measurements in comparison with those of a marine boundary layer site.

In the revised manuscript we refer to the $^{14}CO_2$ measurements performed at Hegyhátsál in 2008-2014, which showed a 1-6 ppm seasonally varying fossil fuel excess CO_2 relative to the Jungfraujoch European high-mountain baseline station.

L 451 Ocean phenomenon, how does it influence the terrestrial site as strongly as the marine boundary layer? (Fig. 13)

Although El Niño is an oceanic phenomenon, it dominantly influences the atmospheric CO_2 concentration through the terrestrial biosphere. The droughts and wildfires it causes add more CO_2 to the atmosphere than the extra release from the warming ocean.

Fig. 13 Move the y-axis to the left

y-axis labels have been moved to the left side of the figure.