Review of "Comparison of OCO-2 target observations to MUCCnet – Is it possible to capture urban XCO2 gradients from space?" by Rißmann et al.

The manuscript compares target viewing mode retrievals of total-column CO2 from NASA's Orbiting Carbon Observatory version 2 (OCO-2) to ground-based portable Fourier Transform Infrared Spectrometers (EM27/SUNs) within the Munich Urban Carbon Column network (MUCCnet). OCO-2 XCO2 retrievals from larger-swath target observations are compared to average XCO2 retrieved from MUCCnet ground-based sensors within the target viewing area for a number of comparison days. Furthermore, OCO-2 XCO2 retrievals are also compared to ground-based EM27 XCO2 to evaluate its ability to capture XCO2 gradients within its target viewing area. Overall, the paper presents a valuable scientific contribution to Atmospheric Measurement Techniques and to the satellite community in general in evaluating the ability for OCO-2 to capture gradients within its target viewing mode region. I recommend publication after addressing the minor comments noted below.

General comments:

- There are a number of areas within the manuscript that refer to XCO2 correctly in ppm, but then also refer to this quantity as both a concentration and/or a mixing ratio in various places within the text. The unit of ppm is a mole fraction and does not include a volume quantity, so please be cautious and consistent with the unit of XCO2 (ppm) throughout the manuscript.
- In general, the manuscript is very well-written and concise, but there are a number of grammatical errors and typos within the manuscript that could be removed with more thorough editing. I have noted some corrections below in the technical comments.
- Figure 2: The units of XCO2 are missing on subplots. It also looks like the target observations overlap quite a bit – how do you deal with this in the comparison methods and does averaging overlapping soundings affect your additional quality flag results in Figure 3? Similarly, Figure 15 is also missing XCO2 units and overlapping observations make it difficult to compare to the model. Is it possible to average these observations in some way to better visualize this comparison?
- For the model comparison, it wasn't clear within the text whether or not the WRF XCO2 calculation takes into account the OCO-2 averaging kernel. Does it? Without doing so, the comparison between OCO-2 and the model is not a true 1:1 comparison.

Specific comments:

L24: please replace "concentrations" with "mole fractions"

L31: Reference is not valid and is also not included in the References section

L39: It would be worthwhile to state that the TCCON monitors the long-term atmospheric growth of total-column CO2, CO and CH4…

L54: I think that the 14-day repeat cycle is incorrect, isn't it 16 days?

L66: Some care should be taken here to define the scale at which OCO-2 may be able to resolve XCO2 fluxes, which is dependent upon the spatial scale of the target itself.

L106: Because it is not possible to truly calibrate XCO2, it is somewhat misleading to call this quantity XCO2 "calibrated". Rather, this is a bias-corrected and scaled XCO2 retrieval that is presented.

L125: Please state to which CO2 scale these retrievals are tied for the reader.

Figure 3 caption: Should "spectrometer locations […]" be moved to Figure 2?

L138: Given the reference to Figure 2 and this statement, perhaps the order of Figure 2 and Figure 3 should be switched?

L144-155: Does the model XCO2 calculation take into account the OCO-2 averaging kernel?

L172: Can you explain more how the collocation radius is chosen? Is this 6 km chosen to equally segment the target area around the EM27 sensors?

L192: Please include punctuation around equations here and elsewhere.

L226: Caution should be taken in stating that OCO-2 "measures" XCO2 mole fractions. Rather, OCO-2 measures a radiance that is converted to a mole fraction of XCO2 via a retrieval algorithm. In this sense, care should be taken to refer to XCO2 from both ground-based and spaceborne instrumentation as "retrievals" here, in Figure 8, and elsewhere throughout the manuscript.

L247: Other potential causes for differences in biases are explained in L254-257, so perhaps it's worth moving this discussion to this paragraph.

Figure 11: These error bars look very small given the error bars in OCO-2 XCO2 in Figure 9. Can you explain a bit more how you've calculated this error? In addition, given that the gradient in XCO2 is very small, it might be worth indicating minor x-axis grid lines here for the reader.

L299: Given that the gradients presented in Figure 11 do not have overlapping error bars and therefore do not represent, qualitatively, similar mean XCO2 differences, would it be more accurate to state that OCO-2 is capable of *detecting intra-target XCO2 gradients of a similar sign as MUCCnet XCO2*?

L327: Again, here I am wondering how the XCO2 from the WRF model is computed because L144-155 does not describe whether or not this XCO2 quantity derived takes into account the OCO-2 averaging kernel.

L331: ‘mixing ratios’ are described in this same sentence in addition to mole fractions. Please use mole fractions and maintain consistency throughout the manuscript.

L344: It would be useful either here or in a previous section to describe what “good measurement conditions” entails.

L345: Similar to L66, “middle” to “larger” sized cities might be irrelevant without a spatial scale. It would be helpful to state the spatial scale that you would expect OCO-2 to be able to resolve urban XCO2 gradients, given the swath area of the target.

Technical comments:

L10: Please change “constraint” to “constrained”

L46-47: Consider rephrasing for readability

L93: … determined “by” performing

L153: Please change “weighing” to “weighting”

L173: Please change “none” to “no”

L223: “Observing systems observe” is somewhat redundant.

L240: Please replace “due to the ” with “by”

L290: Please replace “shows” with “shown”