

***Interactive comment on* “Detection of carbon monoxide pollution from megacities and wildfires on regional and urban scale: The benefit of CO column retrievals from SCIAMACHY 2.3 μm measurements under cloudy conditions” by Tobias Borsdorff et al.**

Anonymous Referee #2

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Review of “Detection of carbon monoxide pollution from megacities and wildfires on regional and urban scale: The benefit of CO column retrievals from SCIAMACHY 2.3 μm measurements under cloudy conditions” (Borsdorff et al.)

This manuscript presents results showing that SCIAMACHY CO column retrievals performed under clear and cloudy conditions provide valuable, complementary information regarding both CO concentrations and height reached by the CO pollution. CO emis-

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sions from megacities as well as from large fires were investigated applying SICOR, a retrieval algorithm developed for the analysis of newly available TROPOMI data. Results from this work will be relevant to future TROPOMI data analyses.

The manuscript presents valuable work in a mostly clear manner. However, important details of the retrieval process are not explained; they should be clarified in a few words so the reader can better understand the validity of method and results. The manuscript would improve if more effort was placed into the interpretation of results. Grammar needs to be revised. Following are comments listed sequentially. Please double check manuscript for additional grammar issues not included here.

- Page 1/line 1: “upcoming TROPOMI Sentinel-5 Precursor CO data product”.
- 1/3: “urban and regional scales [...] from megacities and wildfires, respectively”. Regarding the use of the word “megacities”: megacities are considered, generally, cities with ≥ 10 million inhabitants. According to this definition, LA is a megacity. Paris and Tehran are not, unless their metropolitan areas are included. Please clarify.
- 1/6: “observations with low (<1.5 km) and medium-high (<5 km) clouds”.
- 1/6 and 3/19: “As an example”. Exemplary = “the best of its kind” or “warning, deterrent”.
- 1/7: “SCIAMACHY’s mean clear-sky observations show weak CO enhancements”.
- 1/10-11: Consider Planetary Boundary Layer (PBL) height effects, how they may affect your results. Please see more detailed comments on Section 6.
- 1/13: “information to clear-sky retrievals, which can only be obtained over land”.
- 1/18: “will allow improved detection of CO emissions and their vertical extension over cities and fires, making possible new research applications”.
- 1/22: “Because of its moderate lifetime and low background concentrations”.

- 2/2-5: Please modify (here and elsewhere in the manuscript) this type of citation list as follows: “Gloudemans et al., 2009; Frankenberg et al., 2005; Buchwitz et al., 2007; Gimeno Garcia et al., 2011”.
- 2/7: “The presence of clouds may represent a challenge for the interpretation of satellite observations.” Please reword; consider that certain analysis may actually require (or benefit from) the presence of clouds.
- 2/30-33: Please consider moving to Section 2, where details on the datasets utilized or relevant to this study should be presented.
- 2/35-3/10: Same as above
- 3/11: “We have applied the SICOR algorithm to the full SCIAMACHY 2.3 mm dataset.”
- 3/14-16: Please consider moving to Section 2, where details on the datasets utilized should be presented. What did those validation efforts find?
- 3/18: “We separate CO retrievals under clear-sky, low (<1.5 km), and medium-high (<5 km) cloud conditions. As an example, we discuss CO pollution over Tehran, Paris, and Los Angeles [. . .] and Alaska/Canada 2004.”
- 3/23: Sections 5 and 7 are missing in this list.
- 3/24: Consider modifying title to “SCIAMACHY CO retrievals” or “SCIAMACHY dataset and retrievals”, since the section mostly covers the retrieval process. Section 2 lacks a sufficient description of the SCIAMACHY dataset; for example, its spatial resolution is not provided till the end of Section 5. More efforts are put into describing the TROPOMI dataset, even though it is not utilized in this work. Please properly describe the SCIAMACHY dataset in this section.
- 3/26-27: CO data availability is also discussed in section 7; please avoid repetition.
- 3/30: For simplicity: “Auxiliary parameters like signal-to-noise ratio of the measurement and number of retrieval iterations are also provided.”

