

Review of A retrieval of $x\text{CO}_2$ from ground-based mid-infrared NDACC solar absorption spectra and comparison to TCCON” (AMT-2023-32)

The manuscript introduces a new spectral window to retrieve total column abundances of CO_2 ($X\text{CO}_2$) in the mid-infrared region measured by the NDACC network. Comparisons are made with standard TCCON $X\text{CO}_2$ product as well as the retrieved values from the same spectral window in TCCON. This study is valuable since it adds a new data product to NDACC that could potentially expand the total column CO_2 measurement network around the globe.

The formatting of the manuscript, figures and tables need to be improved for better presentation of the content. Some passages in the text require extra explanation to help the audience understand the ideas more clearly. Here are some general comments that I think would help improve the manuscript:

1. Please consider making the figures, axis labels and numbers, legends, symbols larger so they are easier to read.
2. For CO_2 , O_2 , N_2 , CH_4 , use subscripts throughout the text.
3. There are undefined citations throughout the text shown as question marks. Please make sure to link them to the right references.
4. Define all the variables introduced in the equations before or after the equation.
5. In section 4.2, why don't you apply an airmass correction to the retrievals to see if it improves the retrievals? and maybe use those for comparisons in the following sections?
6. What is the purpose of section 5.1? If it's to evaluate the precision of measurements why don't you use a shorter period of time let's say 20 minutes for averaging. Because as you said we expect $X\text{CO}_2$ to change during the day and the SD wouldn't necessarily represent the precision of measurements. If the reason is the limited number of measurement points from NDACC please state it in the text.
7. In table 4, could you add a column presenting the values from Wunch et al to make the comparisons easier?

Minor corrections and comments:

- **Line 10:** Do you mean precision of 0.2%?
- **Line 10:** I am assuming in the first part of the sentence you are talking about the averaging kernel comparisons and at the end you are talking about the seasonality observed in the retrieved value? Can you make this more clear? Maybe split it up into two sentences?
- **Line 11:** We don't usually refer to specific sections in the abstract. Maybe you can say: In addition, we propose an optimal retrieval strategy to improve the quality of the data product.
- **Line 15:** Define XCO₂ for the first time.
- **Line 15:** main net sources of what? CO₂?
- **Line 20:** validation is repeated twice
- **Line 20:** need additional space after of CO₂
- **Line 25:** do you mean pre recorded spectra?
- **Line 27:** NDACC trace gas products, ...
- **Line 28:** Expand the temporal and spatial coverage of the total column products.
- **Line 30:** Define XCO₂ for the first time.
- **Line 42:** What do you mean by 'topospheric signal is damped in comparison to TCCON' ?
- **Line 60:** ... since 1992 which covers the mid-infrared ...
- **Line 82:** 21113 → 01101 Add more explanation for this notation or remove it here and refer to table F1.
- **Line 85:** Buckingham (1976) should be in brackets.
- **Line 90:** Which appendix?
- **Line 92:** 'on the left' / 'towards the left' : please be more specific. You can use the approximate wavenumber.
- **Line 102:** Please move this to the data availability section at the end of the manuscript.
- **Line 108 :** Wunch et al. (2015) is describing GGG2014. GGG2020 is still in preparation you can cite <https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/675531> for now.
- **Equation 1:** Define VC here.

