**Atmospheric
Chemistry
and Physics
Discussions**

# *Interactive comment on* "Global estimates of CO sources with high resolution by adjoint inversion of multiple satellite datasets (MOPITT, AIRS, SCIAMACHY, TES)" *by* M. Kopacz et al.

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We would like to thank the reviewer for the positive and insightful comments. Our responses to the comments are listed below.

Specific minor comments:

Comment 1: 2.4. SCIAMACHY 25: You cite the paper of de Laat et al. (2007) which introduces a method of how to average by weighting an ensemble of CO column observations. It is not clear whether you also used the negative SCIAMACHY CO columns (as you probably should).

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Response: We used all the CO columns where the quality flag, which is part of the data product, indicates "good" retrievals. One of the criteria for a retrieval to be classified good is that the CO column has to be positive. The fraction of negative CO columns depends on the scene (e.g., on the surface albedo) but is typically very small (see, e.g., Fig 7 of Buchwitz et al., 2007). The implications of this are therefore considered not to be significant for this study although strictly speaking also negative CO columns should be used for the computation of averages as suggested by the referee. We now state this explicitly in the paper:

"SCIAMACHY data have considerable noise, typically 10-100% of the total column. Here we use daily averaged data weighted by the reported instrument error and use available quality flags for data screening, which filter any negative columns that are produced during the retrieval process."

Comment 2: 4. The inverse model It is not clear if you are using daily 2x2.5 grid-box averages of columns of MOPITT, AIRS and SCIAMACHY observations. Am I right if I assume the number of observations in Fig. 6 correspond to 305484 (MOPITT), 923234 (AIRS), and 25773 (SCIAMACHY), respectively? If it is easy to make new plots you could plot the number of observations (or indicate it in the legend of Figure 6) because the number of TES, MOZAIC, and NOAA/GMD observations, respectively, is not mentioned in the paper.

Response: The numbers previously stated are all for 4x5 degree averaged observations, which was confusing as we use 2x2.5 degree resolution as well. We now clarify this by adding the number of observations (n) at 2x2.5 degree resolution in Figure 6 for each dataset, as suggested by Reviewer.

Comment 3: 6.2. Seasonal and regional results 25: The explanation that residential heating and on-road vehicle emissions (cold starts) needs one or more sentence of elaboration if possible because this finding is a central part of the paper. It would be interesting to read a typical estimate what the individual contribution of residential

heating versus cold starts might be even if this estimate is only cited from the literature. Or do they always go hand in hand (if temperatures are low people for example in Europe will heat and 'cold start' their cars).

Response: To our knowledge, no numbers exist (global or regional) that could be directly compared. To further elaborate on the central issue, we now include the following for an Asian case study: "Analyzing hourly evolution of Beijing surface CO concentrations, Han et al. [2009] find that residential heating emissions in Beijing might in fact be overestimated in current inventories, while emissions from non-domestic sources such as transport (and including cold starts) might be underestimated. Cold start emissions depend on many non-temperature factors, such as time since last operation of the vehicle as well as its operation after starting [Wenzel et al., 2000]. Meanwhile, emission factors for domestic burning of coal and wood can differ as well. Therefore, more detailed analysis of our findings requires further regional perspective."

Comment 4: I am not criticising but wondering why the a posteriori adjustment of emissions follows the a priori pattern in the adjoint inversion. To give you an example (I have randomly picked out a region for closer inspection). In Europe for example (Fig. 6 of your work) the a posteriori emissions in winter are being adjusted by as much as a factor of 1.6 in the grid-box covering southern Germany, Switzerland, northern Italy and western parts of Austria. At the same time eastern parts of Austria which cover the adjacent grid-box are not increased (about only 1.1) by as much in absolute terms (Tg CO) as to give a similar a posteriori emissions estimates, even though winters in eastern parts of Austria are as cold as in Switzerland or western alpine parts of Austria. After careful inspection of Figure 1 the a priori in eastern parts of Austria is also lower; maybe the ratio of the two grid boxes of a posteriori emissions follow the ratio of a priori emissions. On the other hand I am intrigued by you results because eastern parts of Austria share a strong contribution from urban gas heating as opposed to western Austria which is dominated still by wood burning and this would support your findings at least for that region in Europe. I have no actual figures for Switzerland or Germany

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though.

Response: We are very grateful to the Reviewer for these two comments. The Austria-Switzerland-Germany analysis would be a great regional focus with detailed information that is beyond the scope of our study. It is encouraging to hear it appears to be consistent with our explanations. We now address the two comments with the following additions to the text: "The upward corrections also correspond to areas of large emissions and as with any least-squares inversion, there is a possibility that the optimization might disproportionally focus on largest sources. Our previous study [Kopacz et al. 2009] analyzed this possibility, however and found no evidence of consistent bias."

"Despite using numerous datasets and a high resolution optimization, our study is still only a first step towards a detail top-down understanding of CO emissions. Many regional details of source estimates and regional dataset discrepancies can be merely highlighted here."

Comment 5: 8. Conclusion You do not mention 'cold starts' in the conclusion. I think you should as you did in the main text mention it as one possible explanation on top of wood burning and coal burning in Asia.

Response: We now include the following in the Conclusion section: "Such large seasonal variation is not recognized in current bottom-up inventories. We hypothesize that it could be due to a combination of emissions from residential heating and vehicle cold starts."

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 19967, 2009.