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- 3/32: (Here and elsewhere) this type of citation list should read “by Vidot et al. (2012), Borsdorff et al. (2014), Landgraf et al. (2016b)”.
- 3/33: Where does the CH₄ a priori come from? Is the same a priori used for all locations? for all seasons? for all years?
- 3/33: Please simplify and reword sentence for clarity. Is this what you mean?: “Here, cloud optical depth and height are estimated using prior knowledge about CH₄, ECMWF surface pressure, and the observed absorption (of CO? CH₄? please clarify) in the spectral fit window.”
- 4/3: Please clarify in a few words “the selection of the retrieval window” so the reader understands what that means without reading the cited work. Is that the spectral range used? How was it determined?
- 4/6: For simplicity and clarity, please reword to “In this study we screen SCIAMACHY CO retrievals based on the number of retrieval iterations and the [...]”.
- 4/16: Please clarify: 1) are data with clouds above 5 km filtered out? 2) are cloud properties calculated based on a priori CH₄ profiles? In a few words: how? 3) are SCIAMACHY radiances corrected or not for cloud scattering effects? for aerosol effects? The later would be particularly relevant when investigating fires 4) how is CO from the “shielded” (by clouds) partial column quantified? Is it ignored? Is it copied/calculated from a priori? If yes, then: What is used as CO a priori? is the same a priori used for all locations? for all seasons? for all years?
- 4/16: “we attribute to erroneous retrievals possibly caused by ...”
- 4/17: “averaging the data over the entire mission period” This was done only for the cities, correct? Please reword accordingly.
- 4/27: if the following is correct, please clarify in the text that low values in the averaging kernel indicate that more of the CO a priori goes into the retrieval. Does SICOR result in averaging kernel values=1 if there is no a priori involved, i.e., if the CO signal is

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strong enough to produce a retrieval which is totally independent of the CO a priori?

- 5/2: is reference profile = a priori profile? Please reword for clarity.

- 5/7: “used by Fioletov”

- 5/8-9: “grid cell”, “radius”, how were they determined? Empirically? Please explain and justify the values used. Are they different for each location analyzed? If yes, then a summary table would be very useful.

- 5/15: references for previous work on Mexico/Guatemala 2005 fires?

- 5/19: “but shifted by about 45 days for both events. We ascribe this temporal shift to the atmospheric response time to built up the high atmospheric CO concentration.” Unclear if this is the case. MOPITT data do not seem to show such 45 day shift. Also, CO plumes from Asia cross the Atlantic in just a couple of days. Either support this claim with further evidence or remove from text; additionally, the relevance of this claim to the manuscript’s main point is unclear.

- 5/20-22: “As expected, CO retrieval values increase during the fire season (March-May???) each year, coinciding with an increase in burned area.”

- 5/30: Please consider swapping the “clear-sky” and “cloudy” order; otherwise, the text seems to imply that cloudy retrievals are the most trustworthy.

- 6/1-26: Please consider organizing text by region for clarity.

- 6/1: “reduced noise in the CO data product” Also: could having more samples reduce the noise?

- 6/4: “This supports our finding that both low-cloud and medium-high cloud retrievals can capture the burning events equally well” Please reword for clarity: this would not be true if the CO plume was confined near the surface, correct?

- 6/7: “0.5 degree” provide in km instead, for consistency.

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- 6/10: However, fires elsewhere do not show up in the clear/low cloud CO maps. Please explain.
- 6/19: “can detect the wildfires in agreement with the MODIS burned area product”. If one tries to locate fires from the burned area map in the high cloud CO map one finds no coincidences in space. Is the high cloud CO map rather showing CO transported away from the fire areas? Please explain and reword text accordingly.
- 6/21: “more than doubled”. That is because now retrievals over both land and water are being obtained; no fires in water-covered regions, though, just CO transported from the fire areas. Please reword to explain this.
- 6/26: Please clarify that what SCIAMACHY “sees” is transported CO away from the fire regions, not the actual fires.
- 6/26: It would be very useful if results from this work were compared to those in Pfister et al. (2005)
- 6/29: “We accumulated all SCIAMACHY observations from 2003 to April 2012 around these cities, distinguishing between clear-sky, low-cloud and medium-high cloud retrievals. Then we applied the oversampling approach with a longitude/latitude grid of $\delta = ???$ km and an averaging radius $r = 40$ km (Figs. 6, 7, and 8).” Please move the information on the MODIS urban area contours of Schneider et al. (2009) to figure captions.
- 7/1: “urban area contours (Schneider et al., 2009)”.
- 7/5: It seems like the red area is to the southeast of where Rouen would be located.
- 7/8: A similarly red area can be seen southeast of Paris. Please explain. Same north of Rouen. Could it be transported CO?
- 7/12: “Los Angeles”
- 7/12: “Medium-high clouds shield the atmosphere below and so the retrieval is less

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sensitive to the city pollution” Does this mean that SICOR retrievals over clouds do not/cannot approximate CO under the clouds? It just uses a priori? Please clarify in Section 2.