- **Line 125:** These are two main important differences...
- **Line 126:** you haven't explained what is airmass and what is in situ correction yet.
- **Line 132:** not abundant (usually less than 20) Be more clear. What do you mean by less than 20? less than 20 spectra per day?
- **Equations 3 and 4:** Define all the elements in the equations.
- **Line 141:** This sentence is not clear.
- **Line 143:** Which retrieval windows are the test spectra from?
- **Line 151:** Strong sensitivity/ high sensitivity instead of good sensitivity.
- **Line 156:** ... follow a similar curvature but at different altitude ... Not clear. Please explain in more details.
- **Line 167:** Add citation to GEOS-FO-IT.
- **Line 171:** Unclear. Break down the sentence into two or three. Explain how you construct the modified a priori separately in another sentence. Also what do you mean by other tests?
- **Line 174:** same retrieval: do you mean same retrieval procedure or same retrieval algorithm?
- **Figure 3:** Define ΔCO_2 both in the plot and in the caption. Is it fixed a priori minus standard a priori or vice versa?
- **Line 177:** correlation coefficient r (between which two parameters?)
- **Line 179:** Please be consistent with Figure 3. δCO_2 is the same as ΔCO_2 ?
- **Line 179:** What do you mean by modified a priori? Is it the same as what you call as the fixed a priori used in Figure 3.
- **Line 181:** a over estimation \rightarrow an over estimation
- **Line 183:** I don't think artifact is a good description for the airmass independent correction. Airmass independent bias might be better.
- **Line 185:** Add brackets to Wunch et al. (2011a)
- **Line 187:** TCCON derives and applies a single empirical airmass correction: It's not in fact a single value. GGG2020 applies airmass correction for each retrieval window separately before averaging them for each gas.
- **Line 192:** the dependence is observed: which dependence are you referring to?

- **Figure 4:** add : after Top in the caption.
- **Line 204:** To investigate if the scaling between 6300 and w4790 is consistent between both locations....
- **Figure 5:** Define the ratio in the caption. Also what do you mean by H₂O content? Is that XH₂O? In addition, readers with colour vision deficiencies might not be able to differentiate between these colors. Please double check.
- **Line 216:** No brackets for Wunch et al.
- **Line 218:** A higher dependence in what? How do you define XCO₂ bias? Do you mean bias between XCO₂ and column averaged in situ profiles?
- **Line 225:** ... , that aircrafts and balloons can't capture, **in addition** to the temperature sensitivity of the spectral window.
- **Line 228:** The mean ratio... specify which ratio you are referring to.
- **Line 229:** These biases or **This** bias
- **Line 229:** airmass correction factor: do you mean in-situ correction factor?
- **Line 239:** are you using 1 standard deviation for 6300 and 2 for 4790? why?
- **Line 240:** why don't you use standard error instead then?
- **Figure 7:** maybe bring the purple histogram forward for better visibility.
- **Line 258:** All tests, except CO₂,... Do you mean CO₂ a priori profile?
- **Line 268:** The w4790 retrieval is more sensitive to pressure perturbations than TCCON. How much is the value for TCCON?
- **Line 271:** ... the perturbation tests performed for this study.
- **Line 283:** For the perturbations of xCO₂ ... Again do you mean perturbations in the a priori profile?
- **Figure 8:** Again here I guess you mean CO₂ and H₂O a priori.
- **Line 306:** in the minimum SZA of 18°. Given that the maximum SZA ...
- **Line 326:** Could you elaborate more on what you mean by the interferometer being abnormal?
- **Line 391:** Add proper citation.
- **Line 347:** how would a good temperature sensor improve errors?

- **Line 328** explain what is a window file.
- **Line 352:** good sensitivity... high sensitivity?
- **Line 354:** where does the bracket close?
- **Appendix A:** Explain the parameters in the table.
- **Line 382:** What do you mean by 1◦AK? Do you mean averaging kernels were binned by 1 degree SZAs?
- **Line 393:** ... each of the filters.
- **Line 403:** refer to the corresponding figures in this sentence and the previous sentence.
- **Figure D2:** is 6300 opd in cm? Also could you add a legend describing colors? Also mention the date and time of measurements in the caption.
- **Line 411:** In resolution Fig D1 cm... not clear what you are referring to here!
- **Figure E1:** this caption doesn't look like describing this figure.
- **Table F1:** Describe the vibrational and rotational levels corresponding to each digit.
- **Figure G3:** caption doesn't match the figure.
- **Figure H4:** InGaAs spectra: which spectral window?
- **Figure H5:** which one is on top and which one at the bottom?