- 7/16: Please comment on the influence of PBL heights. A quick look at maps in Engeln and Teixeira (2013) shows that PBL heights for LA and Tehran are quite different from those for Paris. These differences may explain the detectability or not of urban emissions under medium-high cloud conditions. You may also want to discuss seasonal effects on PBL heights and, thus, on urban emissions detectability affected by clouds. (Also: the work presented here does not separate data by season; comment on this.) For example, the PBL height over Tehran and LA in the summer may be » 1.5 km, allowing for city emissions to be detected in some cases under medium-high cloud conditions. In contrast, the PBL height over Paris is approx. ≤ 1.5 km all year round, thus it may be that no CO signal will be detected if medium-high clouds are present. A simple exercise to test this hypothesis: see if removing summer data in Tehran and LA high cloud maps results in no CO enhancement over these cities.

- 7/17-23: for clarity: summarize in table rather than in text?

- 7/24: Pommier et al (2013) provided CO enhancements over LA, Tehran, and Paris; it would be very helpful if their results were contrasted with results from this work. Even better if their analysis for the 2004-2008 period was replicated with SCIAMACHY data, which is available for this same period.

- 7/26: Please comment on early TROPOMI performance.

- 7/32-8/8: This description of the SCIAMACHY instrument and dataset should be in Section 2.

- 8/10-9/10 for clarity: please consider discussing first cities, then fires (or vice versa) rather than mixing both discussions.

- 8/10: “column retrievals”

- 8/11: “SWIR spectra to study [...] complementary [...]”
- 8/12: “SICOR was developed”
- 8/13: “of SWIR measurements [...]. SICOR provides the possibility [...]”
- 8/20: “it was even possible to detect pollution over the neighboring city of Rouen”. Unclear.
- 8/21: “suitable to locate the source of biomass burning” Clarify that some of the fire regions compiled in the burned area maps were located, but not all of them.
- 8/26: “inferior” Please clarify: coverage was inferior, but not the retrievals themselves, correct?
- 8/28: “Regarding pollution from megacities, the CO results are similar for clear sky and low cloud measurements”. This is probably because both sample inside the PBL.
- 8/31: please change to “retrievals [...] provide complementary information”. Here and elsewhere in the manuscript: please match subject and verb.
- 9/2: “in the SWIR spectral range”
- 9/5: “the retrieval underestimates the total column of CO” TROPOMI’s ATBD seems to state the opposite.
- 9/6: “Los Angeles”
- 9/7: Paris also had the lowest delta CO of the three cities; please discuss. For these three cities: can the amount of CO enhancement be traced to population size?
- 9: Are there any controls to make sure CO transported from elsewhere is not being included in the fires analysis? This may be an issue when averaging long periods of time.
- 9: No wind correction (applied in Pommier’s work) was applied here. Please justify.

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- This should have been discussed early on: why 1.5 and 5 km thresholds were selected?
- 13/fig. 1: Please clarify: is the solid yellow line for clear conditions? If not, include one example.
- 14/fig. 2: Please explain negative CO values in first three panels. For readability, please include monthly markers.
- 15/fig. 3: Why are maps for 2003 not shown?
- 15/fig. 4: Font too small, not legible.
- 16/fig. 5: Is this figure needed?
- 16/fig. 5, 6, and 7: These results are quite remarkable, keeping in mind SCIAMACHY's spatial resolution. To make this point more clear, please consider adding one panel to each figure with actual SCIAMACHY spatial resolution.

Please clarify what is shown in each of the three panels: clear, low, and high cloud results?

Please remove the latitude/longitude box information in captions since maps have lats and lons.

If scale in fig. 5 was 70-110 the reader could compare better results for the three cities.

Clarify that fig. 6 shows the Paris region.

Font is too small, scale and labels in maps are not legible.

- 17: are fig. 9 and 10 needed?

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-423, 2017.

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